INDIA INTERNATIONAL CENTRE

Climate Change Research Institute

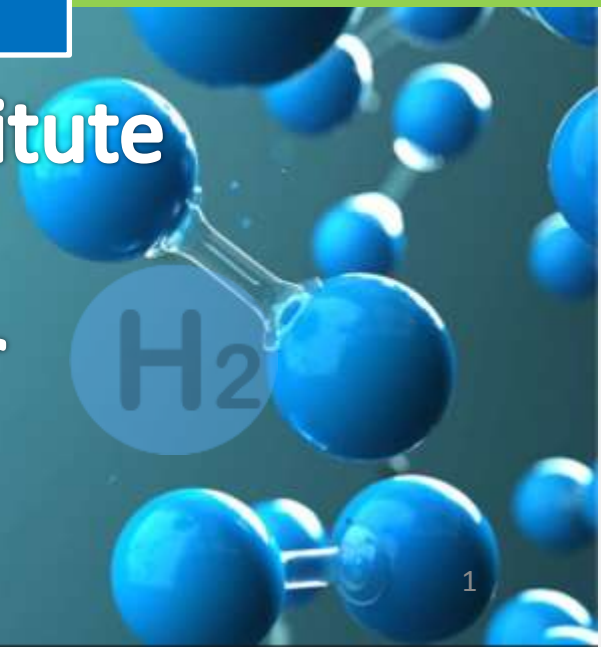
Workshop on

Hydrogen Production and Energy uses: Towards a Net-Zero strategy (ACBHPE-2022)

8th To 10th June, 2022

ACBHPE 2022

Climate Change Research Institute
&
India International Center



Welcome You All

Technical Session

Green Hydrogen Production- Hybrid Approach

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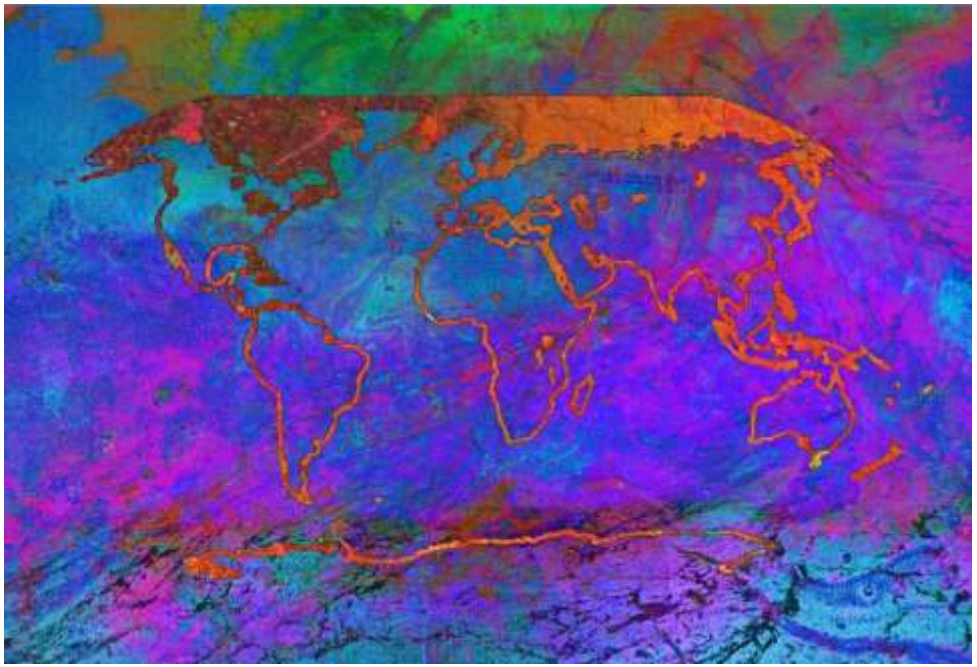
CSIR Emeritus Scientist, JNU

Climate Change Context

The 6th Report of Intergovernmental Panel on Climate Change (IPCC) released on 5th April 2022 stated that "If the world is to reach net-zero emissions, hydrogen will play a vital role". Advocating both for H2 and CCS, the report highlights following challenges;

"Key challenges for hydrogen are: (a) cost-effective low/zero carbon production, (b) delivery infrastructure cost, (c) land area (ie, 'footprint') requirements of hydrogen pipelines, compressor stations, and other infrastructure, (d) challenges in using existing pipeline infrastructure, (e) maintaining hydrogen purity, (e) minimizing hydrogen leakage, and (f) the cost and performance of end-uses."

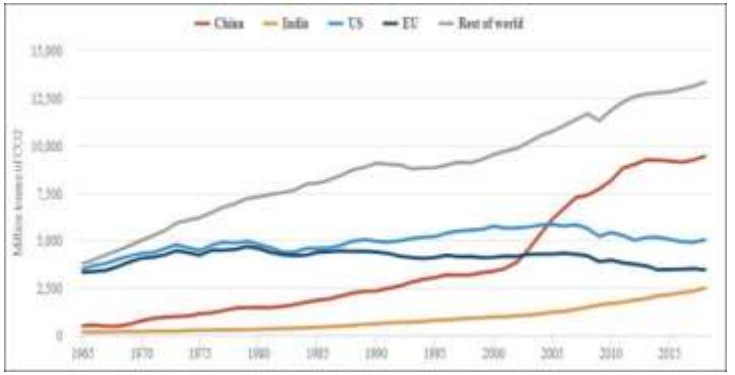


IPCC-AR6_reportcover_lrg.jpg

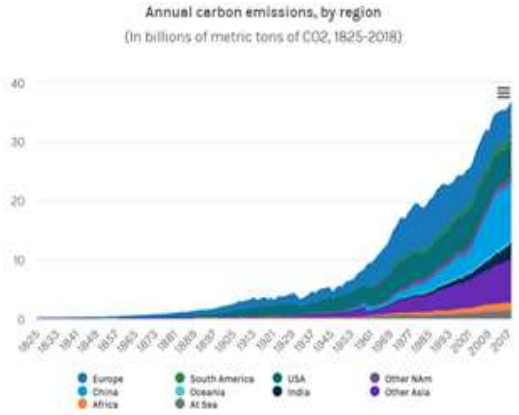
Annual Carbon Dioxide Emissions by Region, Country and annual changes

Over the past 800,000 years, the concentration of CO2 in the atmosphere has mostly fluctuated around 200-300 parts-per-million (ppm).

