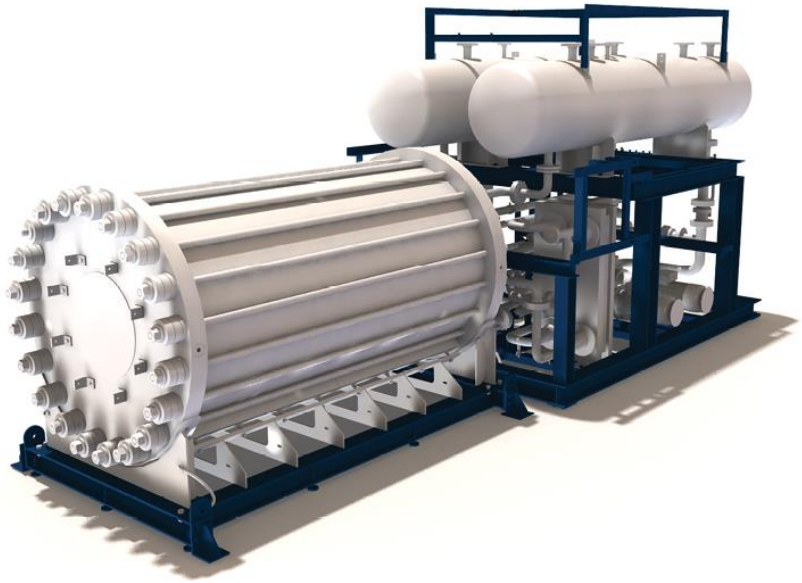
Electrolyzer Technology: A high-tech manufacturing opportunity for India



L&T Energy

Green Mfg & Development

Pillars of L&T Green Energy Business

Govt Thrust on Energy Transition ➡ National Green Hydrogen Mission

PLI scheme (~ Rs. 4,440 Crs) for Electrolyser Mfg. to make India a leader in manufacturing

- **₹35,000 Crs allocated in budget for capital investment** towards energy transition, net zero obj. & energy security
- **5 MMTPA GH_2 production by 2030 – Rs. 13,050 Crs Incentives**
- **Global hub for production/uses/export of GH_2 & Derivatives**

- Strategic H2 Innovation Partnership – **SHIP**
- PPP framework; Creation of a dedicated R&D fund : **₹ 400 Crs**

Make in India

Demand creation of Green H_2

Green H_2 / NH_3 Export hub

Development & self Reliance on Tech

Manufacturing

Development

EPC

R&D

L&T's Green Hydrogen Plant at AM Naik Heavy Engineering Complex, Hazira

Aerial View of the Green Hydrogen Plant, Hazira

India's 1st Green Hydrogen Plant commissioned by L&T for Application as fuel in Hydrogen Blending with NG

- Capacity: **15 TPA** (30 TPA in Phase II)
- Alkaline technology – 380 kW
- PEM (Polymer Exchange Membrane) technology to be added in Phase II
- **99.99% purity** of hydrogen

Powered by Rooftop Solar Plant

State-of-the-art Control System

15% H_2 blended with NG used in Furnaces in manufacturing shop

Current Members of L&T Green Energy Council

Prof. Christopher Hebling

- Advisor to EU & IEA in Green H2
- Head : Hydrogen Research @ Fraunhofer ISE
- Global stature in H2 research

Mr. Bart Biebuck

- Ex Executive Director Clean Hydrogen Partnership
- CEO : HYBART
- Global Stature & Network in Green Molecules sector

Prof Eicke R Weber

- Co President : EU Solar Manufacturing Council
- Ex Head : Fraunhofer ISE
- World Leading authority in RE sector

Prof. Patrice Simon

- Head : French National Battery Program
- Prof – University Paul Sabatier, Toulouse, France
- Leading expert in Sodium ion & Super-capacitors

