Green Hydrogen Development initiatives at ONGC Energy Centre

Shaping the Sustainable Future

ONGC
ENERGY CENTRE

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ONGC Energy Centre

ONGC Energy Centre Trust set up by ONGC in August, 2005

ONGC Energy Centre started collaborative R&D Projects in 2007

VISION: "Harness science and technology to meet national energy needs of tomorrow, in a clean and sustainable manner…"

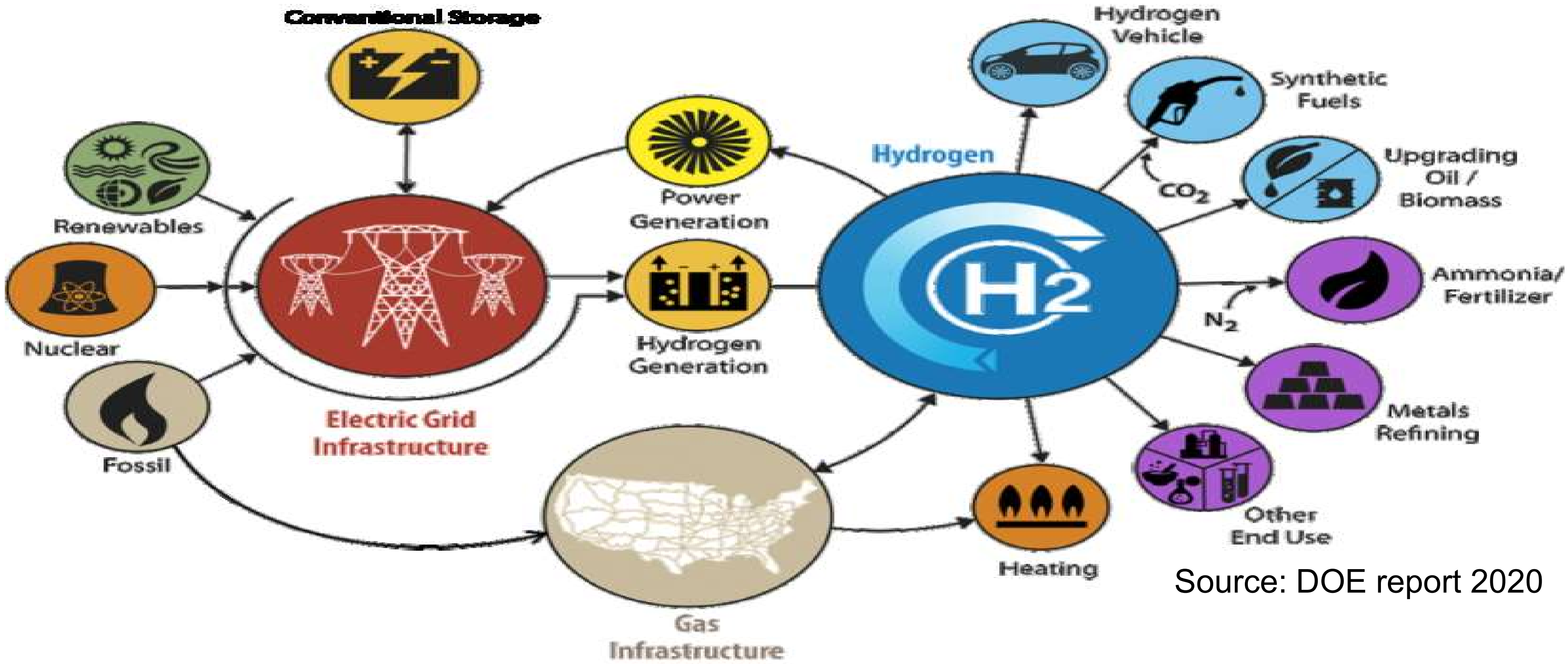
Undertake/assist/collaborate in research in clean and renewable energy technologies

ONGC Energy Centre: Key Areas of R&DD

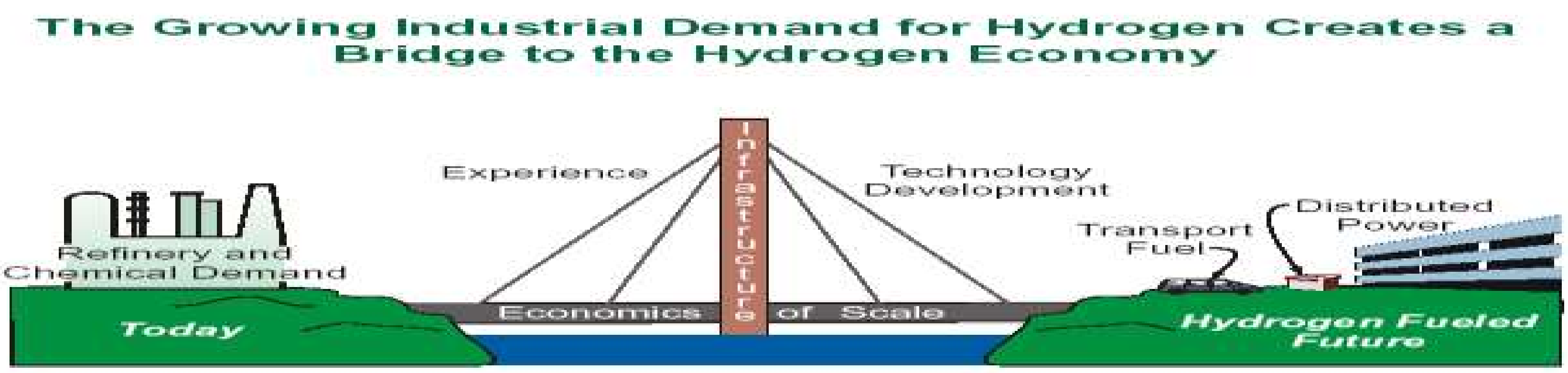
- **Hydrogen**
  - **Thermochemical Hydrogen generation**
  - **Other methods like HTE, Sear water Electrolysis,**
  - **Heat source integration, Materials Development for Hydrogen programme**
  - **Fuel cells**
  - **Hydrogen Storage**
- Solar
  - Power generation, storage, specialized coatings, applications in oil/gas sector
- Bio- Technology for Energy
  - --Conversion of sub-surface unrecoverable oil / coal / lignite to Methane
  - -- Controlling Reservoir souring
- Uranium
  - Subsurface exploration
  - Development of process for In-situ Leaching (Chemical, Microbial, hybrid)
- Geothermal
  - Assessing potential in sedimentary regions for power and heat
- **Others**
  - **Energy Storage, Efficiency / Energy Recovery relevant to Oil & Gas sector**

