Electrolyser – Key Components and Material

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Thermax Limited

Alkaline Electrolyser System

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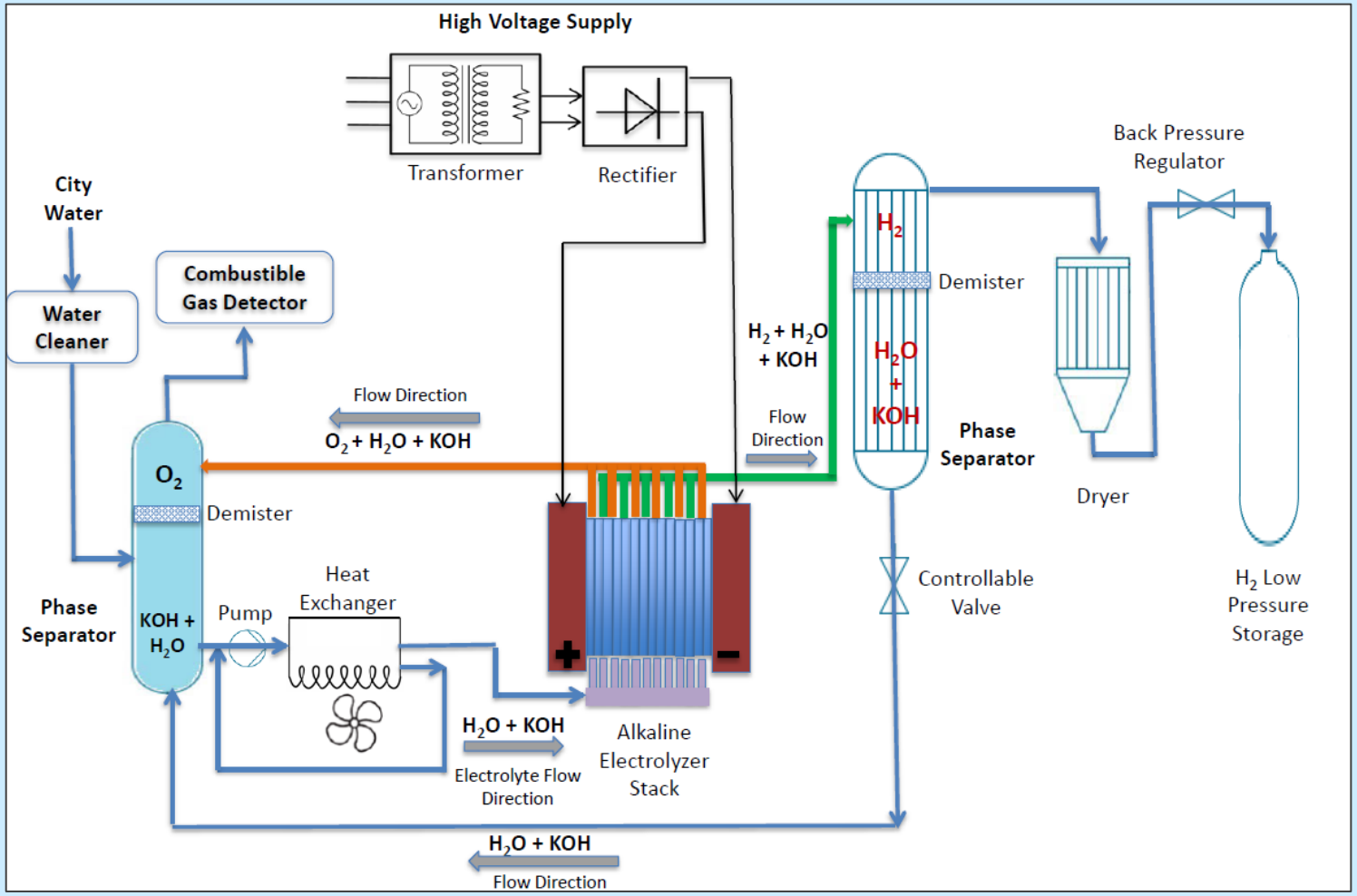
- **Electrolyser Stack**
  - Membrane / Separator
  - Electrodes (Anode & Cathode)
  - Porous Gas Diffusion Layer
  - Bipolar Plates
  - End Plates & Structural Ring
  - Sealing Gaskets

