

Cost Reduction in Water Electrolysis

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ITRI - GEL Research Fields

Low-Carbon Environment

- Sustainable Environment
(Resource Circulation Technology, Pollutant Prevention)
- Low Carbon Energy and Energy Storage
(Bioenergy, Hydrogen, Geothermal, Marine Resources, CCS)



Energy Efficiency

- Smart Energy-saving System
(EMS, sensing and Monitoring, smart lightening, control and simulation analysis)
- Energy-saving Equipment
(High-Speed Turbomachinery, ORC)

Electrical Energy System

- Photovoltaics (PV)
(Photovoltaic System and Reliability Advanced Photovoltaic Material)
- Grid and Power Electronics
(Smart Grid, Virtual Power Plant (VPP))



Environmental and Energy Policy

- Policy and Promotion
(Net Zero Strategy, Energy, Environmental & Social Planning)
- Green Energy Industry Promotion
(PV, Wind)

Presentation Outline

- I. Comparison of Various Hydrogen Production on GWP
- II. Green Hydrogen Cost Reduction Pathway
- III. Water Electrolysis Technology Development at ITRI, Chinese Taipei
- IV. Conclusion - Opportunity and Challenge

I. Comparison of Various Hydrogen Production

- IEA projects the demand for low-emissions hydrogen grows quickly in the NZE. Low-emissions hydrogen production increases from 0.6 Mt today to 70 Mt in 2030 and **420 Mt in 2050** and **3,300 GW installed Electrolyser** is needed to meet 2050 NZE Scenario. *IEA 2023*
- GWP of different hydrogen production methods

Production Method	GWP (kgCO ₂ eq/kgH ₂)
Grid	28.6~29.5
Solar PV	0.37~2.5
Wind	0.03~2.2

Grid : assume electricity carbon emission factor ~0.52 kgCO₂eq/kWh ,
electrolyzer efficiency ~55 kWh/kgH₂

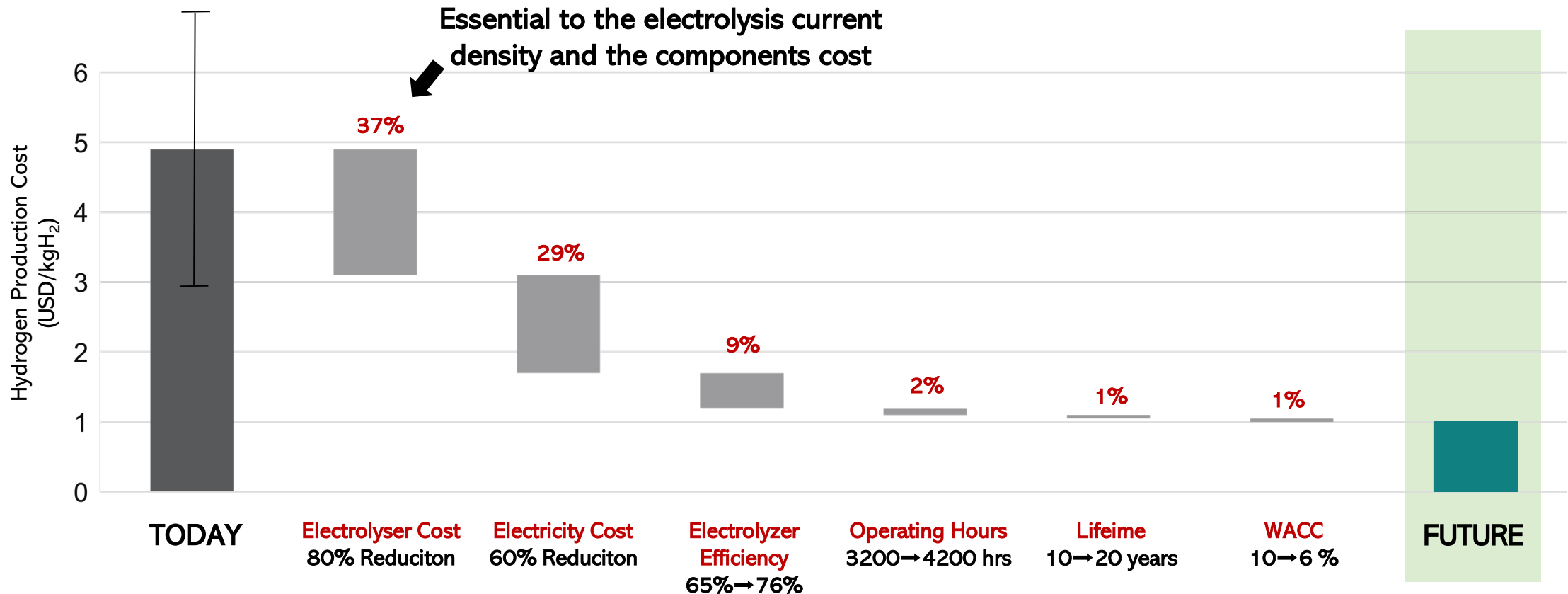
Production Method	GWP (kgCO ₂ eq/kgH ₂)
SMR	10.5~13.8
CG	19.4~25.2
CG + CCS	4.1~7.1