  Eg: Redox Flow batteries, Waste water treatment; CO_2 storage, utilization etc.,

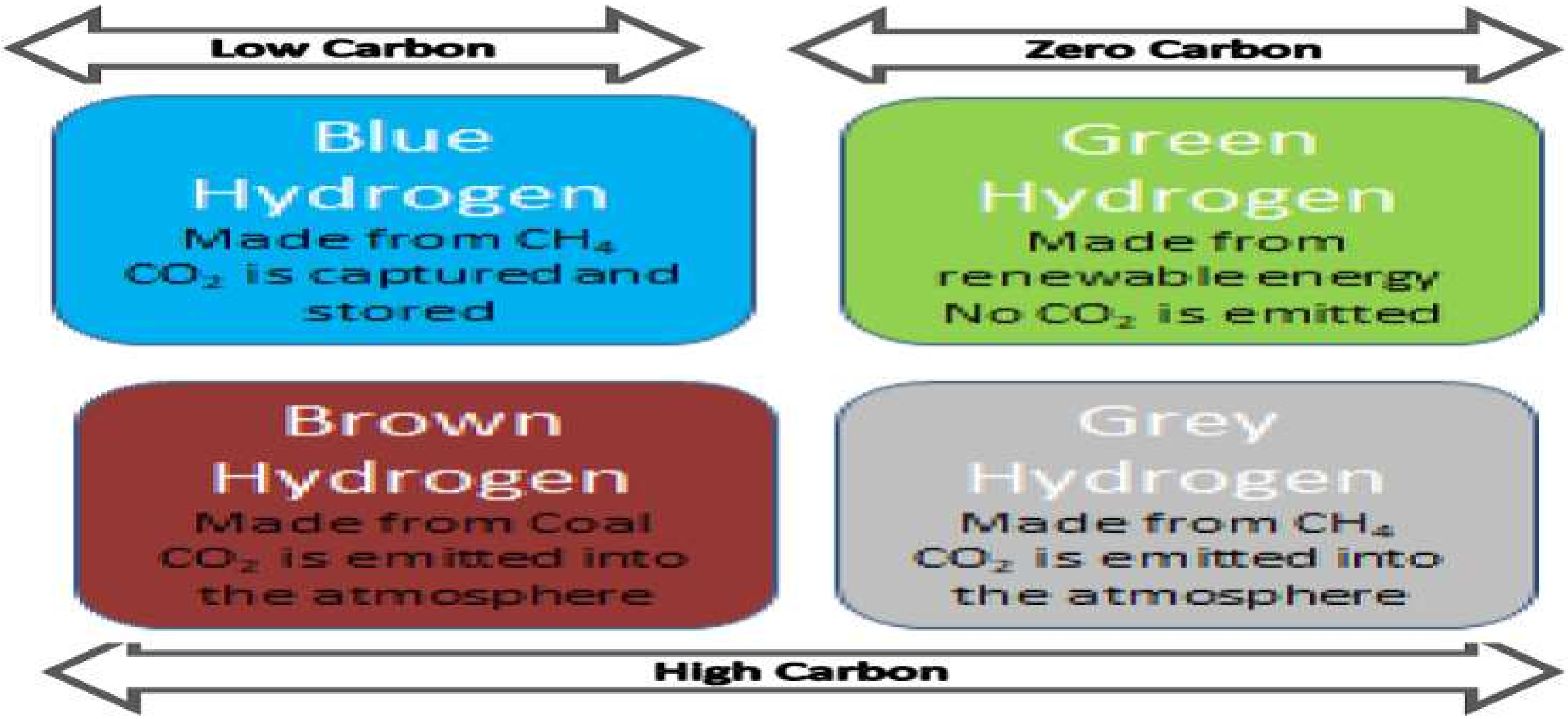
Hydrogen Economy



Source: DOE report 2020



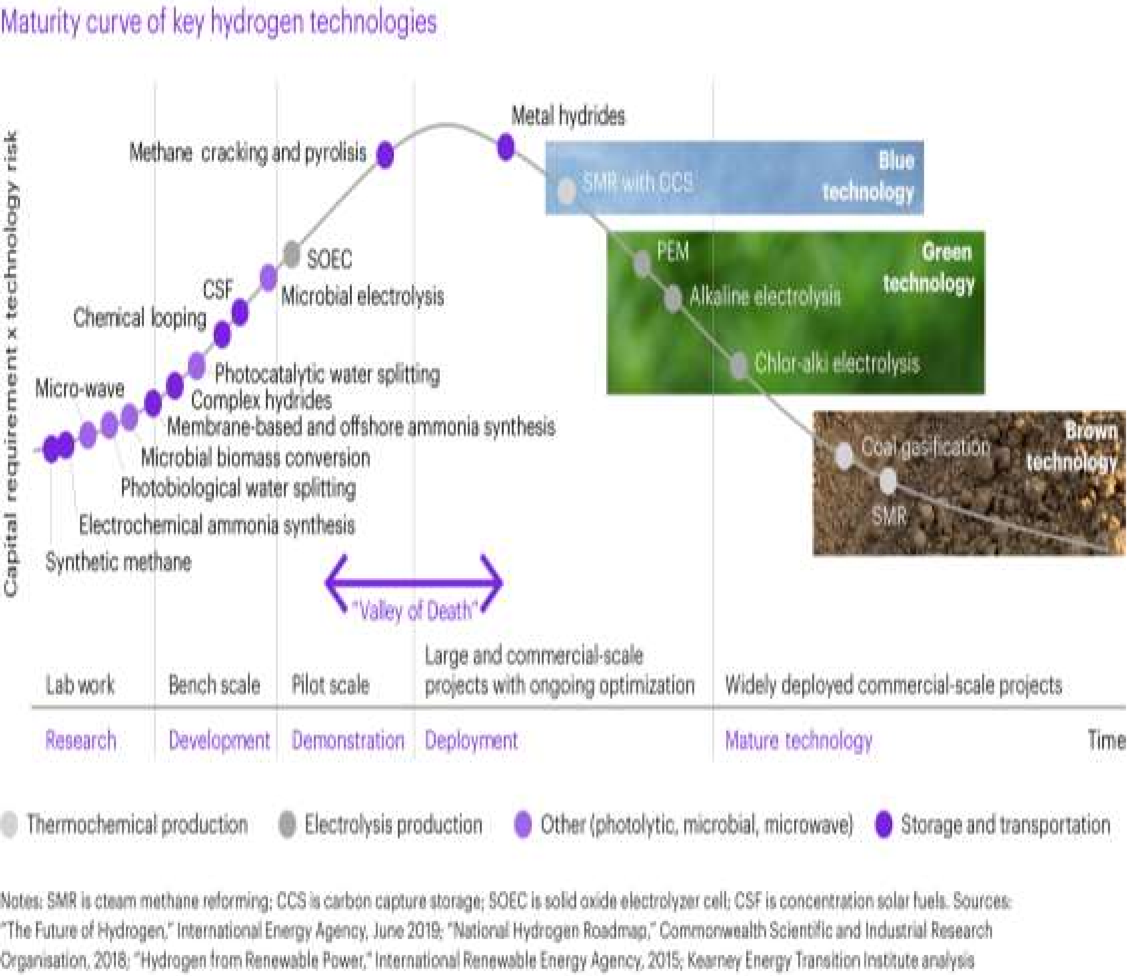
Changing colors of Hydrogen



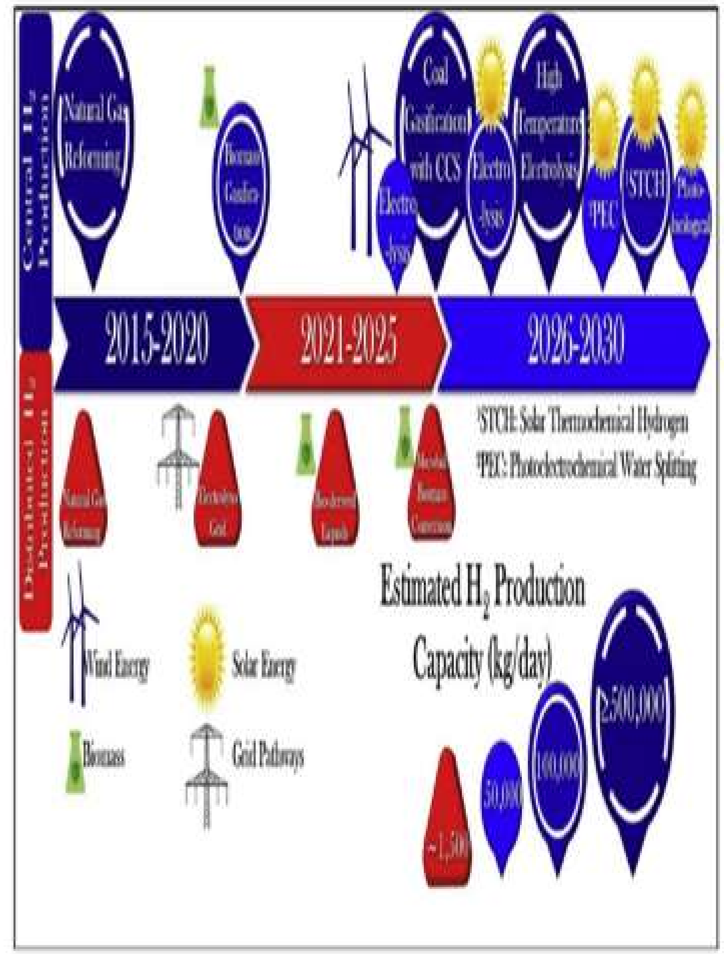
- Today, hydrogen produced from brown sources (90¢ to $2.10 per kg) is 2 to 10 times less expensive than green hydrogen ($2.50 to $9.50 per kg) or blue hydrogen ($1.50 and $2.50 per kg)
- By 2030, the levelized cost of hydrogen (LCOH) for blue hydrogen is expected to close the gap
- Nevertheless, the LCOH is highly impacted by conditioning and transportation steps, which can double the cost.