- **BOP**
  - Power Supply Equipment
  - Deionized water circulation system
  - Hydrogen processing
  - Cooling
  - Control System
  - Miscellaneous



Typical Scheme of Alkaline Electrolyser System

Polymer Electrolyte Membrane Electrolyser System

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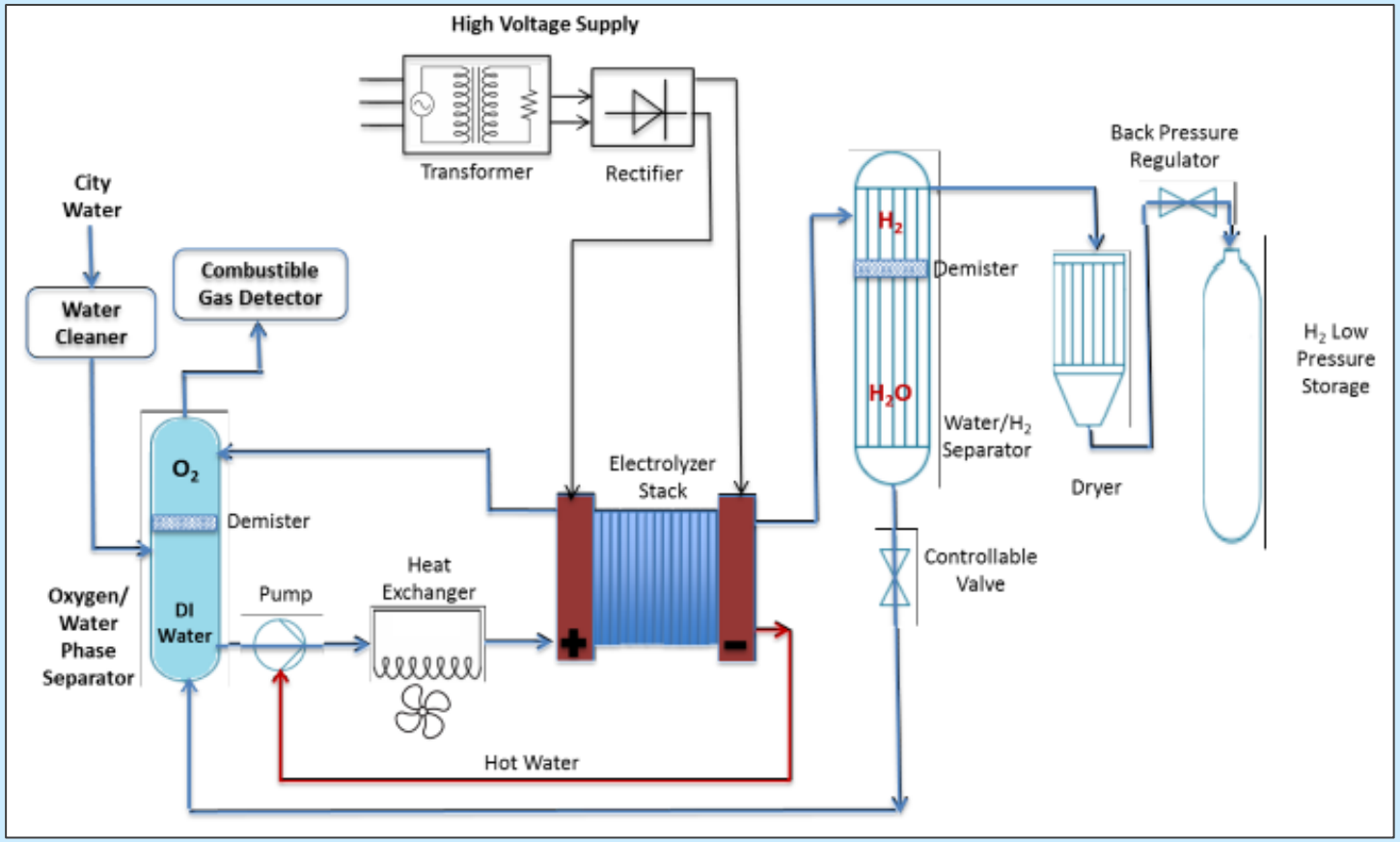
- **Electrolyser Stack**
  - Membrane Electrode Assembly (MEA)
  - Gas Distribution Layer (GDL)
  - Seal / Frame
  - Bipolar Plates
  - Stack Assembly

