Green Hydrogen

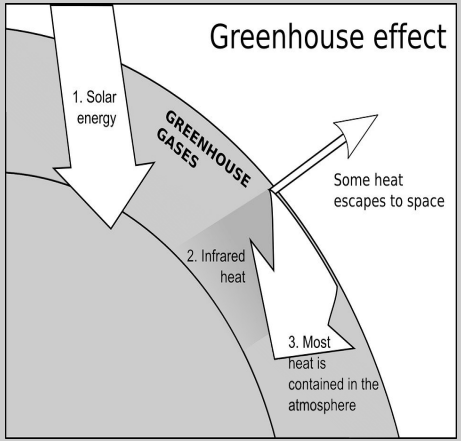
Gurudatt Rao
M.Tech (IIT Bombay) & MS (Ohio State University)

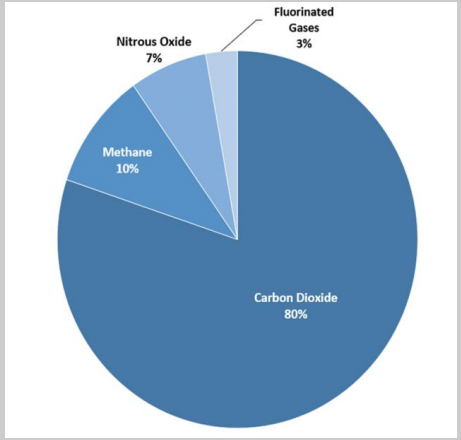
Presentation Flow

1. ***Background to Climate Change***
2. ***Why Hydrogen?***
3. ***How to Produce Hydrogen?***
4. ***What is Green Hydrogen?***
5. ***Challenges in Realizing Green Hydrogen?***
6. ***Current Progress***
7. ***References***

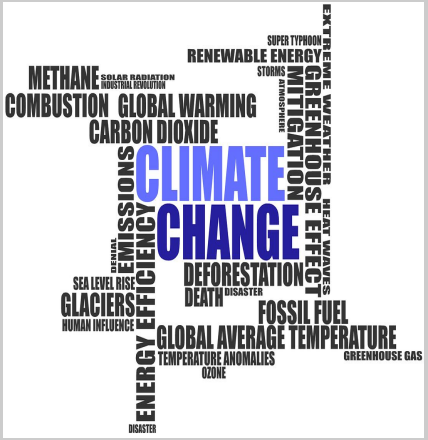
Background to Climate Change

- Human Activities since Industrial Revolution has led to Carbon Dioxide(CO_2) and other Gas Emissions (together called Greenhouse Gases - GHG)
- These Gases have led an increase in the Global Temperatures owing to trapping of Sunlight insight the atmosphere
- Each greenhouse gas has a Global Warming Potential (GWP) i.e. ability to remain in the atmosphere and its energy absorption capability. Higher the GWP, deadlier the gas[1]
- Agriculture, Energy Sector, Industry and End-of-Life Waste in Landfills are the sources of GHG emissions





Overview of U.S. Greenhouse Gas Emissions in 2019



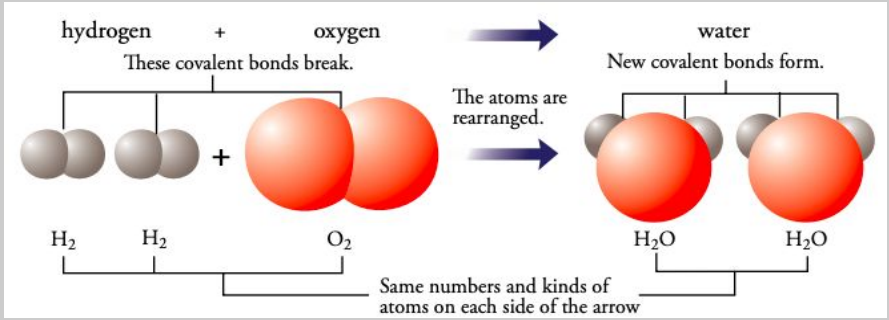
Why Hydrogen?