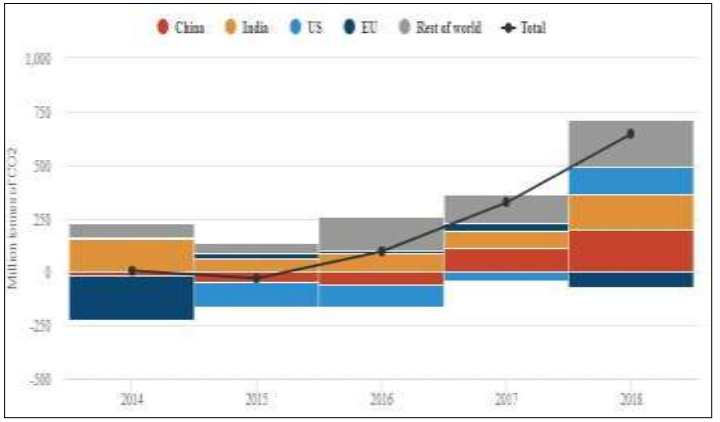
Since the 1950s, the atmospheric CO2 concentration has grown from about 310 ppm to 421 ppm in 2021.



China, India, the US and EU added to around 70% of the global increase in CO2, in the last 50 years.

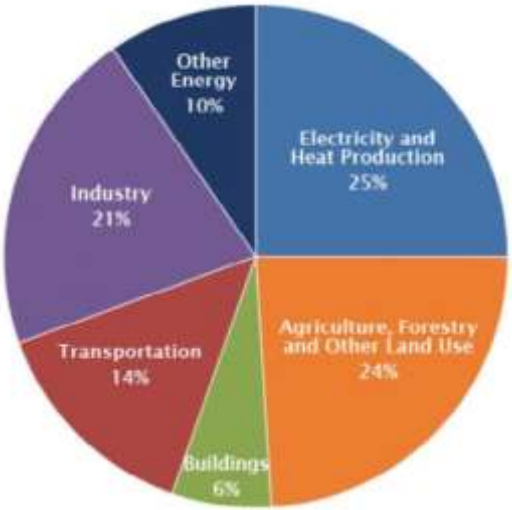


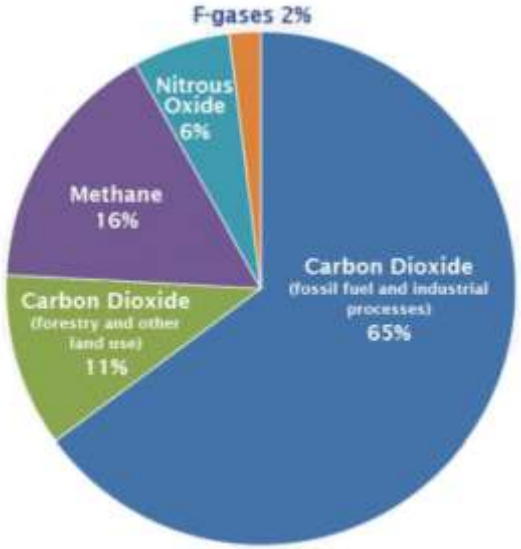
Morgan Stanley, September 18, 2020

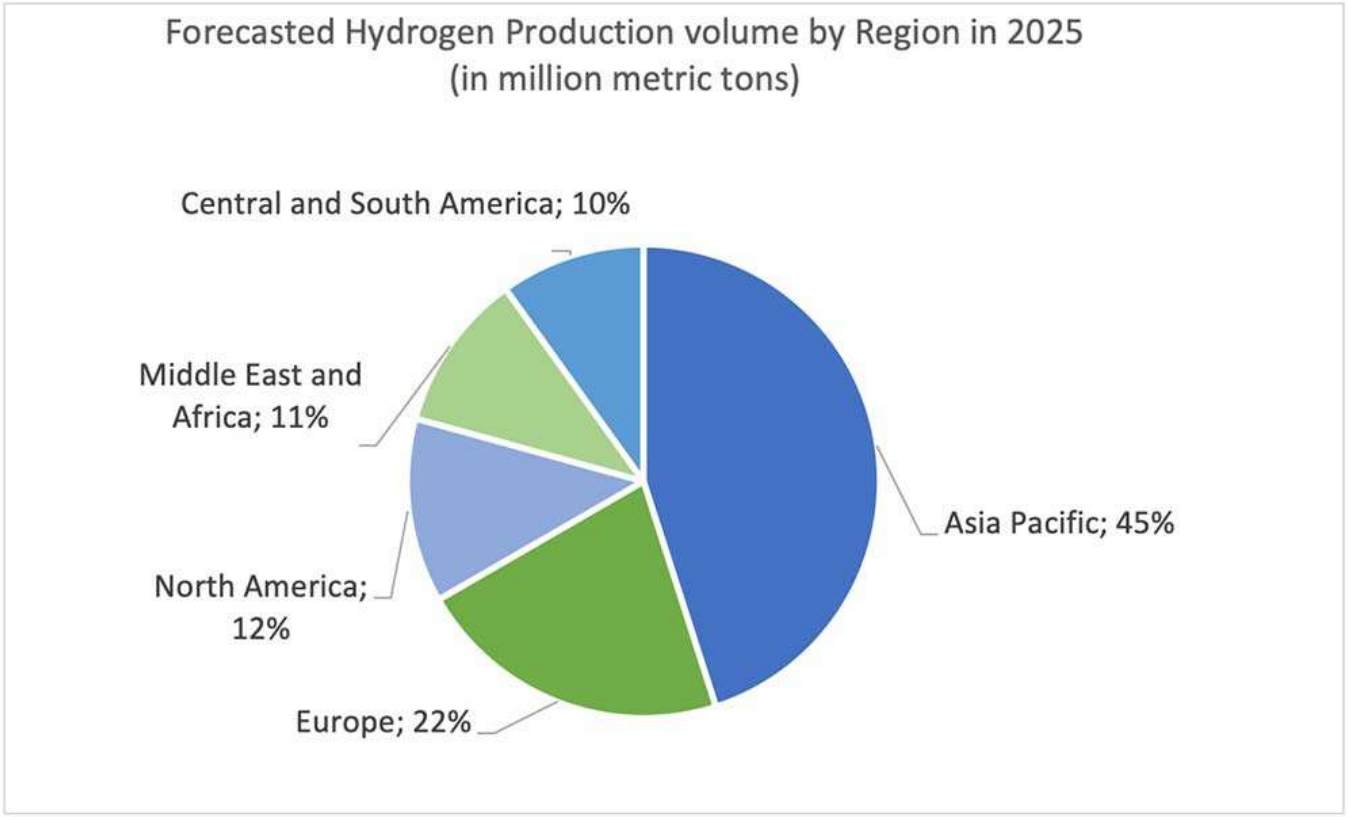


Annual changes of CO_2 emission by country. The black line depicts total global annual CO2 emissions changes.