Global Hydrogen Development Programme

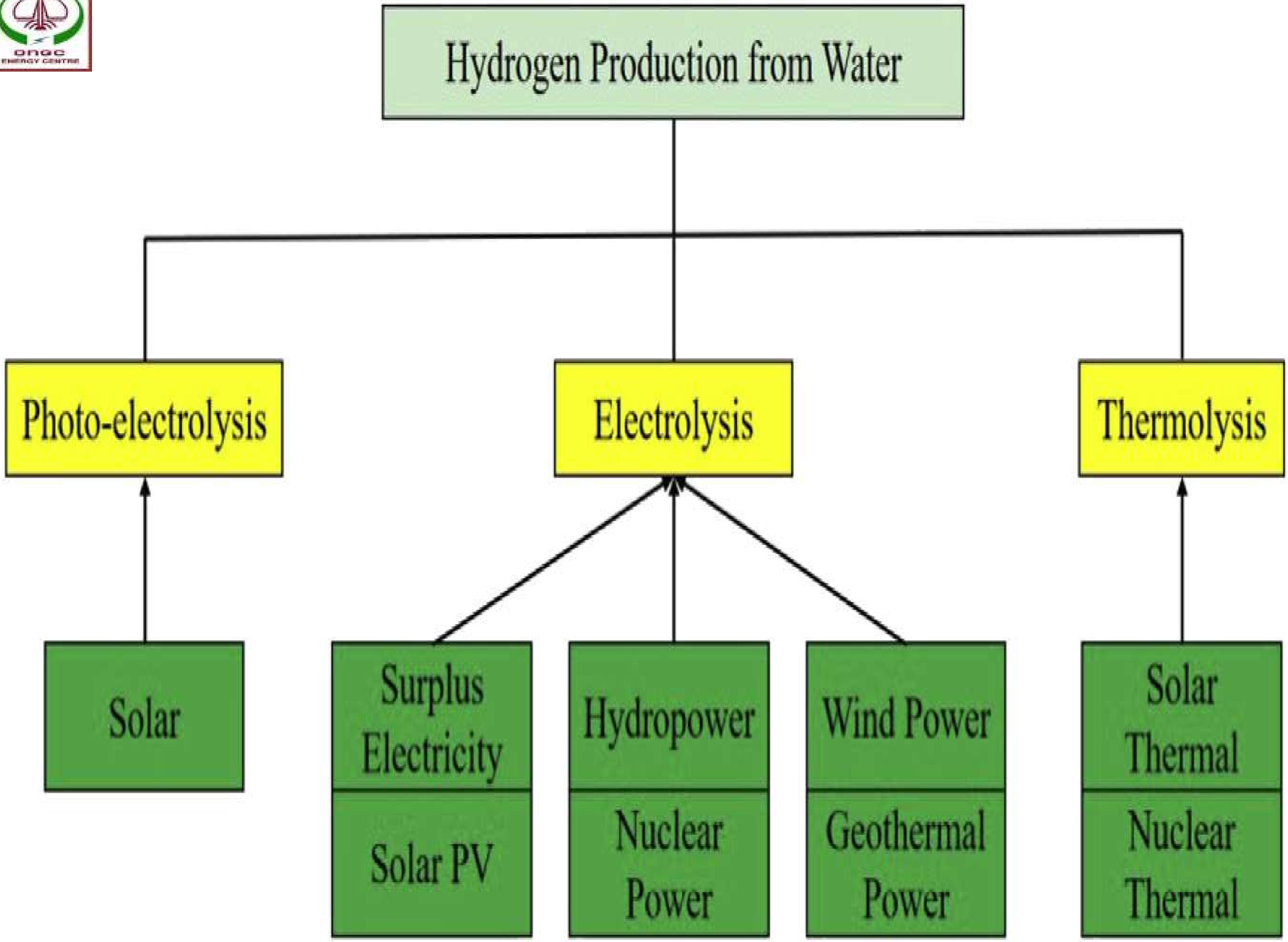
✓ Green hydrogen by electrolysis and Grey / Brown hydrogen technologies are commercially proven; Remaining all at various RD&D stages



Source: Kearney Energy Transition Institute 2021



DOE production targets


Hydrogen Production from Water
Photo-electrolysis
Electrolysis
Thermolysis
Solar
Surplus Electricity
Solar PV
Hydropower
Nuclear Power
Wind Power
Geothermal Power
Solar Thermal
Nuclear Thermal

Hydrogen program at ONGC Energy Centre

✓ ONGC Energy Centre (OEC) Hydrogen Program focuses on indigenous development of hybrid thermochemical water splitting processes for large scale green hydrogen production.