- **BOP**
  - Power Supply Equipment
  - Deionized water circulation system
  - Hydrogen processing
  - Cooling
  - Miscellaneous



Scheme of PEM Electrolyser System

Solid oxide (SOEC) Electrolyser System

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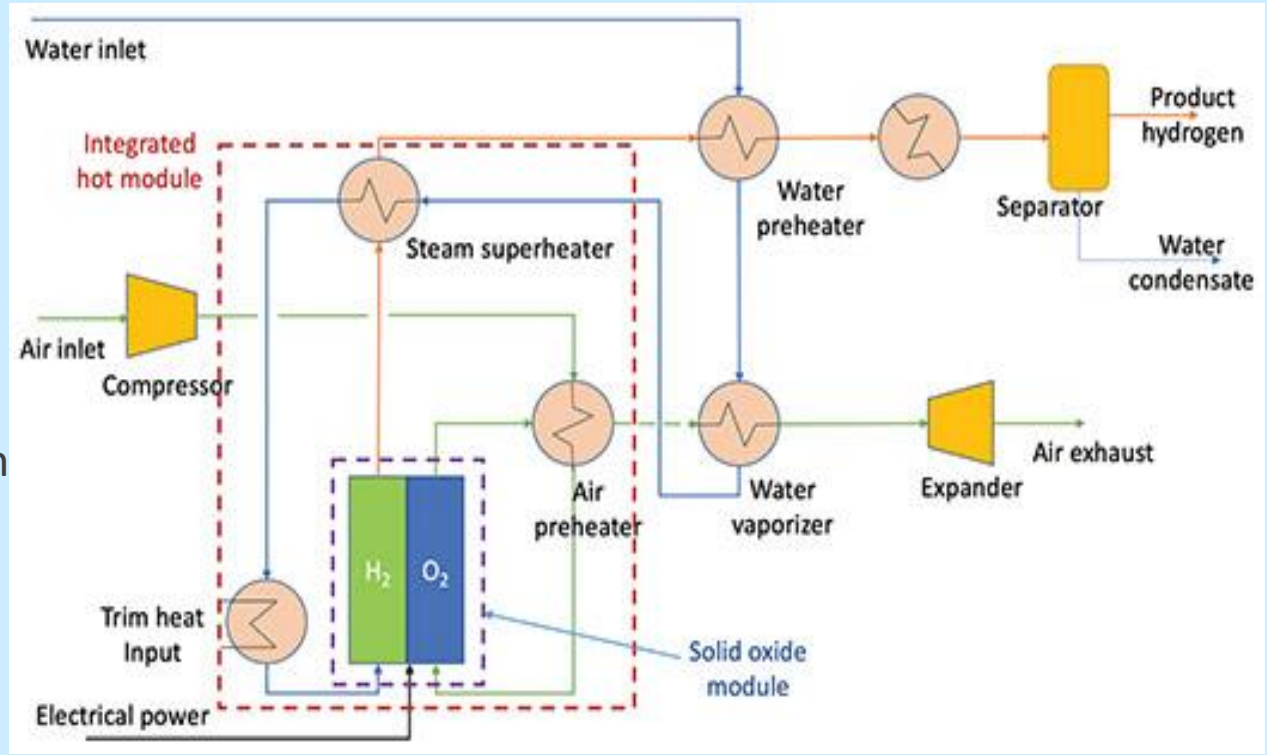
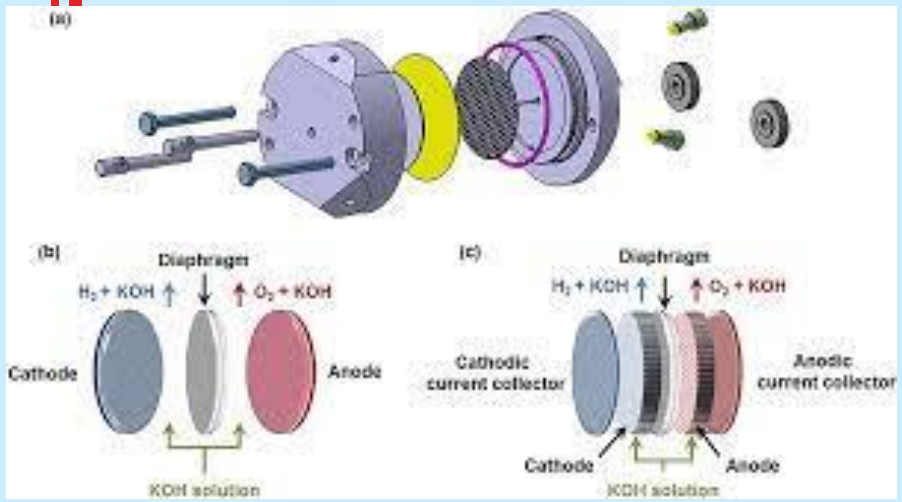
- **Electrolyser Stack**
  - Electrode Electrolyte Assembly
  - Gas Distribution Layer (GDL)
  - Seal / Frame
  - Steam / Air Flow field Interconnect Plates
  - End plates