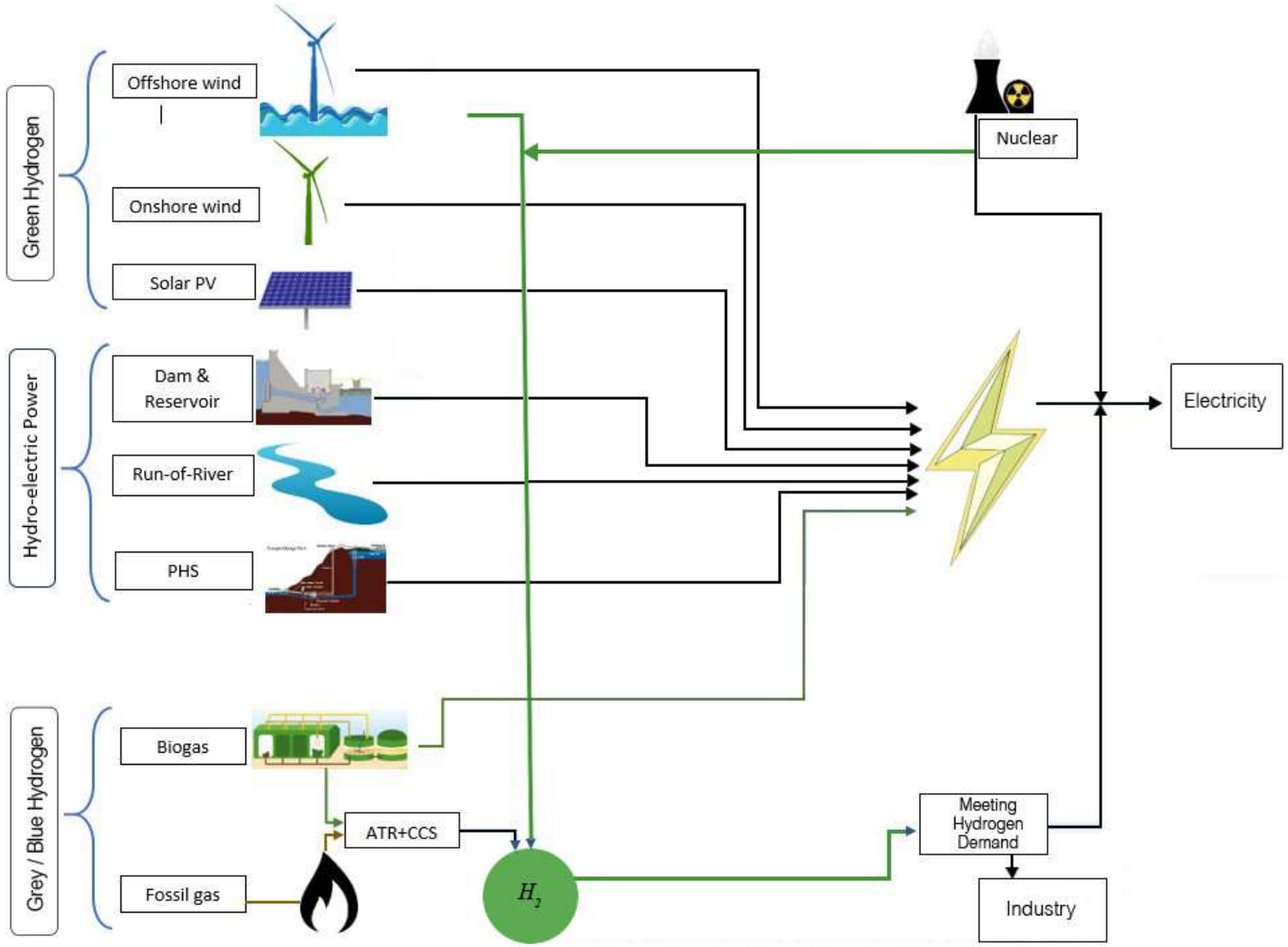
Economic Sectors, GHG Emissions and Role of Hydrogen







Hydrogen Production Pathways in Energy systems

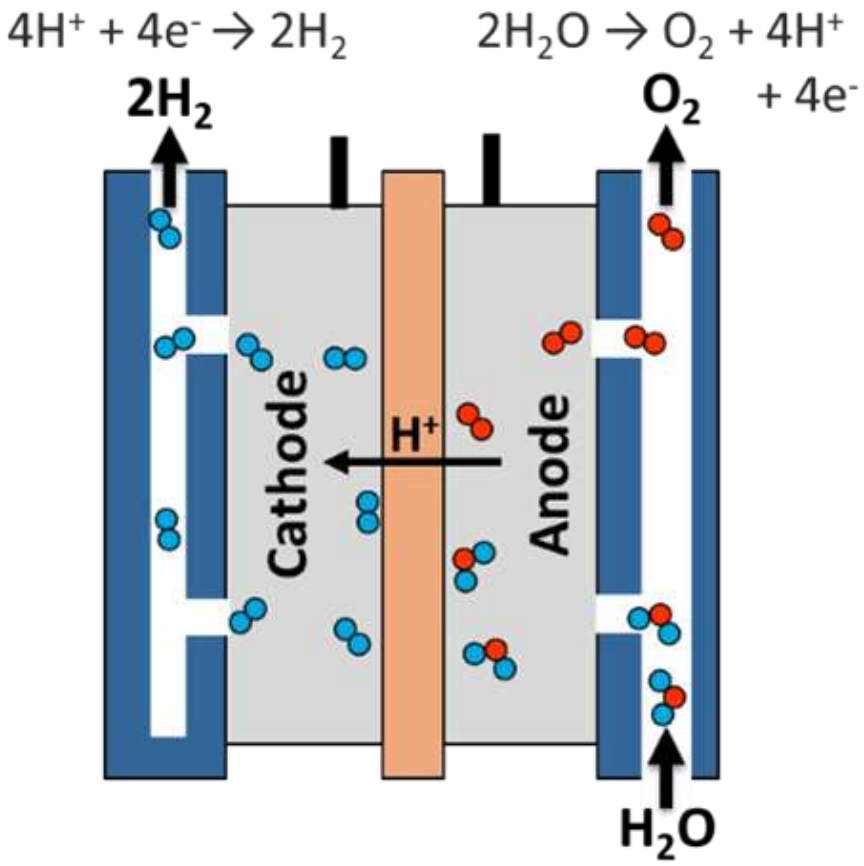


Hydrogen Production Technologies

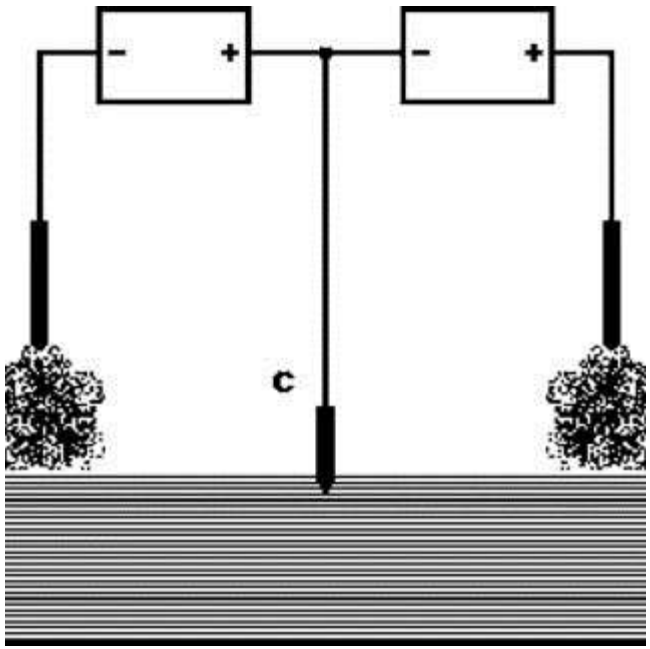
The Hydrogen Production Technology can be grouped into