Making India a global hub for electrolyzer manufacturing

L&T's Stride into Electrolyser Manufacturing

Aug'22

Commissioning of GH_2 Plant at Hazira, Gujarat

Mar'23

Electrolyser Technology Collaboration with Europe's McPhy Energy

Apr'23

Foundation Stone laid for the Manufacturing Facility

Dec'23

Ready to Supply Electrolyser Package to Market

Mar'24

Maximum Indigenous Electrolyser package

L&T Upcoming Electrolyser Manufacturing Facility – Key Highlights

Bird's eye view of A M Naik Heavy Engineering Complex, Hazira

L&T Ship Manufacturing at Hazira

Manufacturing Location
Hazira, Gujarat

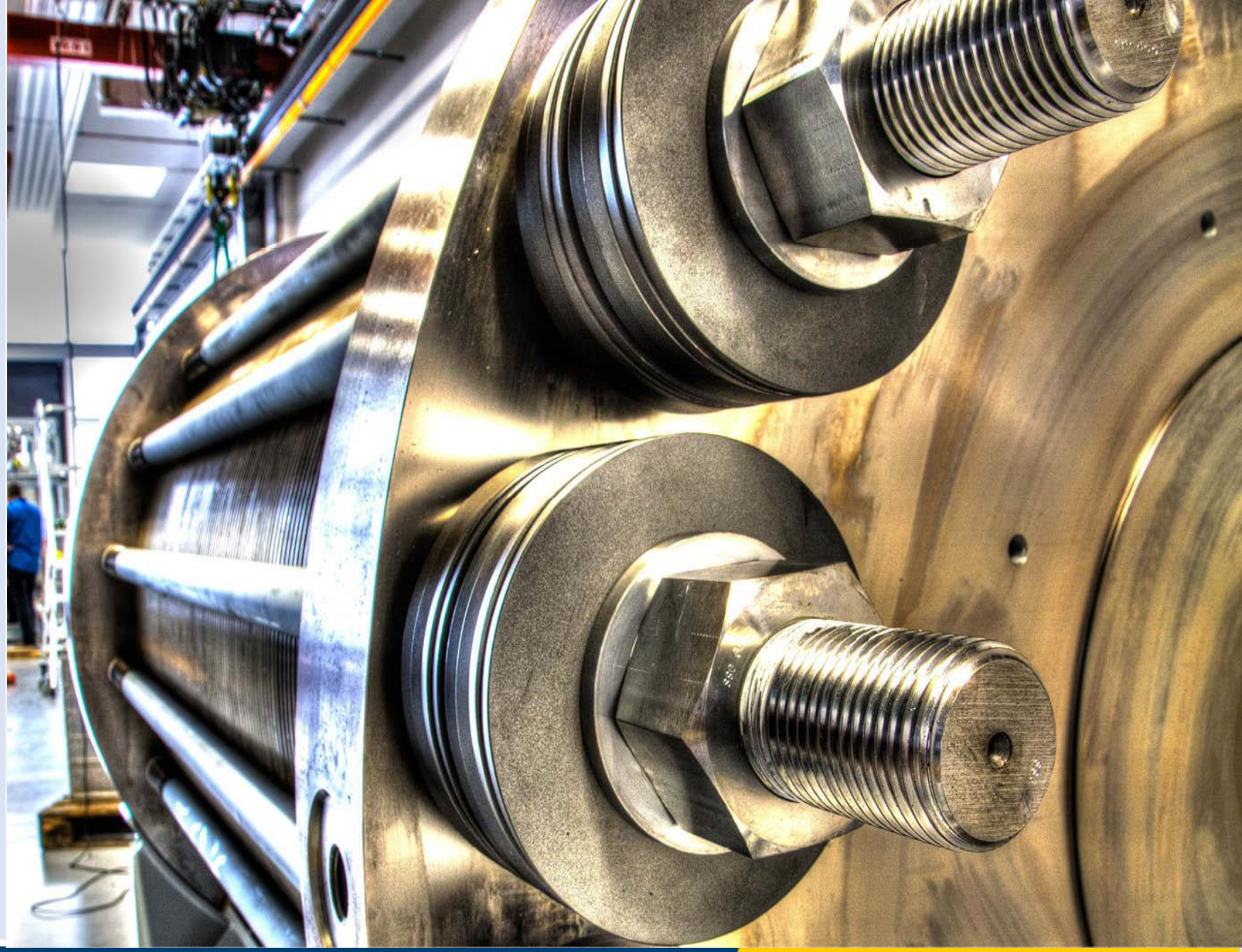
Capacity 1 GW (2024)