SMR : Steam Methane Reforming
CG : Coal Gasification
CCS : Carbon Capture and Storage

- Different Country Different Case: Take a GWP of <4 kgCO₂eq/kgH₂ for example. The 'Grid Electricity' cannot be introduced to be greater than 13% in electrolysis for H₂ production.
(Electricity Carbon Emission Factor ~0.52 kgCO₂eq/kWh , Electrolyzer Efficiency ~55 kWh/kgH₂)

II. Green Hydrogen Cost Reduction Pathway

- IRENA projects the largest cost driver in producing renewable hydrogen is the **electricity price**. The next major hurdle in achieving low-cost green hydrogen is to reduce the investment cost of the **electrolyser**.



Green H₂ Cost Reduction from Electrolyser Sector

- Cost decreases are expected to be driven by advancing in materials, increasing current density, achieving manufacturing economies of scale, and leveraging learning-by-doing effects in electrolyzer deployment.

Electrolysis Technology	AWE	PEM	AEM	
Technology Readiness Level	TRL 9	TRL 9	TRL 6	
Critical Raw Material	Nickle	Pt, Ir, Ti	Nickle	\$↓ Free from Rare Earth Materials
Current Density	Typ. 0.5A/cm ²	Typ. 2A/cm ²	>1A/cm ²	\$↓ Larger Current Density, Higher Production Rate
Load-Following	Limited Operation Window	Wide Operation Window	Wide Operation Window	\$↓ Varies H ₂ Output and Efficiency to Minimize the LCOH
Stack Size	MW-class Mature Case	MW-Deployment Expansion	MW-Project On-going Testing	\$↓ A Large Role in System Cost

AWE : Alkaline Water Electrolyser
 PEM : Proton Exchange Membrane Electrolyzer
 ARM : Anion Exchange Membrane Electrolyzer

III. Shalun H2 Energy Technology Demonstration Site

- Mission : Hydrogen energy technology incubator including hydrogen generation, transportation, storage and application technology.
- Features : We aim to cooperate with industry encompassing technology demonstrations from the hydrogen generation, hybrid energy storage and low carbon emission power generation by taking advantage of 1MW renewable energy in this campus.