- **Electrical**
- **Thermal**
- **Hybrid**
- **Biological processes**

Electrical Methods

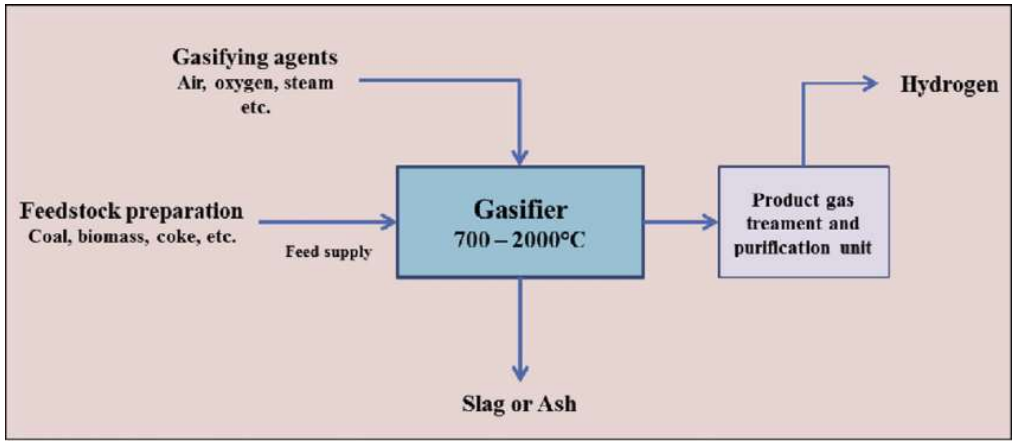


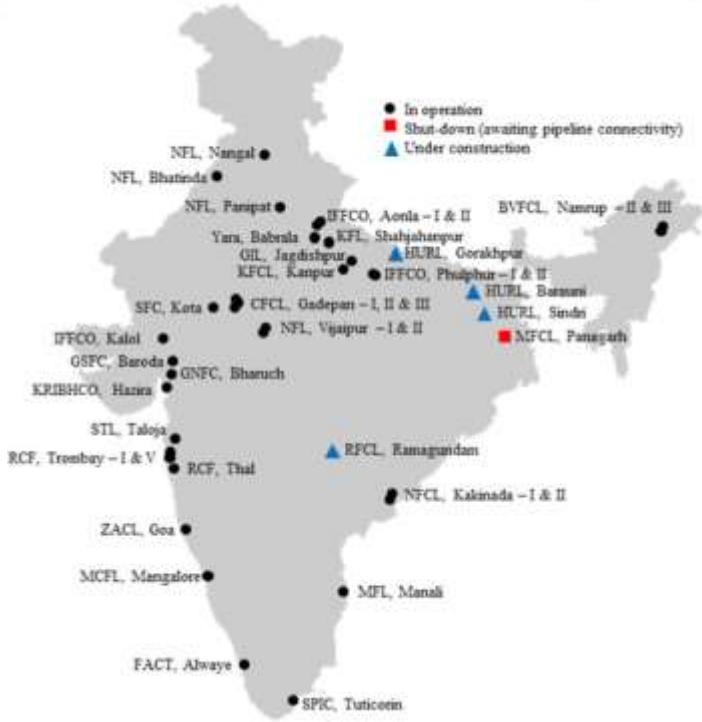
Water Splitting by Electrolysis

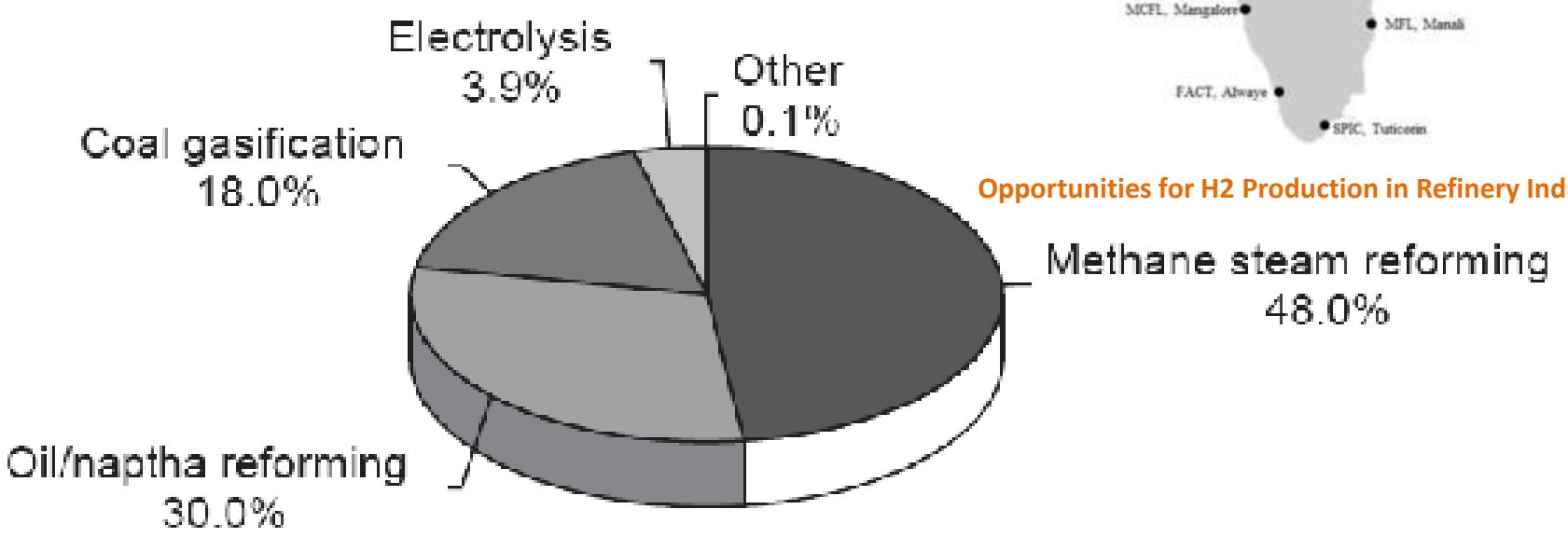