Technology
Pressurized Alkaline Electrolysis

Products Lines
Stack & Process Unit

Proximal Advantage
Connected to Industrial Corridor and Port

Technology



Thermodynamics of water electrolysis

$H_2O \rightarrow H_2 + \frac{1}{2}O_2$ $\Delta G^0 = 237.1\ kJ/mol$

$\Delta G^0 = n \times F \times E^o$

$E^0 = {}^{\Delta G}/_{nF}$

Equilibrium potential, $\boldsymbol{E^0 = 1.23\ V}$

Since, the reaction is **endothermic**, a constant minimum energy is needed to be supplied for the electrolyser to operate at a **constant temperature**.

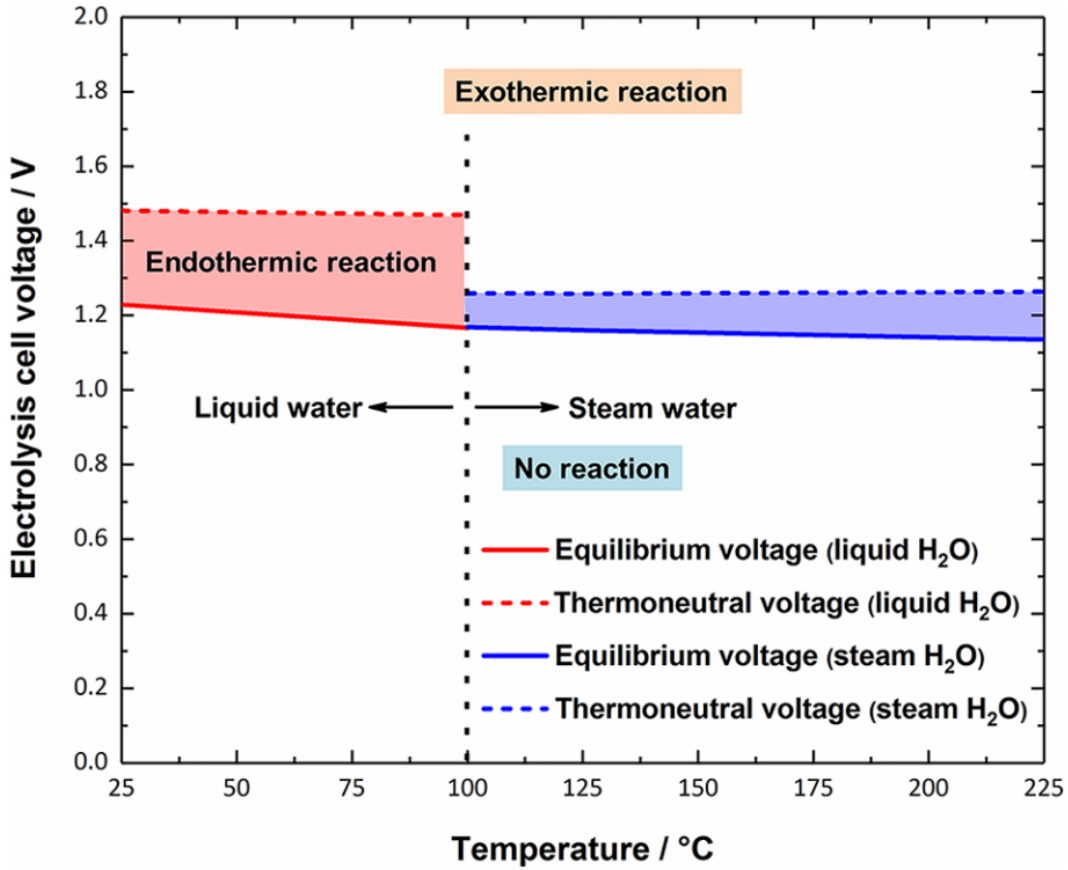
$\Delta H = 285.8\ \mathrm{kJ/mol}$

Thermoneutral potential, $\boldsymbol{E^0_{th} = 1.48\ V}$