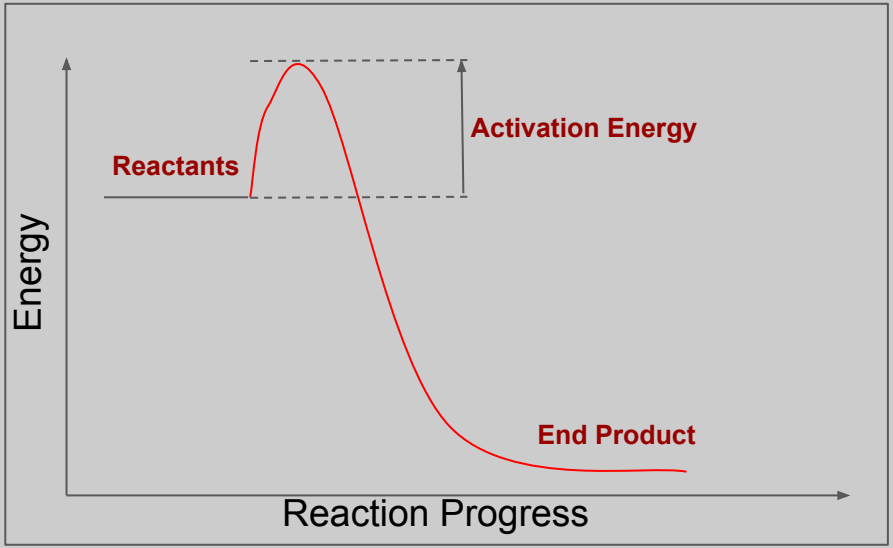
- Hydrogen is the lightest element and it occurs often as a constituent of Methane gas(CH_4) which is a by-product from hydrocarbon extraction & refining process

- Despite Hydrogen Gas being 8 times lighter than methane gas, Hydrogen is more efficient fuel in terms of energy provided per weight. An energy of 286 kJoules is released for every mole of hydrogen gas burned[2][3]

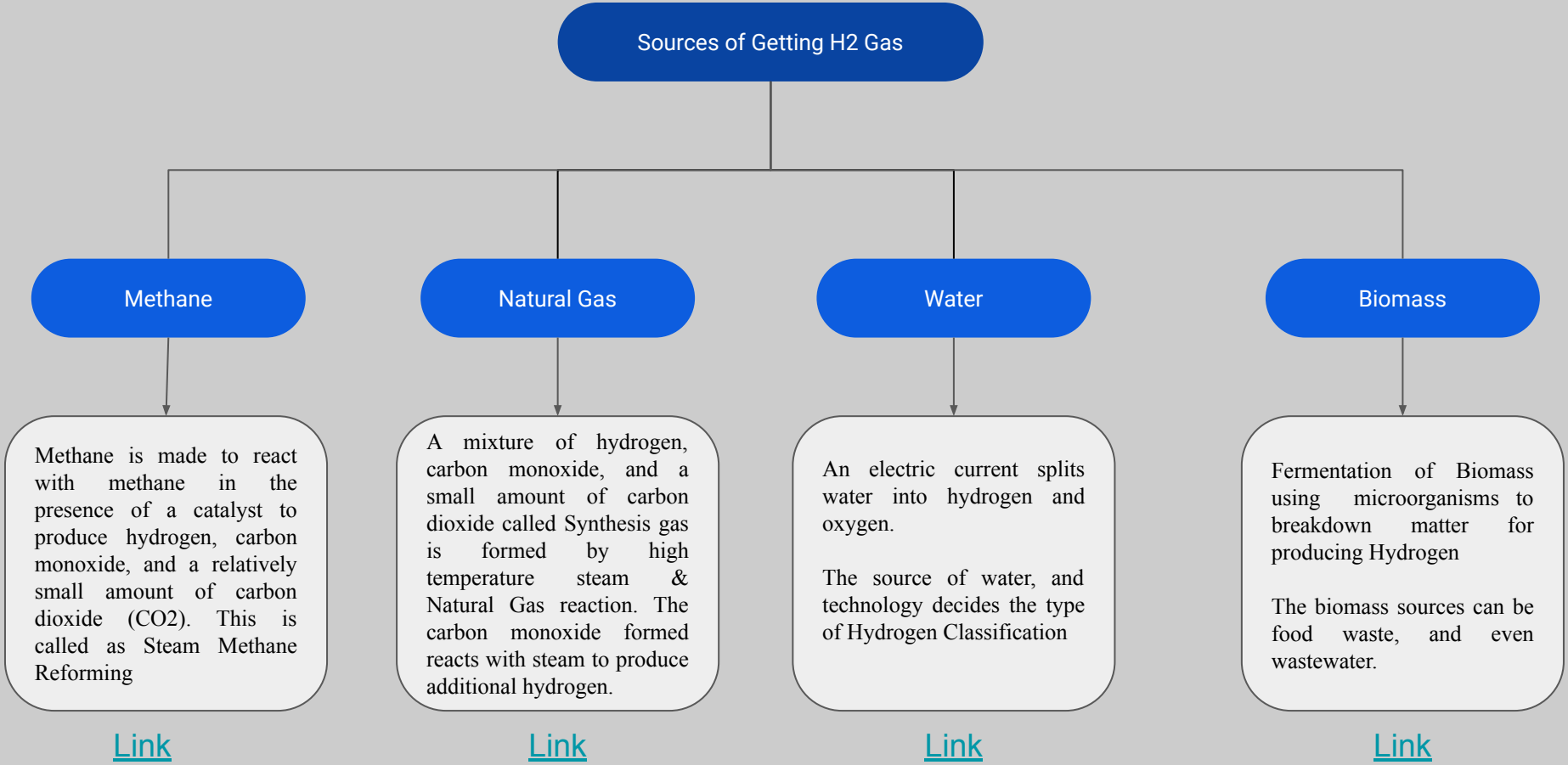
- Hydrogen(gas) when combusted in an aerobic atmosphere(Oxygen Rich) provides output as H_2O(vapors) at the output[2][3]