Plasma Arc Electrolysis

Thermal Processes using Fossil Fuels

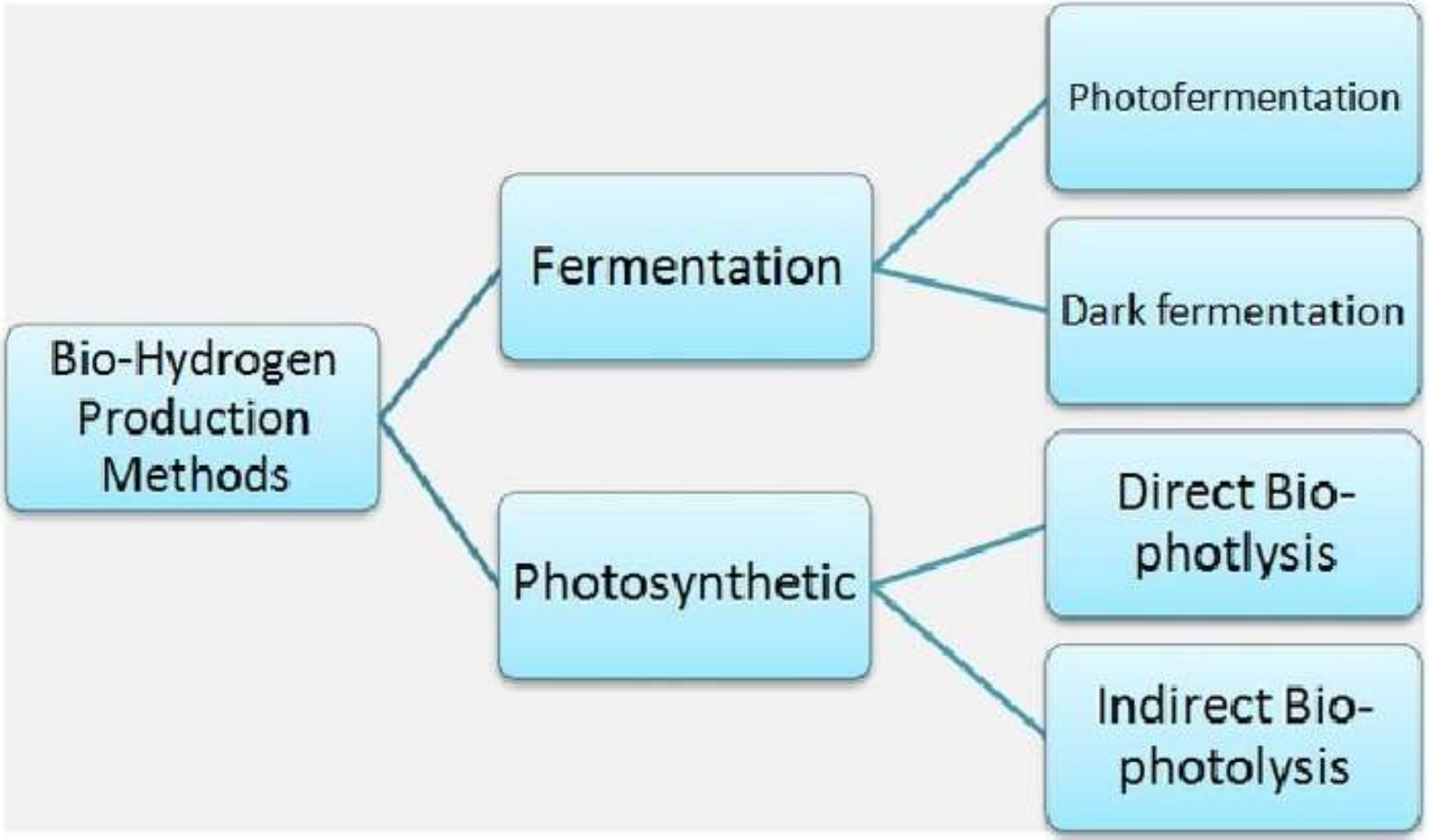






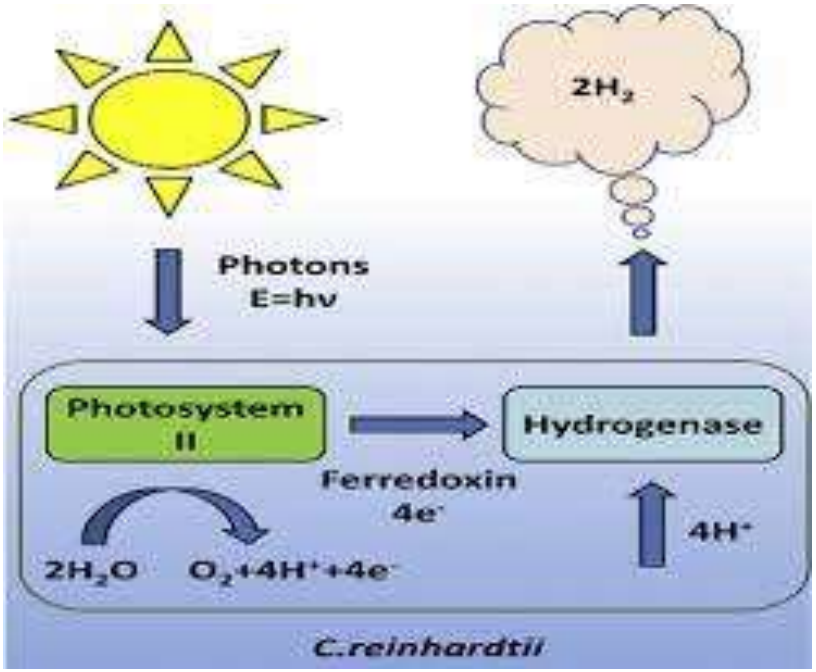
Opportunities for H2 Production in Refinery Industry in India