LHV	$\Delta G = 237.1\ kJ/mol$
HHV	$\Delta H = 285.8\ kJ/mol$

Constants:

- No. of electrons per mole of H2 production, **n = 2**
- Faraday's constant, **F = 96485 C/mol**



DOI: 10.1021/acssuschemeng.7b04173

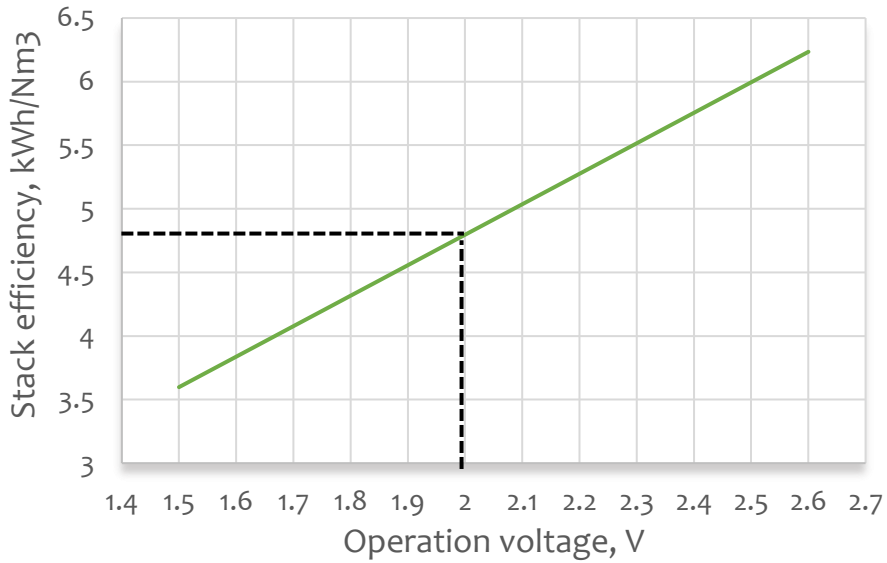
Theoretical Vs State-of-the-Art for low temperature electrolysers

Energy required at equilibrium,

$$\Delta G = 237.1 \frac{kJ}{mol} \leftrightarrow 2.94 \frac{\text{kWh}}{\text{Nm}^3} \leftrightarrow 32.66 \frac{\text{kWh}}{\text{kg}}$$

Min. energy requirement to run electrolyser at const. temperature.

$$\Delta H = 285.8 \frac{kJ}{mol} \leftrightarrow 3.54 \frac{\text{kWh}}{\text{Nm}^3} \leftrightarrow 39.33 \frac{\text{kWh}}{\text{kg}}$$