- **BOP**
  - Power Supply Equipment
  - Deionized / steam water circulation system
  - Hydrogen processing
  - Heating / Cooling
  - Air Compressor/Expander
  - Miscellaneous

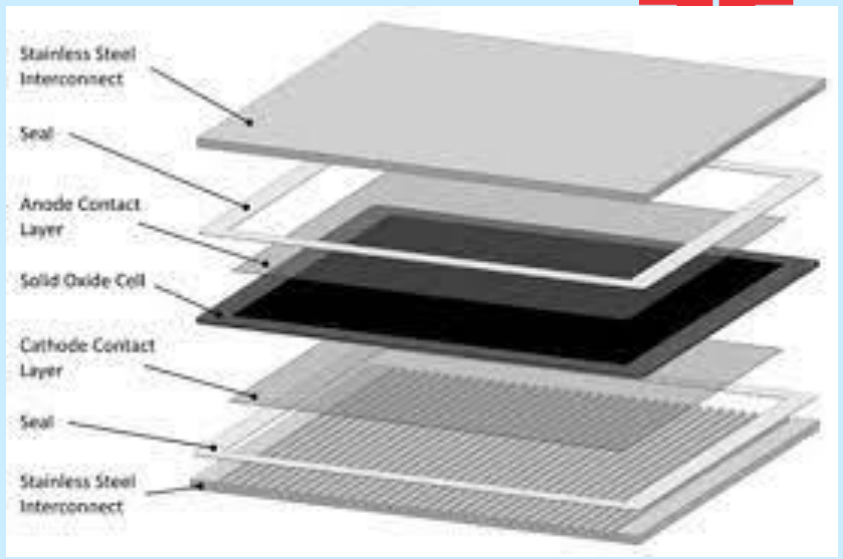


Scheme of SOEC Electrolyser System

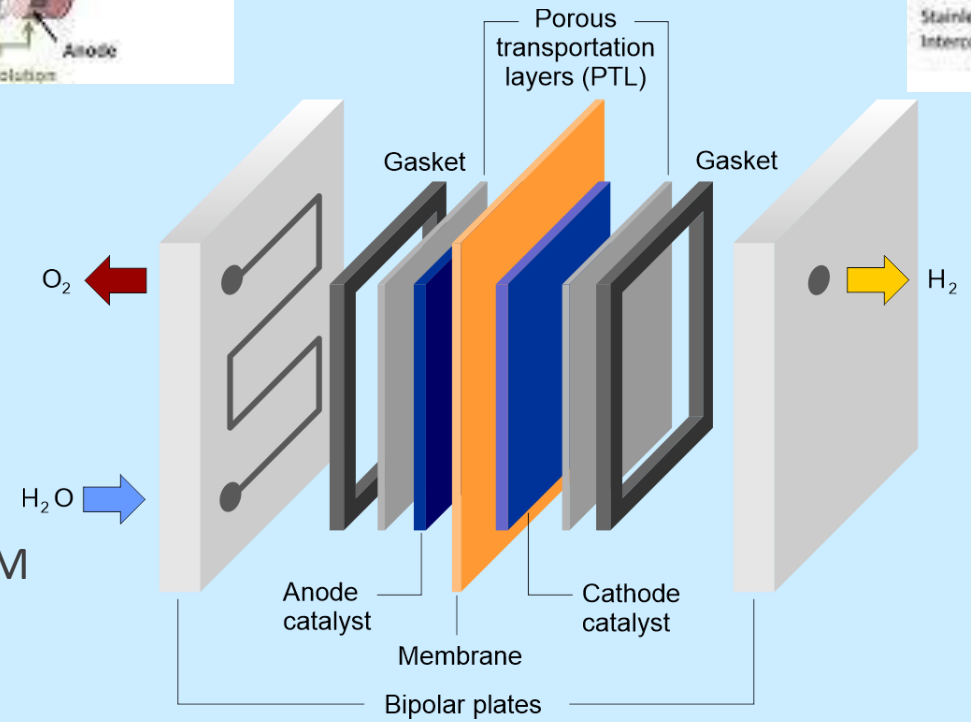
Electrolyser stack details



Alkaline



Solid Oxide



PEM / AEM

Electrolyser Stack Components

	Alkaline	PEM	AEM	Solid Oxide
Operating Temperature	70-90 °C	50-80 °C	40-80 °C	700-850 °C
Operating Pressure	1-30 bar	<70 bar	< 35 bar	1 bar
Electrolyte	Potassium hydroxide (KOH) 5~7 mol/L	PFSA membranes (Perfluoro sulfonic acid)	DVB (Divinylbenzene) polymer support with KOH < 1 mol/L	Yttria-stabilized Zirconia (YSZ)
Separator	ZrO_2 Stabilized with PPS (Polyphenylene sulfide) mesh	Solid Electrolyte (above)	Solid Electrolyte (above)	Solid Electrolyte (above)
Electrode / Catalyst (Oxygen side)	Ni Coated Perforated Stainless steel / Ni Coated Ni Mesh	Iridium oxide	High surface area Nickel or NiFeCo alloys	Perovskite-type(e.g. LSCF (Lanthanum strontium cobalt ferrite),LSM (Lanthanum strontium manganite)
Electrode / Catalyst (Hydrogen side)	Ni Coated Perforated Stainless steel / Ni Coated Ni Mesh	Platinum nano particles on Carbon Black (Engineered)	High surface area Nickel alloys	Ni/YSZ
Porous transport Layer anode	Ni Mesh (sometimes)	Pt Coated sintered porous Titanium	Nickel foam / SS Porous Paper /Titanium Foam	Coarse Nickel Mesh
Porous transport Layer cathode	Ni Mesh	Sintered porous titanium or Carbon Cloth	Nickel foam / Titanium Foam / Carbon cloth	None
Bipolar Plate anode	Ni - coated stainless steel	Pt coated Titanium	Ni - coated stainless steel	None