Biological Processes and Hybrid Approach

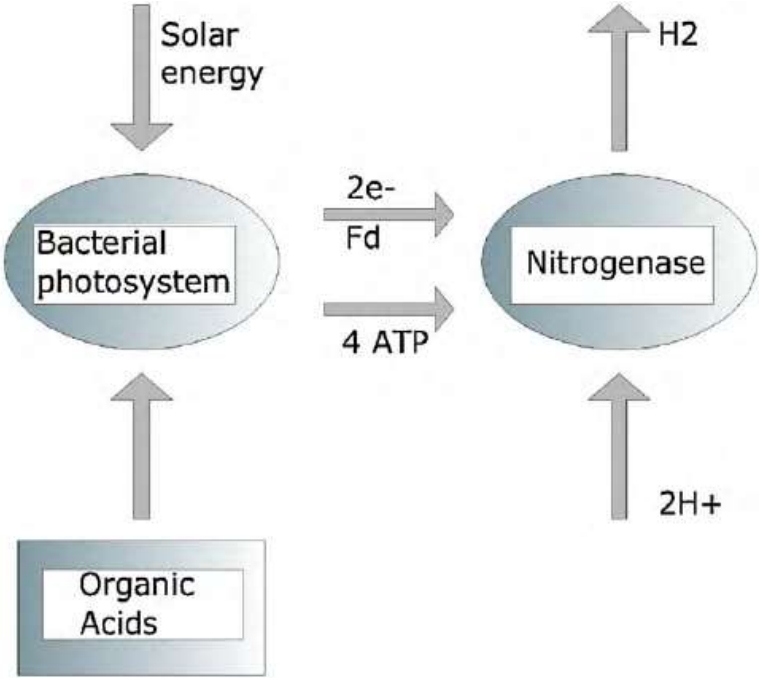


Hybrid Process of Hydrogen -

Biophotolysis



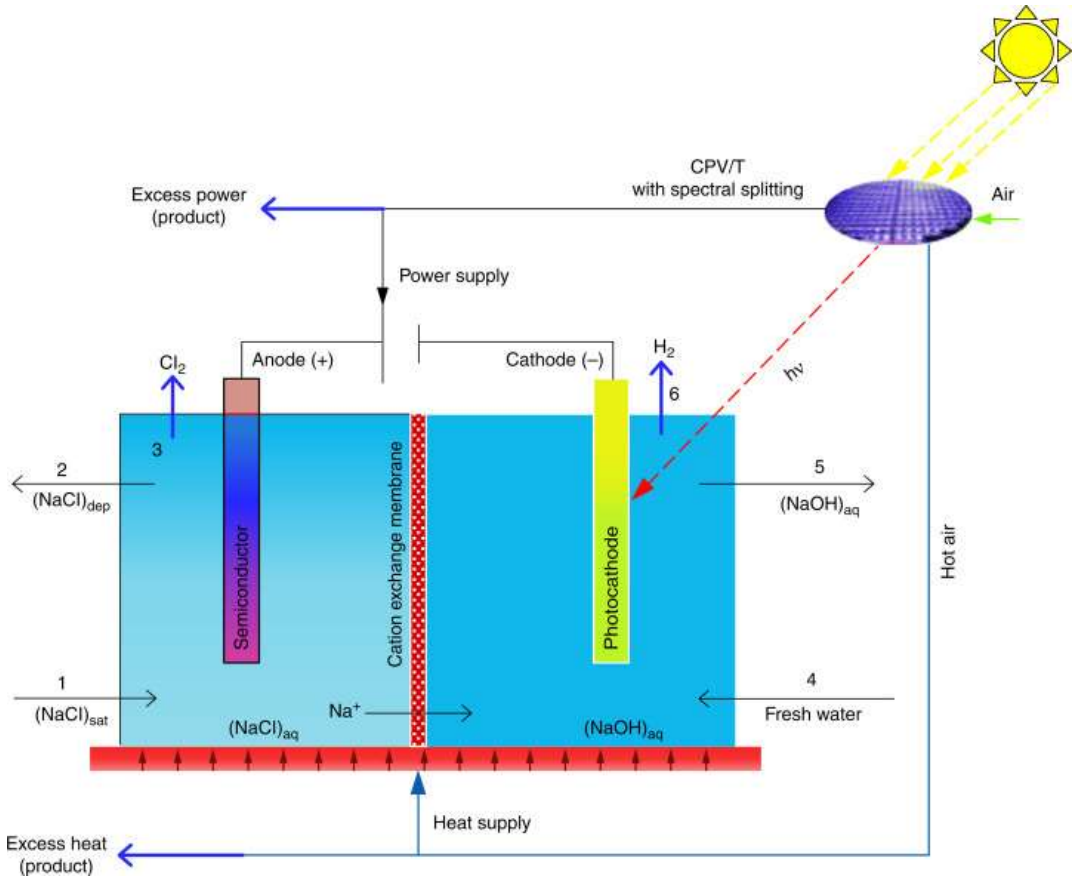
Direct biophotolysis



Indirect biophotolysis

Hybrid Processes of Hydrogen

Photo-electrochemical (PEC)



Artificial Leaf

Solar factories of tomorrow

CSIR-National Chemical Laboratory Pune, India, has developed an ultra-thin artificial leaf device consisting of semiconductors stacked in a manner to simulate the natural leaf system. In the presence of solar light, electric current flows through the semiconductors and results in water splitting. The results are promising and suggest that it could become the basis of **'solar factories'** in which solar collectors' arrays are used to split water into hydrogen.

Possible Green Hydrogen Pathways

Water electrolysis among electrical methods, biomass gasification as being CO2 neutral among thermal methods, photo-electrochemical and photo-fermentation production among hybrid methods and bio-photolysis among biological methods makes hydrogen production “green”