State of the Art

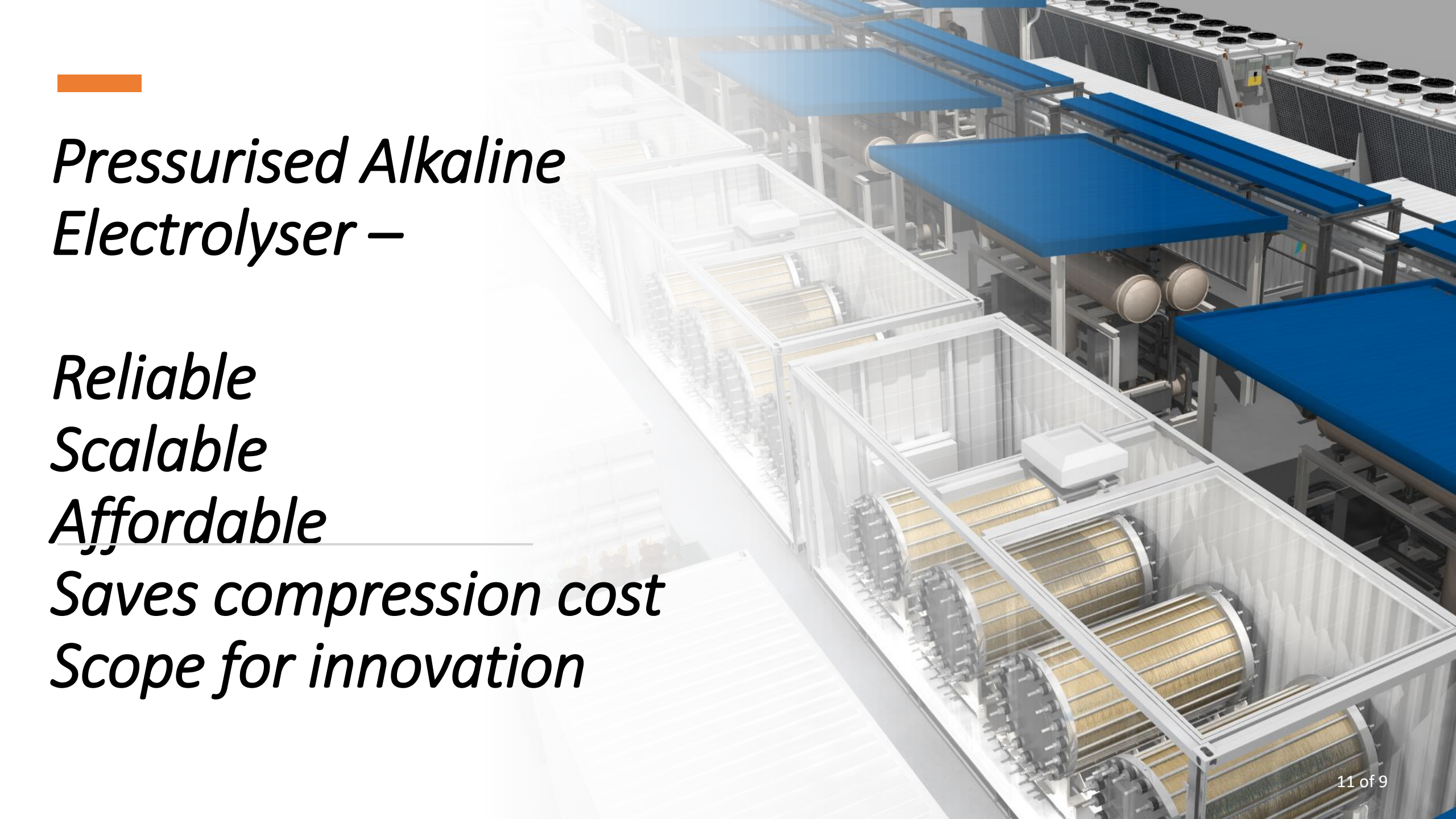
$$54 - 58 \frac{\text{kWh}}{\text{kg}}$$

	ALKALINE (AE)	PROTON EXCHANGE MEMBRANE (PEM)	ALKALINE EXCHANGE MEMBRANE	SOLID OXIDE
DESCRIPTION	 **Work horse** Reliable, proven and low upfront cost	 **Race stallion** Fast and flexible, but high upfront costs	 **New colt** New and promising, but low endurance	 **Cross country horse** High performer, when in the right environment
ADVANTAGES	• Low upfront cost • No need for critical raw materials • Long lifetime	• High H2 output pressure • High flexibility to load changes • Compact design	• High flexibility • Compact design • No need for critical raw materials	• Highest efficiency (if waste heat is available) • Resilient towards impurities
DISADVANTAGE	• Low flexibility (long cold starts and limited load window) • Limited output pressure	• Need of rare and expensive materials	• Low lifetime • Emerging technology (low bankability)	• Long cold start