Bipolar Plate Cathode	Ni - coated stainless steel	Pt / Gold coated Titanium	Ni - coated stainless steel	Cobalt coated stainless steel

Stack Components - Materials

- End Plates
  - Requirements
    - High Strength, Stiffness with Low Density
    - Vibration and Shock resistance
    - Low cost
    - Corrosion Resistance
    - Electrical Insulation
  - Materials
    - Metallic Plates
      - Pros
        - Strength, Vibration resistance
      - Cons
        - Low Corrosion resistance which can affect the ionic conductivity
    - Non-Metallic Plate
      - Pros
        - Electrical conductivity,
        - Corrosion resistance
        - Ease of Manufacturing Like Injection Moulding
      - Cons
        - Low Mechanical strength
    - Composite / Sandwich plate Structure
      - It can have advantage of both metallic and non-metallic
      - Cost manufacturing needs to be checked

- Bipolar Plates
  - Requirements
    - Coefficient of Thermal Expansion
    - Mass Manufacturability
    - Low cost
    - Corrosion Resistance
    - Electrical conductivity
  - Materials
    - Metallic Plates : Aluminium alloy, Stainless steel , Titanium and Nickel
      - Suitable for Mass Production
      - Can be very thin and Low weight
      - Low Corrosion resistance which can affect the ionic conductivity
    - Graphite – Carbon Composite Plate
      - This is made of thermoplastic/thermosetting Plastics
    - Stainless steel + graphite + Polycarbonate
      - SS is provides rigidity, graphite gives corrosion resistance and polycarbonate has chemical resistance
      - This can be manufactured using injection moulding an can be easily shaped according to gasket requirement