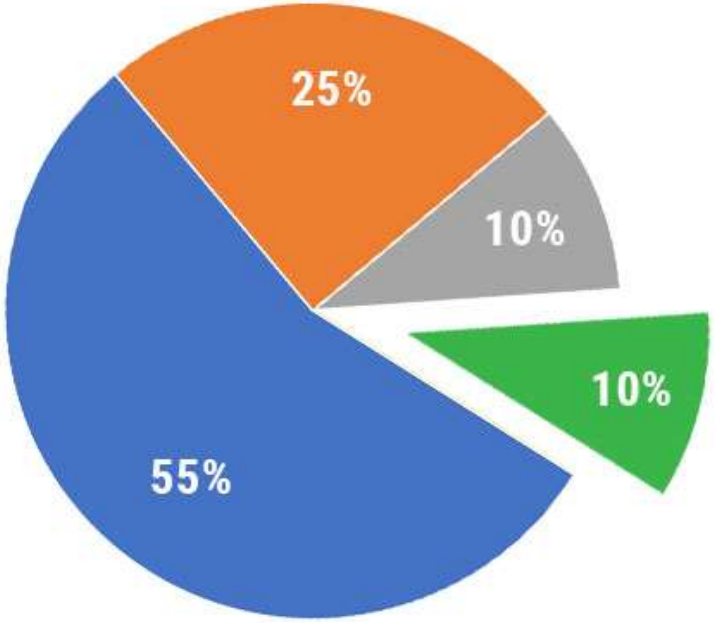
Source- D Duzgun, M. Yildiz, IJHE, 2017

Ladder of Hydrogen Colors

Petroleum Refining
25%

Ammonia Production
55%

GLOBAL HYDROGEN CONSUMPTION BY INDUSTRY

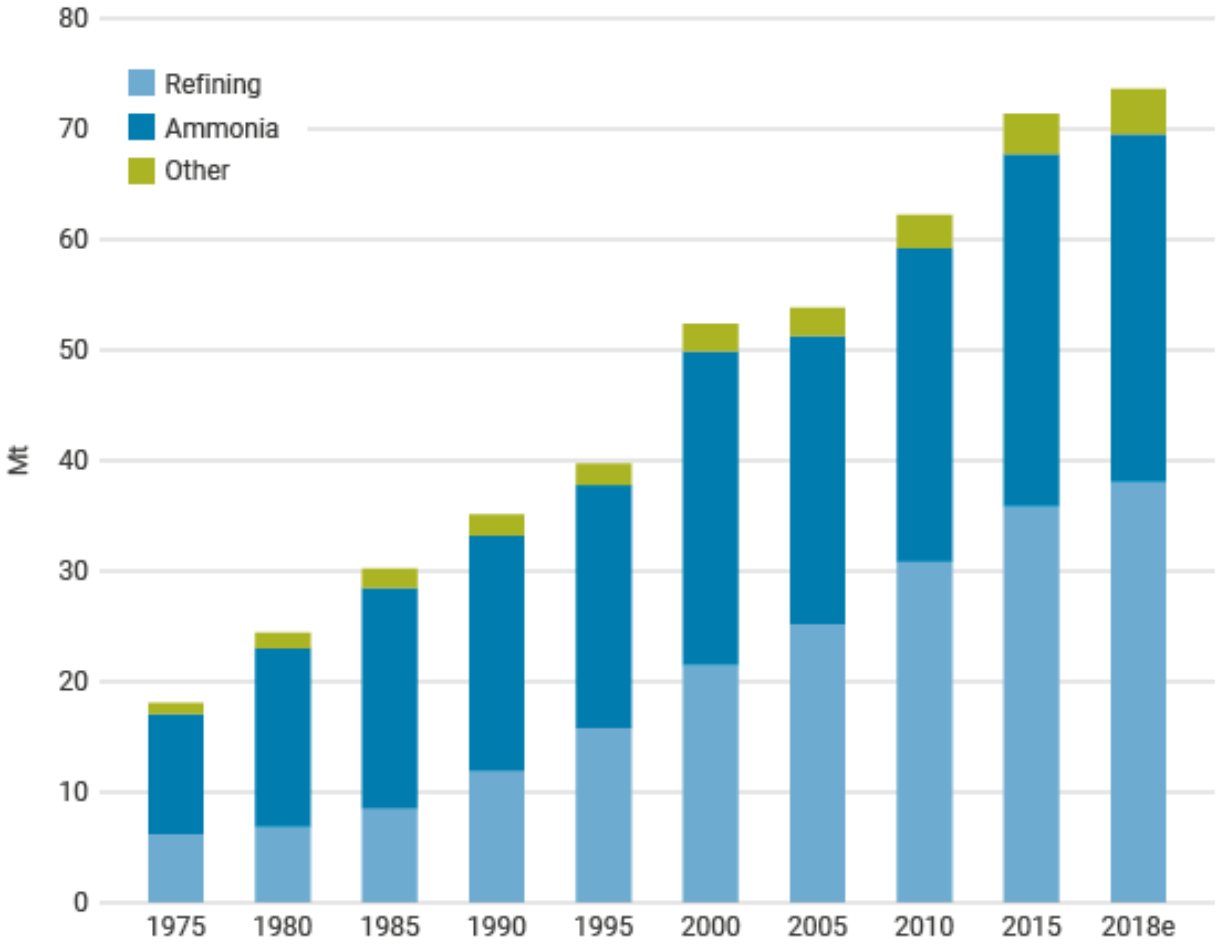


Data from Hydrogen Europe (hydrogeneurope.eu/hydrogen-applications)
Illustration © WHA International, Inc. (wha-international.com)