Pressurised Alkaline Electrolyser –

Reliable
Scalable
Affordable

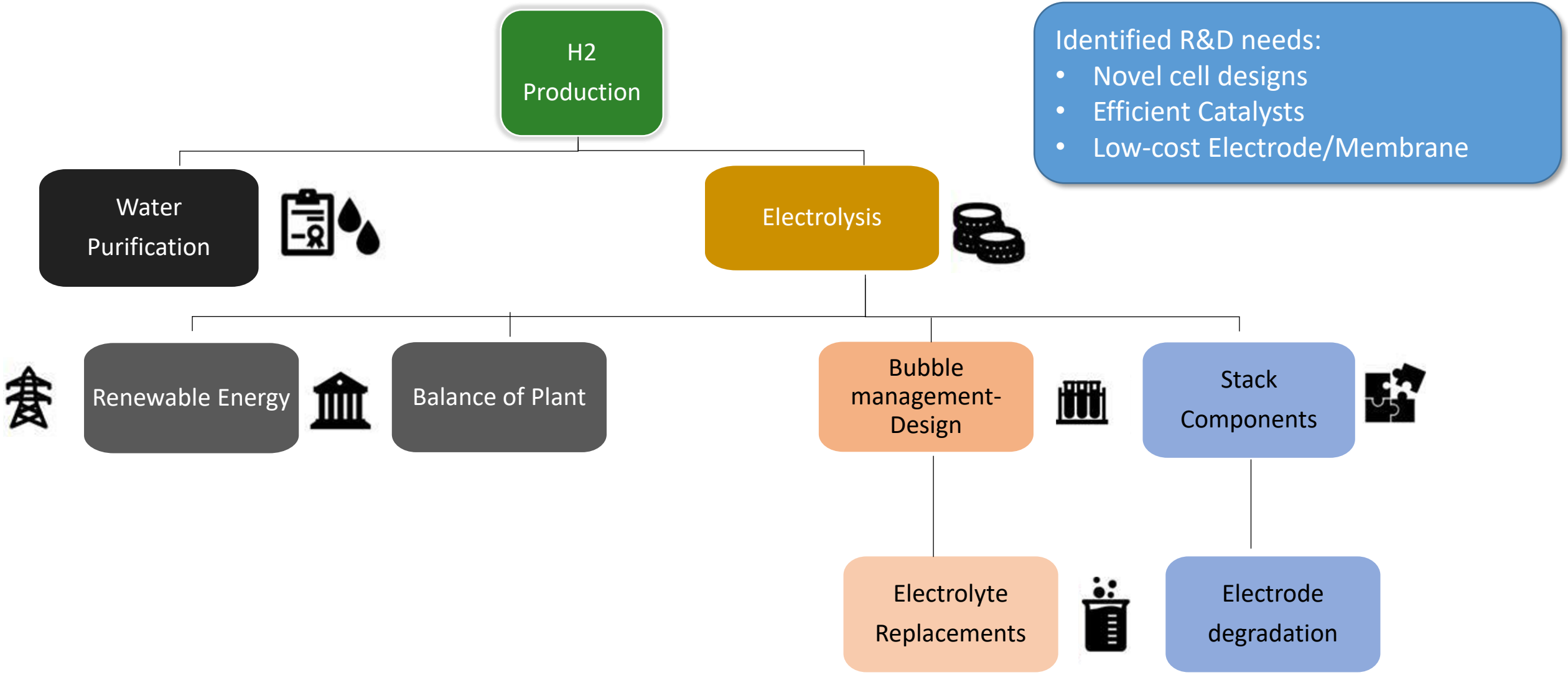
Saves compression cost
Scope for innovation