Stack Components - Materials

- Current Distributor Plates
  - Copper with Gold coating
  - Titanium plate
  - SS Plate with coating
- GDL / PTL
  - Ni Mech / Foam /Felt
  - SS Porous Paper
  - Titanium
  - Carbon Cloth /Paper
- Catalyst
  - PGM / Non PGM Catalyst
  - Coating Technique
    - Electro Deposition
    - Sputtered Coating
    - Ultrasonic spray coating
- Hardware
  - Design for Thermal/Mechanical Strength
  - Corrosion Resistance
- Sealing / Gasket
  - Design of Gasket with respect to Compression
  - Silicon / EPDM /PTFE / Viton etc.
  - Suitability for Alkaline / Acid environment

Electrolyser System – Balance of System

- Balance of system
  - Water treatment
    - Water quality – Selection of system
  - Power Electronics and controls
    - Rectifier
    - Transformer
    - Control system / Instruments
  - Heat exchangers
    - Air-cooled / Water cooled
    - Less Power consumption
    - Material of Construction
  - Gas purification system
    - Localisation of Catalyst
    - Efficient design
- Balance of system designed to optimise the Auxiliary power consumption to reduce over all Cost of Hydrogen

Electrolyser System – Current Challenges

- Localising the Stack Component
- Mass Manufacturing process development
  - Bipolar Plate with Flow Field
  - Gasketing technique
  - Stack Assembly
  - Coating Technique
- Development / Localisation of Membrane and separator
- Non PGM based Catalyst development
- Catalyst Development - Different water quality
- Reduce the Power consumption

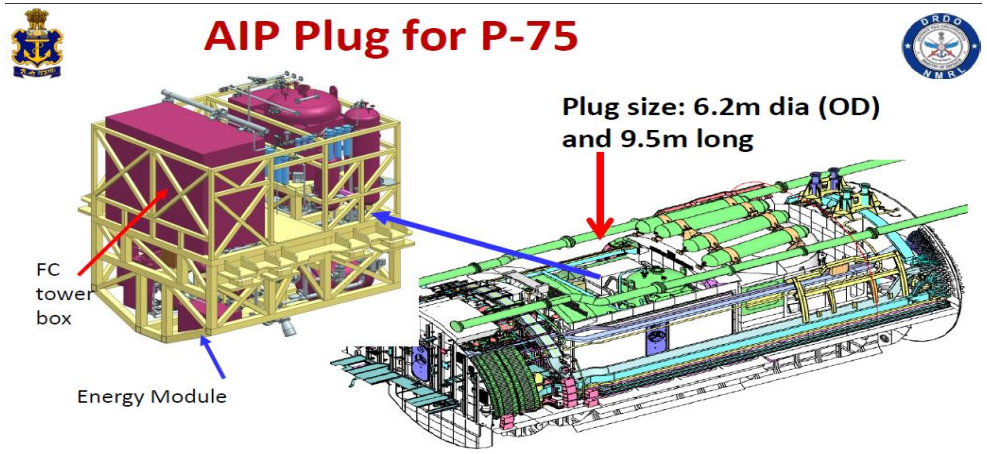
Hydrogen Experience

Fuel Cell

Manufacturing and supply of fuel cells stacks for submarines for last 11 years

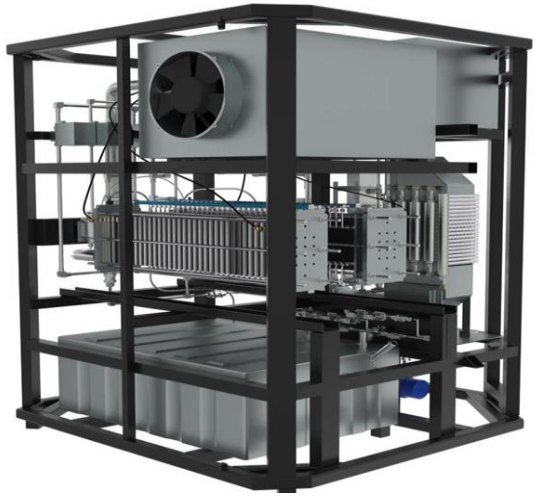
State of the art manufacturing facility developed at Chinchwad

Technology transfer by DRDO



Stationary Fuel Cell

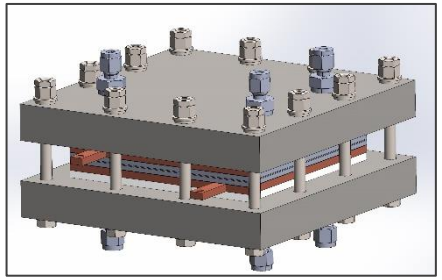
- Thermax-CSIR joint program on HTPEM Fuel Cells for 1st prototype of Stacks.
- Thermax Fuel Cell Stacks using BASF MEA's for 2nd Prototype
- Complete inhouse design of the fuel cell including Bi-polar plates (under NMITLI program), cooling system and mechanical design.
- Development of auxiliary components such as DC/DC Converters, Control systems along with vendor-partners.