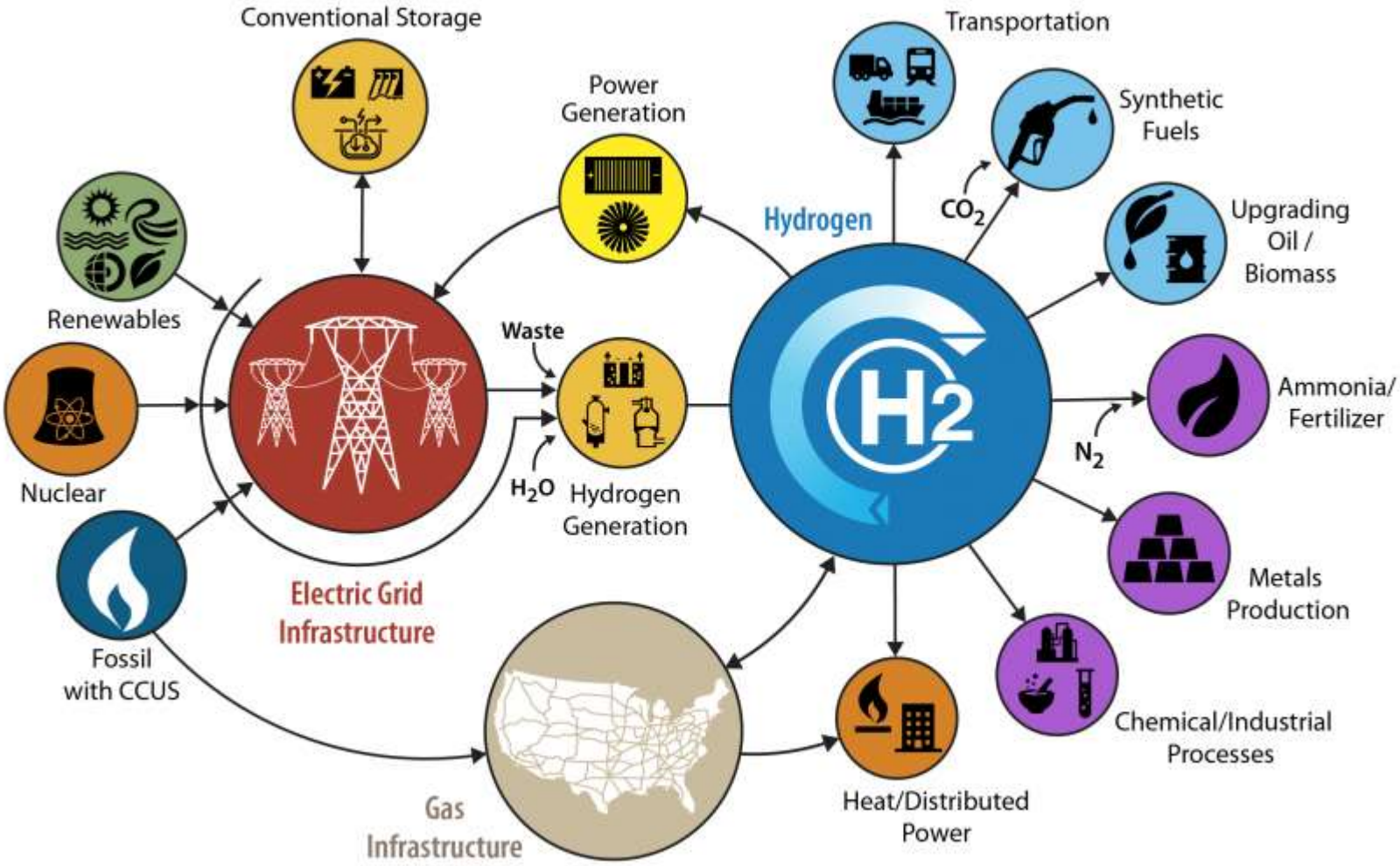
Methanol Production
10%

Other
10%

Growing Hydrogen Use in Industry since 1975



H2@Scale – a DOE Project Initiative



Early Hydrogen Initiatives in India

- In 2003 National Hydrogen Energy Board was formed
- In 2006 the Ministry of New and Renewable Energy laid out the National Hydrogen Energy Road Map identifying transport and power generation as two major **green energy initiat**ives.
- MNRE R&D programme on '**Hydrogen Energy and Fuel**' was launched to address challenges in production of hydrogen from renewable energy sources, its safe and efficient storage, and its utilization for energy an transport applications through combustion or fuel cells.
- R&D was intensified focusing on improving the efficiency of water-splitting reaction, and finding newer materials, catalysts and electrodes to accelerate the reaction. More than 100 research groups engaged in fuel cell technology.
- Institute of Chemical Technology and ONGC Energy Center collaborated to develop cost-effective production of Hydrogen

Recent Initiatives

- In 2015 India participated in Mission Innovation Challenge for clean hydrogen and shares the objective to accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage and use of hydrogen at gigawatt scale.

- In 2018 the India Country Status Report on Hydrogen and Fuel Cells, Mission Innovation, and Department of Science & Technology was published.

- In 2020 Indian Institute of Science (IISc) and the Research and Development Centre of Indian Oil Corporation Limited have signed an MoU to develop and demonstrate biomass gasification-based hydrogen generation technology for producing fuel cell-grade hydrogen at an affordable price.

- In 2022 Ministry of Power announced Green Hydrogen Policy aimed to aid the government in meeting its climate targets and making India a green hydrogen hub.

India's Success Stories

- First **Electric Fuel Cell Vehicle** based on Hydrogen pilot project started on roads by Toyota Kirloskar Motors and ICAT in March 2022
- ICEV are run on Hydrogen as fuels and being tested in **Delhi and Ladakh region** with NTPC taking the lead
- The MoP&NG has launched a "**Hydrogen Corpus Fund**"(HCF) for funding R&D(Research and Development) and is planning pilots projects on Green Hydrogen.
- The MoP&NG has began a pilot project on **Grey Hydrogen** or Hydrogen CNG (H-CNG) initiative, where hydrogen is blended up 18% in CNG. It also aims to strengthen infrastructure.
- Maharashtra Institute of Technology-World Peace University plan a **Hydrogen Research Centre** at Pune for carbon neutrality

How Nations are responding?

USA - $8 billion for at least four hydrogen hubs to produce, store and use. Passed Infrastructure Bill that mandates at least one for blue hydrogen and another for green hydrogen.

EU - In July 2020, the EU published its “Hydrogen strategy for a climate-neutral Europe” consisting of a roadmap for the establishment and scale up of value chains based on the production of “green” hydrogen.

UK - Plans to unlock £4 billion investment by 2030. Announced competition to develop hydrogen as the super fuel of the future

India - On August 15, 2021 the Government of India has allotted Rs 25 crore in the Union Budget 2021–22 for the research and development in hydrogen energy and announced launch of National Hydrogen Mission (NHM) while commemorating the 75 years of *Azadi ka Amrit Mahotsava*.

Transitioning to India's Climate Policy

1997	Kyoto Protocol- beginning of the process of climate change policy –India was exempted from taking actions
2005	Common But Differentiated Responsibilities (CBDR) took shape
2015	Paris Agreement on Climate Change – next step is follow-up of what the exempted countries had already committed through INDCs
2021	COP26 – India's *Panchamrita* were stated by our Prime Minister
2022	Launch of Green Hydrogen Policy

Panchamrit Policy Guidelines – In COP26

i. To raise the non-fossil fuel based energy capacity of the country to 500 GW by 2030.

ii. By 2030, 50% of the country's energy requirements would be met using renewable energy sources.

iii. The country will reduce the total projected carbon emission by one billion ones between now and the year 2030.

iv. The carbon intensity of the economy would be reduced to less than 45% by 2030.

v. As the final point, the country would become carbon neutral and achieve net zero emissions by the year 2070.

National Green Hydrogen Policy

- Hydrogen and Ammonia are envisaged to be the future fuels to replace fossil fuels.
- Sets a target of production of 5 million tonnes of Green hydrogen by 2030
- Aims to reduce dependence on fossil fuel and also reduce crude oil imports.
- India to emerge as an export Hub for Green Hydrogen and Green Ammonia.

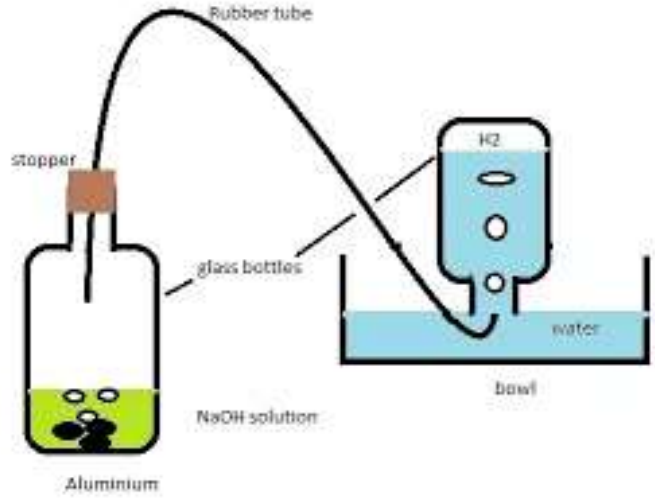
Identifies facilitating Mechanisms for transmission of renewable energy and Regulations for environmentally sustainable energy security of the nation

Green Hydrogen – Five Questions

- Can Hydrogen be widely viewed as an important fuel for a future energy transition?
- How Green is Green Hydrogen?
- How Green is Blue Hydrogen?
- Why there is IPCC urgency to scale up Hydrogen Technology worldwide?
- Which processes for hydrogen production should be considered leading to Green Hydrogen?

"Sustainability is about ecology, economy and equity"

THANK YOU



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