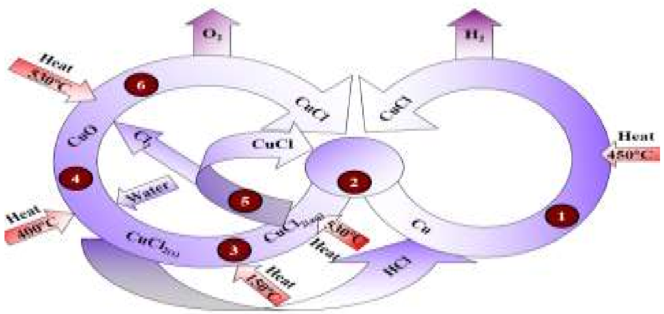
Reaction:

$$H_2\ (g) + O_2\ (g) \leftrightarrow H_2O\ (l) + 286\ kJ/mole$$

✓ Utilizes Renewable sources of energy especially the high temperatures from solar / Nuclear sources

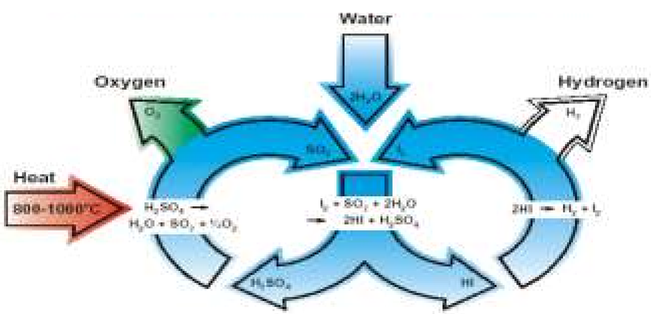
Thermochemical Hydrogen Generation Technologies

OEC has chosen following 3 processes for development

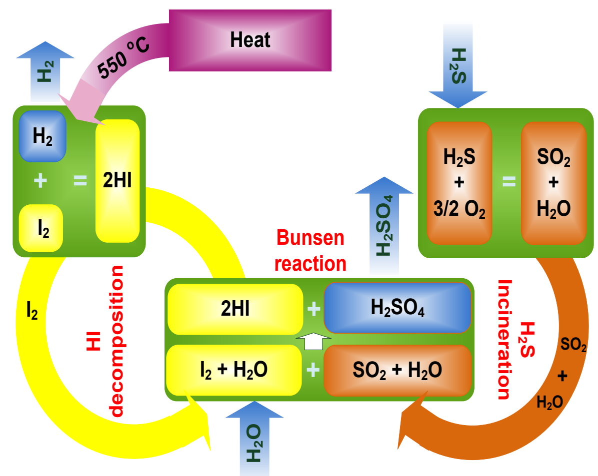


Copper-Chloine Cycle 550°C

- USA-Canada and collaborators hydrogen @ 55 M3 H2 / day
- India: OEC in collaboration with ICT, Mumbai has developed lab scale Engg facility @ 25-30 l/h Hydrogen & patented; planning for 350 M3/day



Iodine-Sulfur close-loop Cycle
900°C



Iodine-Sulfur open-loop Cycle
550°C

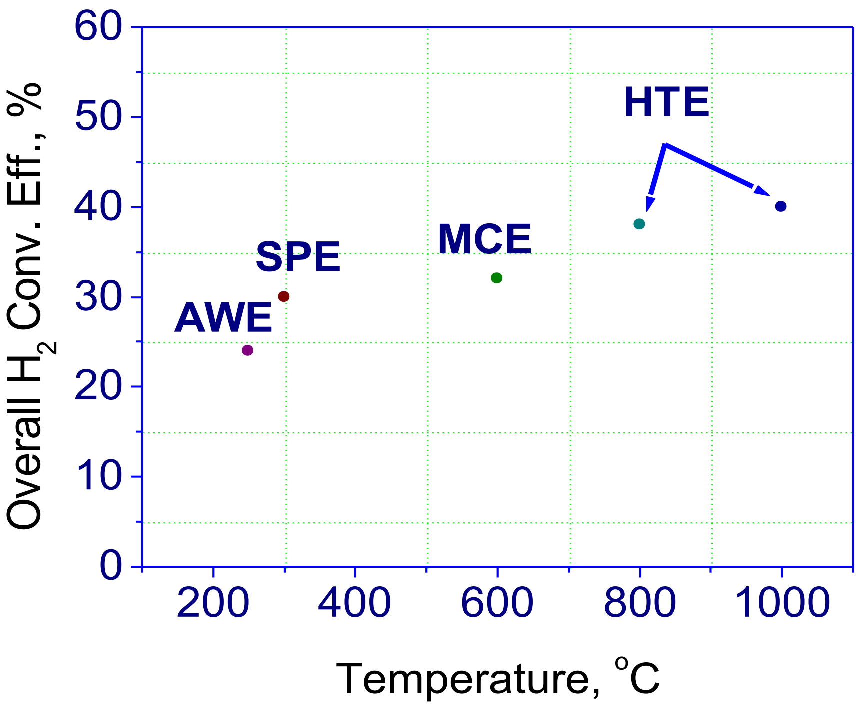
Lab / Bench scale Hydrogen @10-150lph:

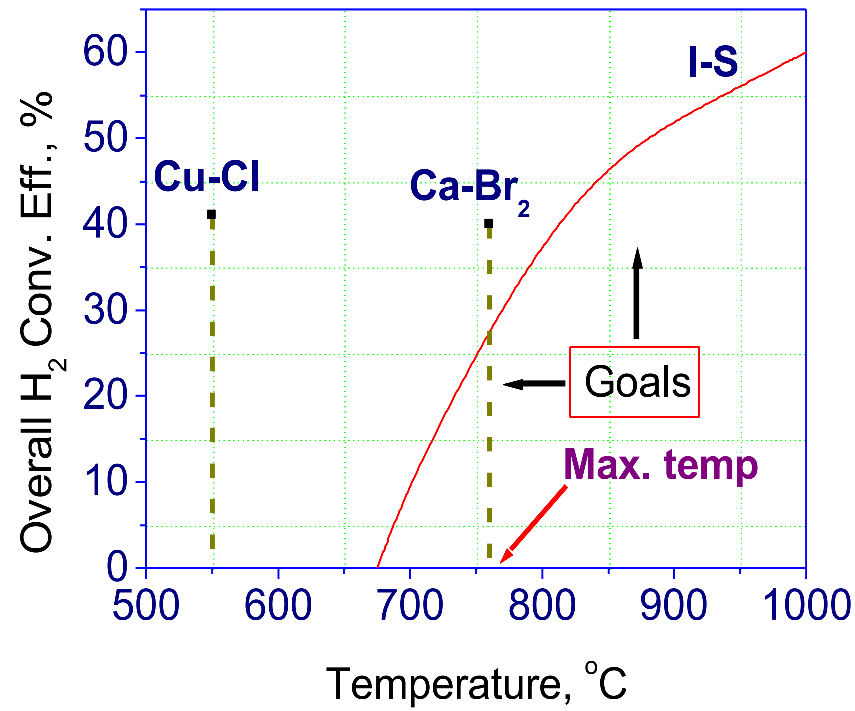
- Global: Japan, USA, China, Korea, Europe (UK, France, Italy)
- India: BARC, OEC & Collaborators

India is the first country to develop this concept to Lab Engg scale

Efficiencies & Goals

Electrolysis ← **Water** → Thermo-chemical cycle





Electrolysis Processes:
AW: Alkali Water, MC: Molten Carbonate
SP: Solid Polymer, HT: High Temperature

Ref: IAEA-TECDOC-1085:

Thermo-chemical Processes:
Cu-Cl: Copper - Chlorine, Ca-Br_2 : Calcium-Bromine, I-S: Iodine-Sulfur Process

Ref: G.E. Besenbruch, L.C. Brown, J.F. Funk, S.K. Showalter, Report GA–A23510 and ORNL Website

OEC Hydrogen programme

Concept to commercialization

Hydrogen generation through thermochemical splitting of water is the focus

- **Cu-Cl cycle** - Lab scale metallic plant @ 25 lph capacity operational since 2016 based on a new process developed. Both national and international patents for process granted. **Scale up activities @12 MT/Year (15 M3/h) are planned in 2023.**
- **I-S cycle – Closed-loop** in quartz system was established @5LPH Hydrogen generation and operational since 2018; Indian Patents granted for catalysts developed. **Scale up in metallic system @300 l/h (27g/h) in 2023 leading to pilot scale demonstration @12MT/Y in 2025.**
- **I-S cycle – Open-loop:** Proof of concept in quartz system was established in quartz system. **scale up to 25-50lph activity in progress. Pilot plant setup for H_2SO_4 production @10-12 M.T /day equivalent hydrogen@ 90MT/Y planned at MRPL in 2025.**

• **Alternate means of Hydrogen generation:** Initiated proof of concept work on High Temperature Electrolysis SOEC and planning for Sea water electrolysis.

Hydrogen programme

- **Hydrogen storage:** Hydrogen Storage using Colloidal gas Aphrons(CGAs) and CGAs loaded with Metal hydrides
- **Hydrogen for Fuel cell application:** Initiated activity on SOFC technologies
- **Development of support systems :**
  - ✓ H.T-H.P corrosion Test facilities for selection of Materials
  - ✓ MoC for reactors, other process gadgets etc.
  - ✓ Molten salt system for Solar thermal storage for high temperature reactions,
  - ✓ Electrochemical and Ceramic Gas separation membranes
  - ✓ H_2S, SO_2, H_2, Cl_2 gas sensors etc.,
  - ✓ Sources of fabrication in progress with collaborative approach
- **Development of Other Support systems:**

✓ Oil field Effluent water purification for Green hydrogen campaign sustainability

✓ Energy Storage devices for stationary back up using Vanadium Redox Flow and Iron Redox Flow Batteries, Graphene oxide based Super capacitors for Electric mobility

✓ CO_2 valorisation using Hydrogen and water processes etc.