Domestic 100kW Water
Electrolysis System
Development Project

PV 1 MW/ Electrolyzer 100 kW
(commercial system demonstration
platform)

100kW Fuel cell power
generation system
demonstration
Type: PEM / SOFC
Feedstock: NG/H₂/NH₃

VRB System test and
verification platform
Commercial system 78kW/220kWh
Under independent development: 100kW/400kWh

Hydrogen
Storage Area

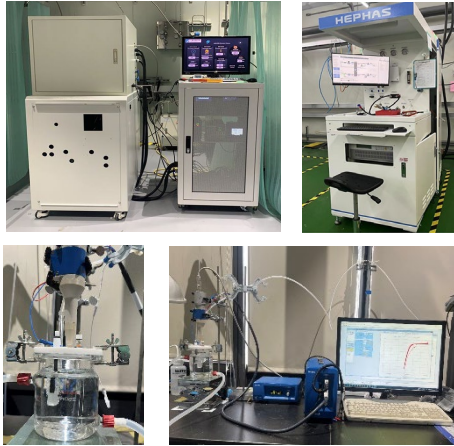
Reserved area for
transportation
application and
refueling station

500kWh Hybrid energy
storage and management
control system
(hydrogen and battery)

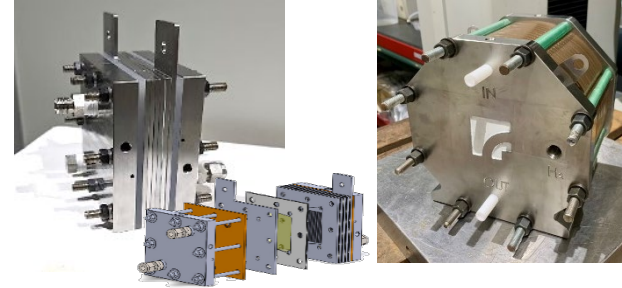
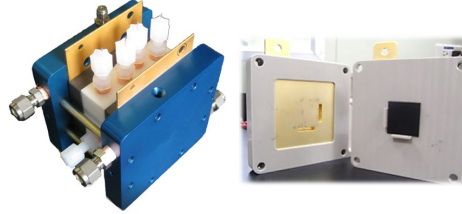


III. Water Electrolysis Technology Development

- Domestic 100kW Water Electrolysis System are developing from fundamental components to large-scale validation with a growing electrolyzer capability at ITRI-GEL

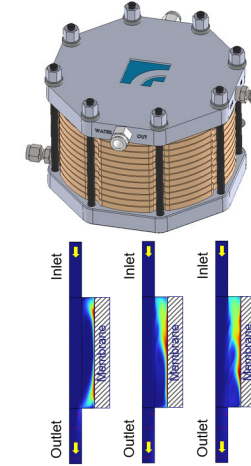


- In-Situ studies for benchmarking e.g. Polarization, CV, EIS
- Ex-situ studies for performance factors, e.g. Ionic Conductivity, IEC, SEM, TEM, FIB, MIP for PtL, Interfacial Conductivity.



High-pressure electrolyzer development

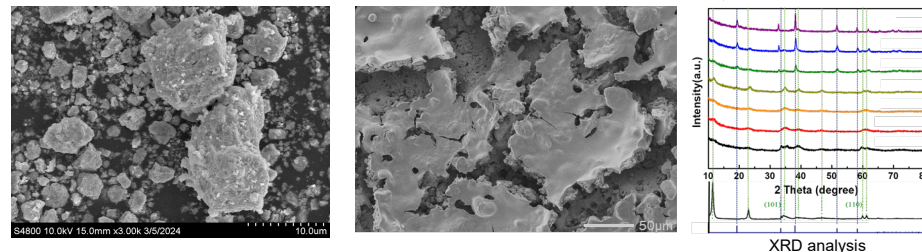
- Structural analysis and assembly technology
- Optimal flow field design
- Transport phenomena modeling



Material Synthesis | In/Ex-Situ Evaluation

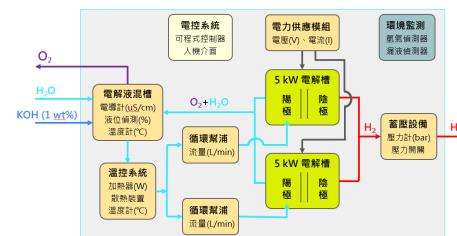
Catalyst & Ink Modification to improve the performance

- RDE for ECSA, LSV screen materials
- Study the impact of substrate, the stability of ink involving solids content, binder and solvent ratio