- As there is no GHG emitted in Hydrogen Burning, it is considered as a cleaner fuel to replace gasoline for automobiles





How to Produce Hydrogen?



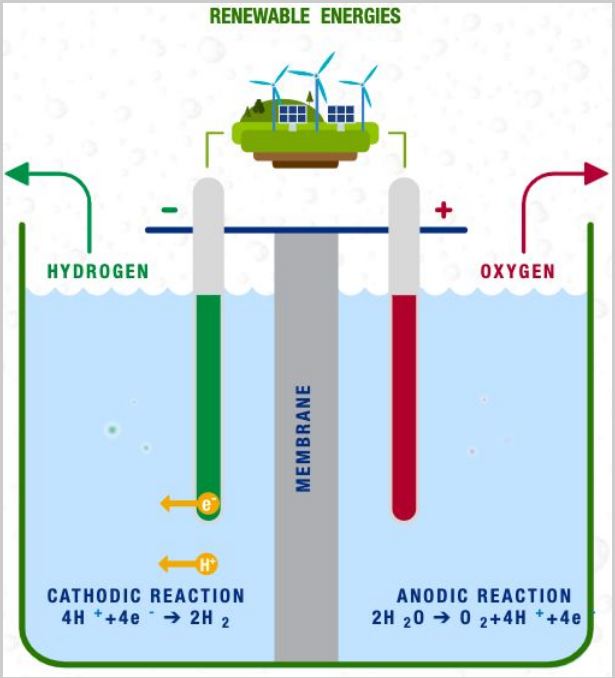
What is Green Hydrogen?

The term ‘Green Hydrogen’ is coined for Hydrogen Gas generated using renewable energy(Wind and/or Solar Energy) to power the electrolysis(splitting) of water

Producing green hydrogen by electrolysis from renewable sources involves breaking down water molecules (H_2O) into oxygen (O_2) and hydrogen (H_2).

1. The water used in the electrolysis must contain **salts and minerals** to conduct the electricity.
2. Two **electrodes are immersed in the water** and connected to a power source and a direct current is applied.
3. The dissociation of hydrogen and oxygen occurs when the electrodes attract **ions with an opposite charge** to them.
4. During the electrolysis, an **oxidation-reduction reaction** occurs due to the effect of the electricity.

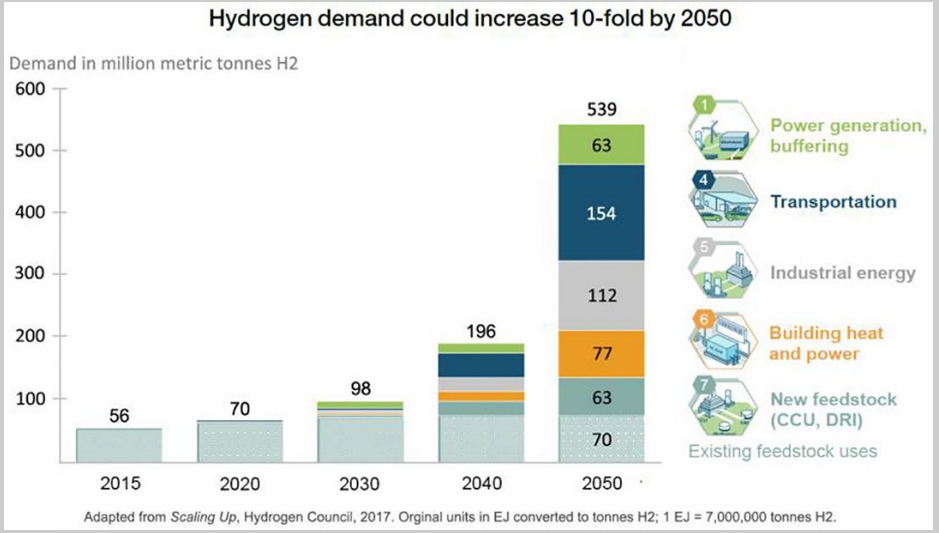
Process flow for making Green Hydrogen from Renewable Energy[8][9]