Hydrogen Experience

Electrolyser - AEM

- CSIR NCL - Thermax joint program on AEM Type Electrolyser Development is under way
- Target to develop stack with non PGM Catalyst with current Density 1.0 A/cm²



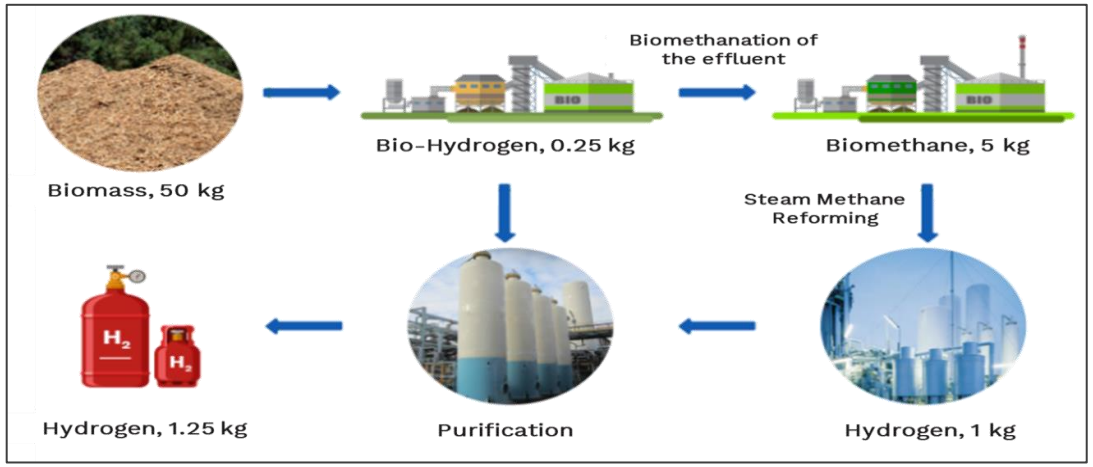
AEM SINGLE CELL ASSEMBLY

Biomass to Hydrogen

Working with partners (ARI & KPIT) on a novel microbial consortium to produce Hydrogen directly from biomass

Suitable for cellulosic biomass such as rice straw, wheat straw, Napier grass etc.

Pilot plant under commissioning. Patent filed



Thermax play in Green Hydrogen

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Renewable Power

Development of renewable assets to power electrolysers with green electrons

Electrolyser Manufacturing

Complete local manufacturing of electrolysers

Project Development

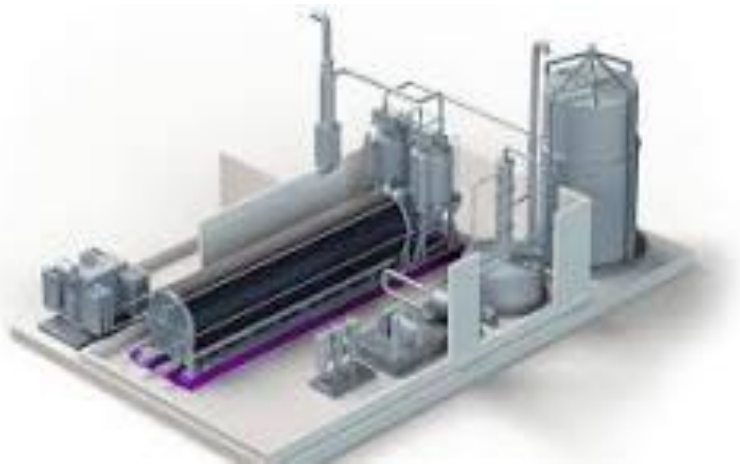
Green H_2 generation projects on build own operate basis

EPC Projects

Green hydrogen and green ammonia project execution on EPC basis

Biomass to Hydrogen

Green hydrogen generation projects through microbial digestion route



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Thank you