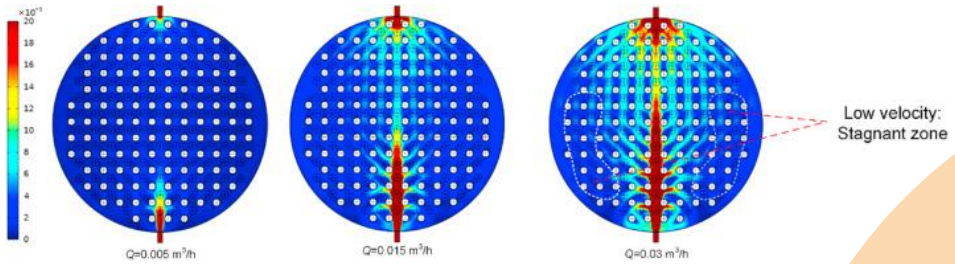
L&T CGET – a hub of technical excellence to innovate in India

Develop in India
Build in India

Technology Gap Analysis: Research Needs

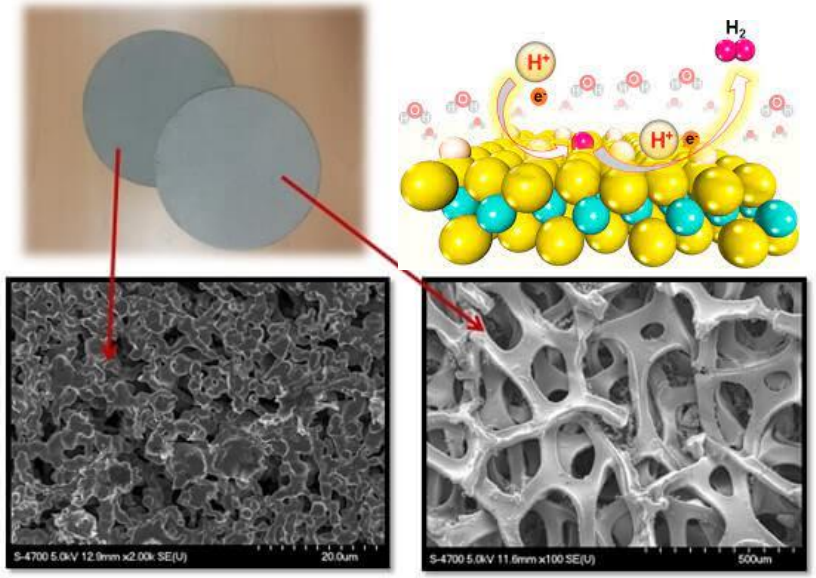


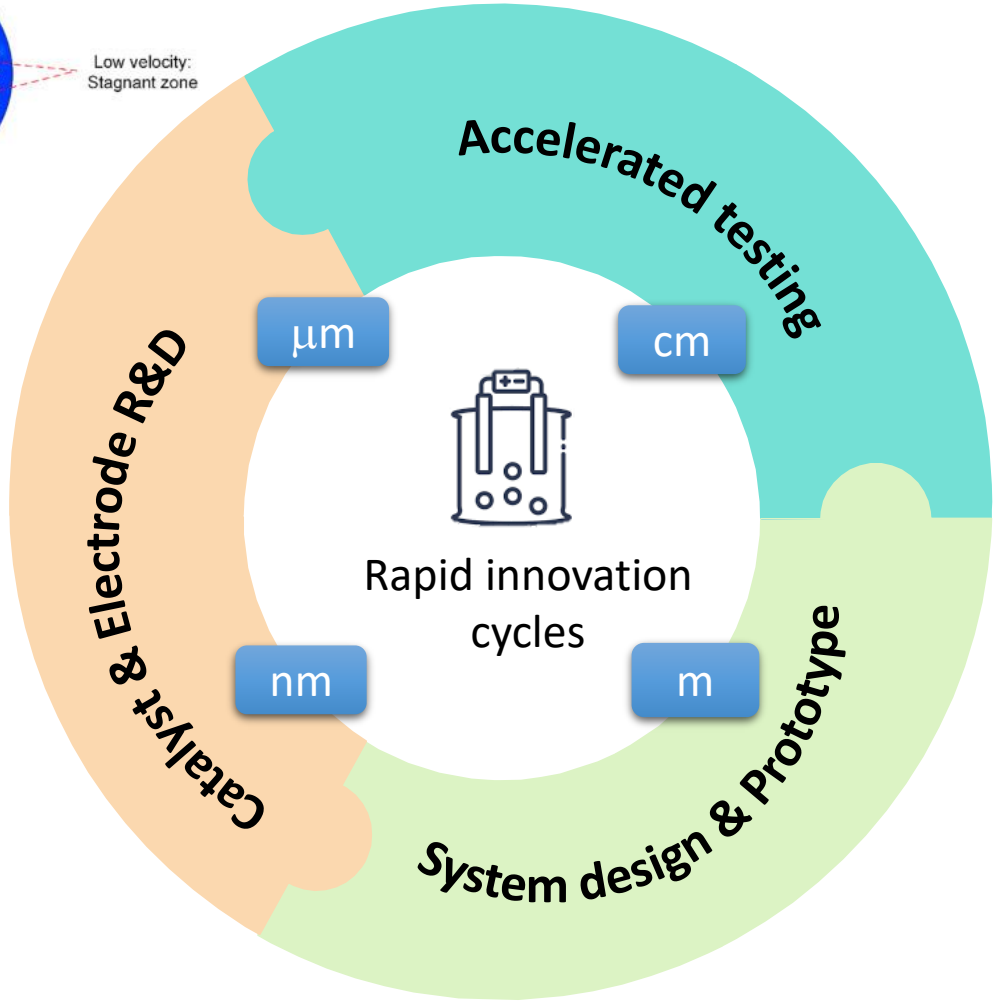
Technology Enhancement Strategy



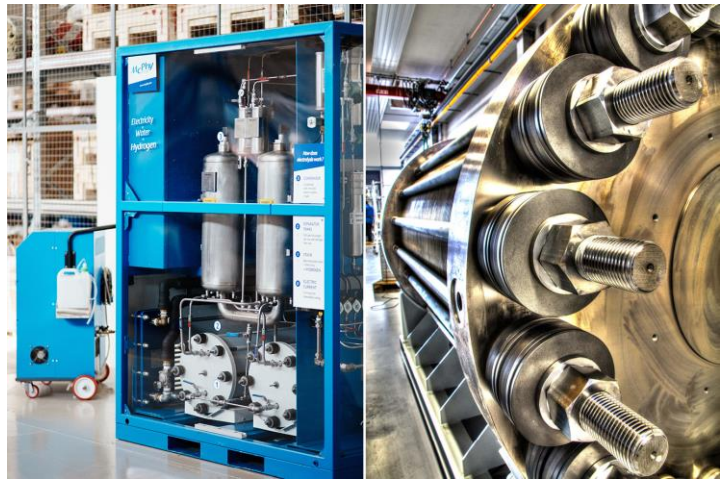
Stress testing- failure mode analysis

Electro-chem testing:
Efficiency, durability





System level analysis &
scale up studies



Key Steps that will help propel Green Hydrogen economy

***Promote R&D** with increased allocation and incentives*

- The proposed allocation of Rs. 400 crs. under India - NGHM is a boon for Indian academia
- Need to step up funding for Industrial product innovation, to retain competitiveness
- Policy initiatives for promoting Industrial Innovation in India will be crucial to ensure technology security for the nation.

India has opportunity to become a leader and Global Hub for production, usage and export of Green Hydrogen and its derivatives

L&T is uniquely positioned to leverage its expertise in Manufacturing and Projects to support India's Energy transition and committed to make a success of the Govt of India initiatives on energy decarbonisation .

Positioning Our Business Offerings To Accelerate Energy Transition and to Support Our Partners In Their New Energy Journey

Thank You

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