Basic Layout for Green Hydrogen[8][9]

Challenges in Realizing Green Hydrogen

- Overall Cost of renewable energy that is to be utilized for undertaking Electrolysis/splitting of water[8][9]
- Higher Cost of Green Hydrogen versus low cost Hydrogen from Coal, Natural Gas, Biomass etc.
- Difficulty in Hydrogen Gas Storage, Transportation and Distribution owing to high volatility and flammability. A possible workaround is liquefying it(diluting it in natural gas or adding ammonia for extraction at the final destination.)[8][9][10]
- Lack of Demand from Industry for Green Hydrogen Usage (rather than that for making value added products like Methanol, Ammonia, Gas to Liquid Fuels)[9][10]



Growth in Hydrogen Demand in the next 3 Decades[10]

Current Progress

Shell teams up with Norsk Hydro to work on green hydrogen projects

Link

DEWA Green Hydrogen Plant

The Middle East's first solar-driven hydrogen electrolysis facility

Link

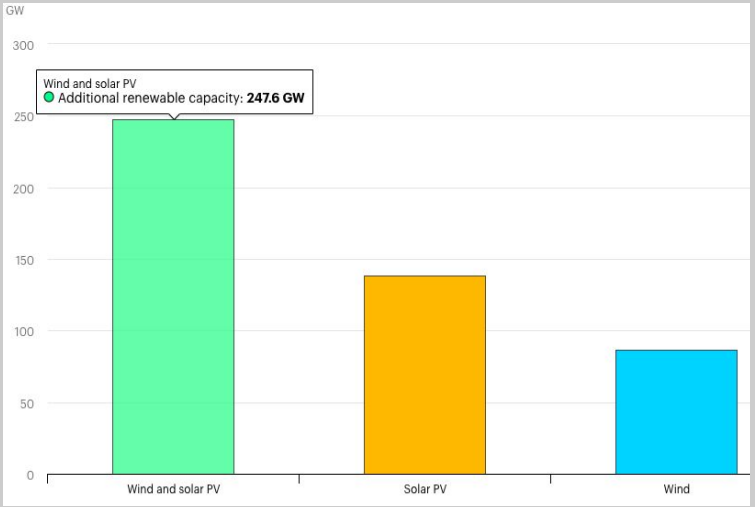
British firm JCB signs multibillion-dollar deal to import green hydrogen

Link

World's largest green hydrogen project – with 100MW electrolyser – set to be built in Egypt

Link

What is in Store for 'Green Hydrogen'



Reference: IEA, Additional renewable capacity according to planned and announced green hydrogen projects, IEA, Paris (Link)

References

1. https://www.epa.gov/ghgemissions/overview-greenhouse-gases
2. https://www.webassign.net/question_assets/prepchem1/prepchemaf1/Bishop_eBook_AF7-1.pdf
3. https://personal.utdallas.edu/~metin/Merit/MyNotes/energyScience2.pdf
4. https://afdc.energy.gov/fuels/hydrogen_production.html
5. https://www.energy.gov/eere/fuelcells/hydrogen-production-processes
6. https://www.eia.gov/energyexplained/hydrogen/production-of-hydrogen.php
7. https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming
8. https://www.iberdrola.com/sustainability/green-hydrogen
9. https://www.greentechmedia.com/articles/read/green-hydrogen-explained
10. https://www.frontiersin.org/articles/10.3389/frsus.2020.612762/full
11. https://www.renewableenergyworld.com/hydrogen/the-challenges-in-pursuit-of-a-green-hydrogen-economy/#gref
12. https://www.h2verdebrasil.com.br/en/challenges-for-green-hydrogen/
13. https://www.iea.org/data-and-statistics/charts/additional-renewable-capacity-according-to-planned-and-announced-green-hydrogen-projects