Implementation Strategy

Concept to commercialization

Work Execution Strategy

1. Collaborations with Centers of Excellence in India to establish proof of concept
2. Lab scale Engineering Experiments using indigenous resources
3. Heat source integration, Materials, Sensors, Membranes etc., development
4. Indigenous Vendor development for fabrications
5. Collaborative Consortium to pool & integrate national resources for technology development
6. Bridge the gap experiments, Scale up decisions
7. Pilot scale demonstration

All Efforts Leading to

- **Indigenous Technology development for hydrogen generation at mass scale for commercial decisions**

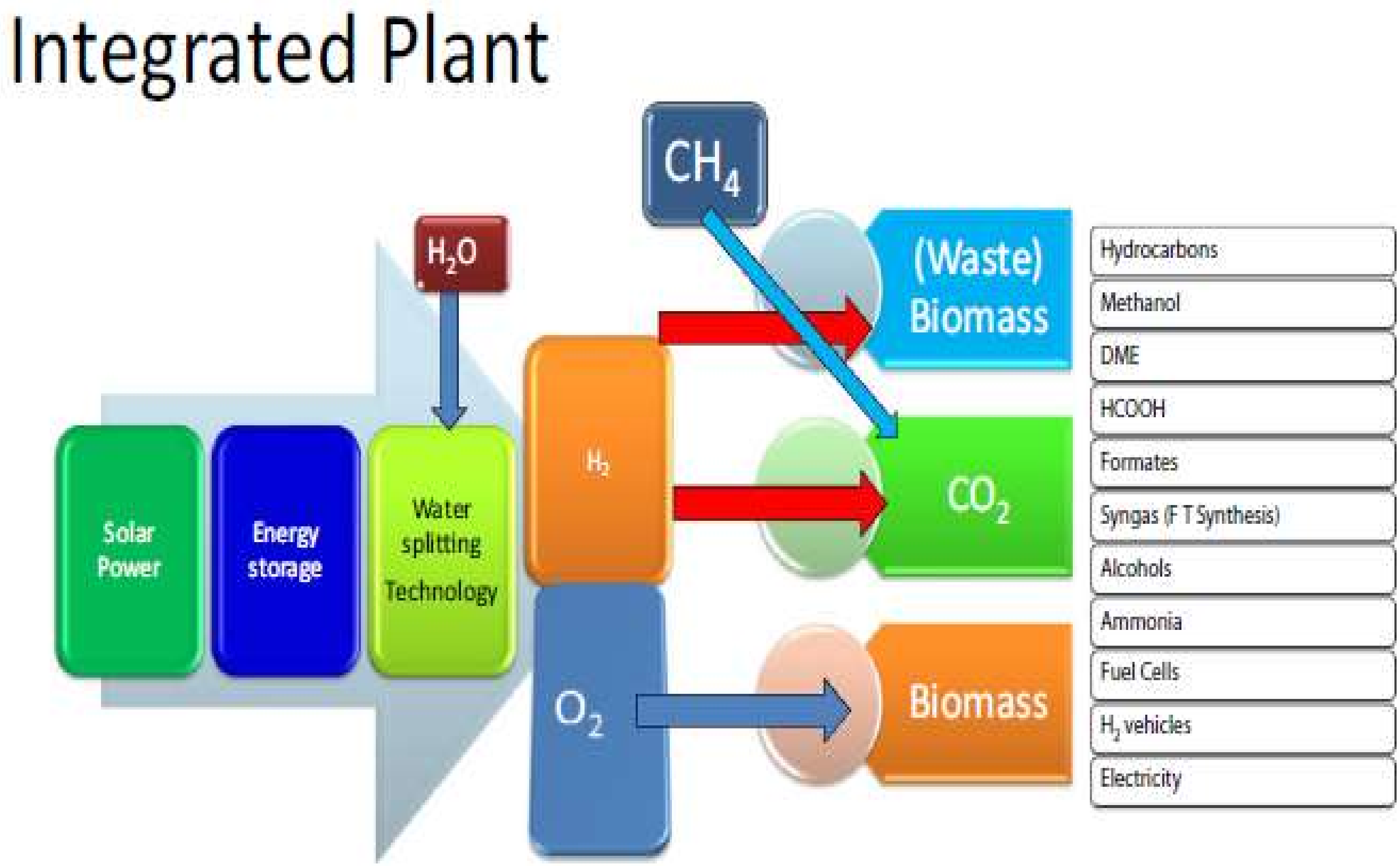
Convergence of R&D Activities

OEC conceptualized Hydrogen Eco-System

Indigenous Green Hydrogen mission

- CO_2 valorization
- C S P
- Oil field Water purification
- Fuel cells
- Development of MoC, corrosion test facility
- Molten salts
- Cost effective Electrodes, catalysts, sensors
- Membranes
- Process intensification
- Pilot Demonstration
- Safety, Energy systems

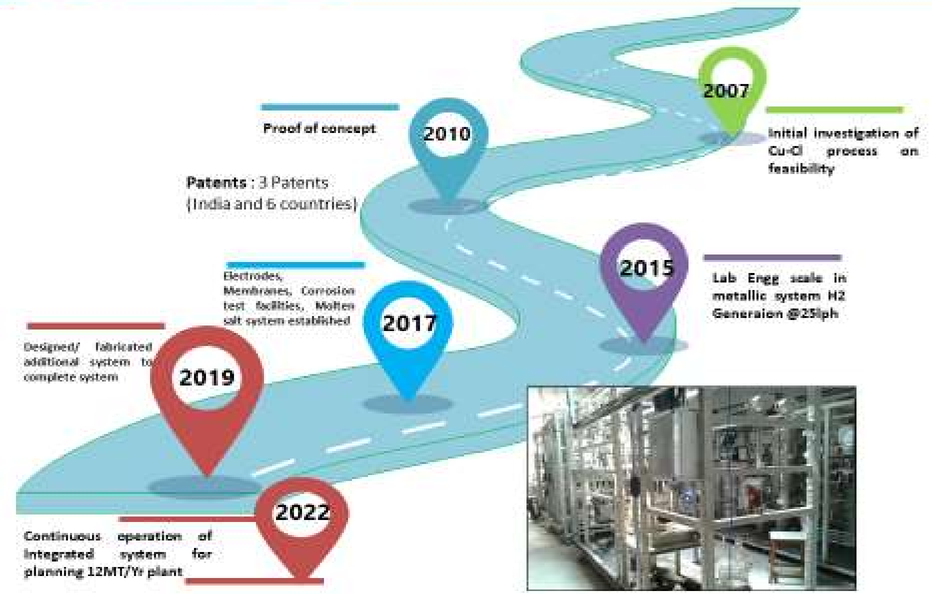
Conceptual Green Hydrogen valorization pathways during and beyond transitions



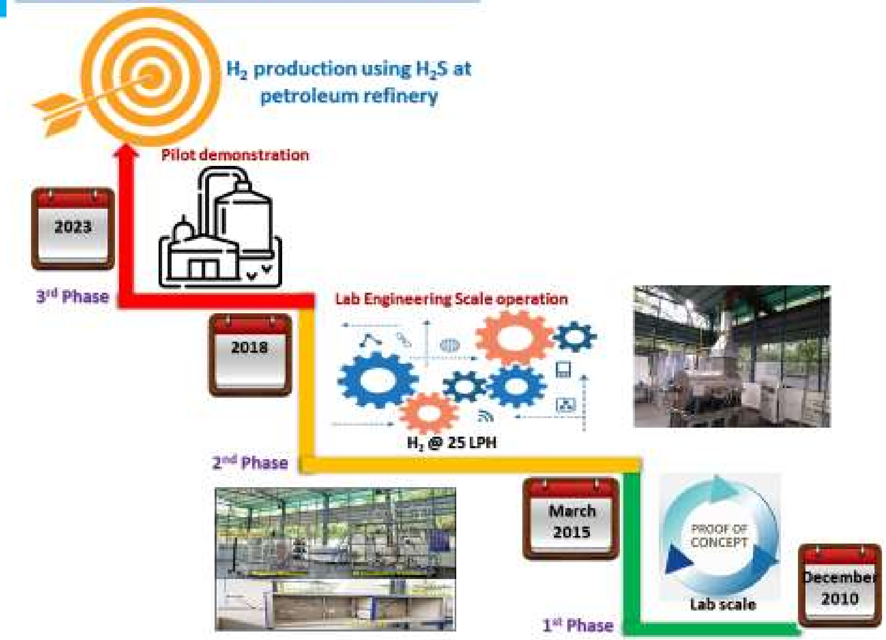
GD Yadav et al., Clean Technologies and Environmental Policy, 2020

A Glimpse of OEC collaborative efforts……

Cu-Cl cycle Milestones



I-S Open loop process milestones



I-S Close-loop mile stones

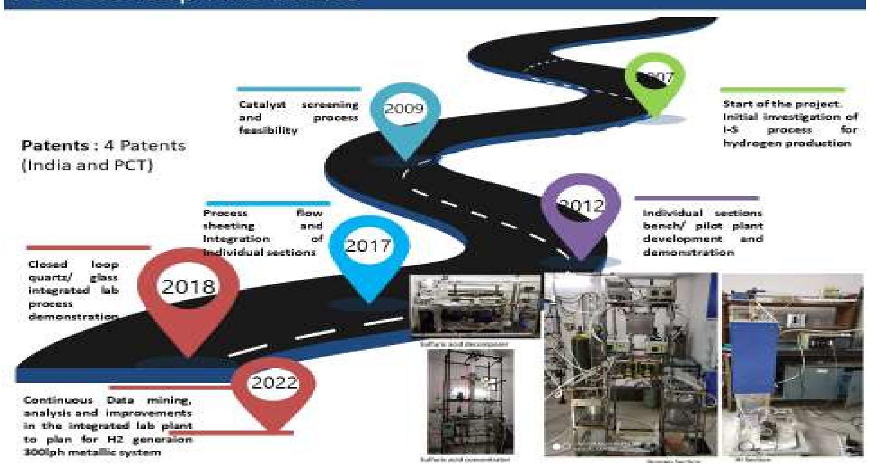


Figure 4: TRL Stages for S-I process for Hydrogen production IITD-OEC Project

Presently, the integrated lab scale experimental skids were designed to meet the following criteria:

i. Demonstrate the three individual sections operation of the Iodine-Sulfur process.
ii. Design and install the integration equipment needed in between the three sections.
iii. Demonstrate the operation of the integrated S-I loop and generate hydrogen gas at 5NL/hour.
iv. Operate the total loop continuously at ambient pressure and temperature in the range of 120-850°C.

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Thank You

all for kind attention

& our collaborators