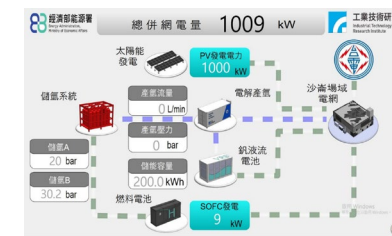
Stack

- BOP optimization of multi-module electrolysis system
- Optimized control of hydrogen production from RE
- Scenario analysis of renewable energy



System Integration

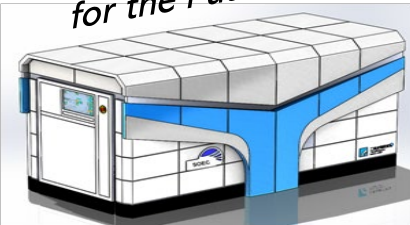
Electrolysis system integration



2027

Domestic 100kW AEM Electrolyzer System

Conceptual Design for the Future

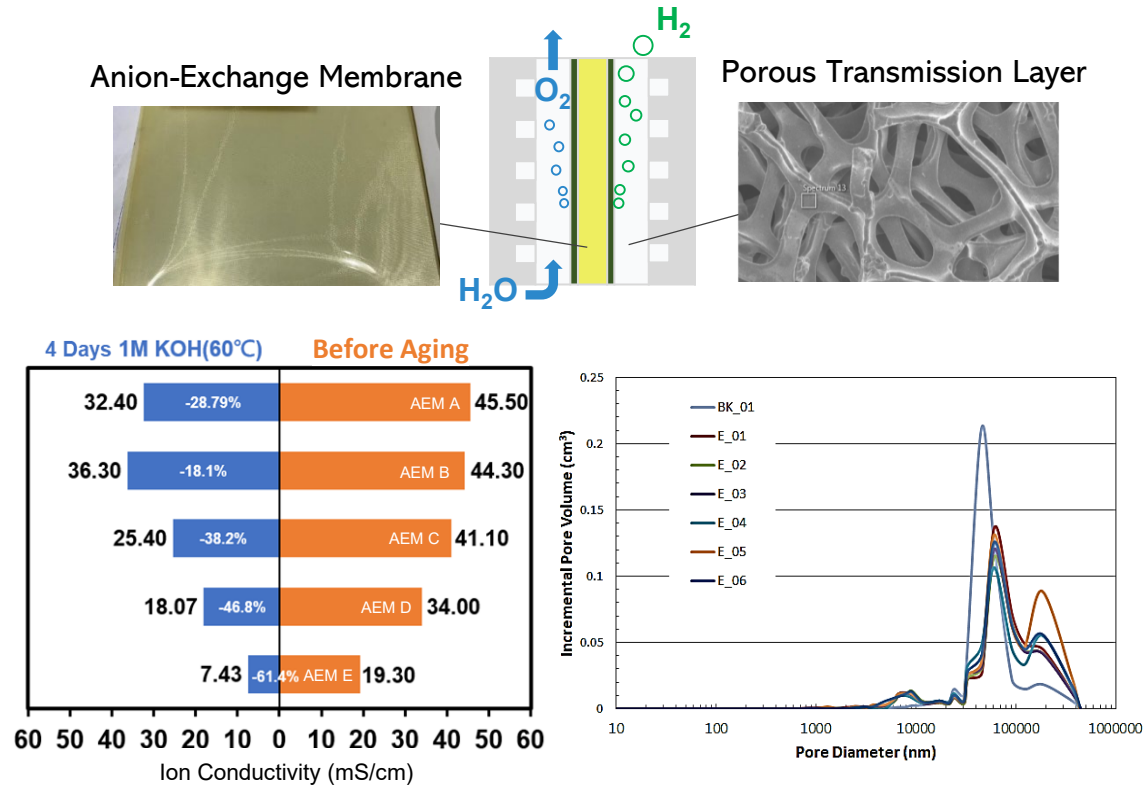


AEM 100kW system efficiency $\geq 65\%$



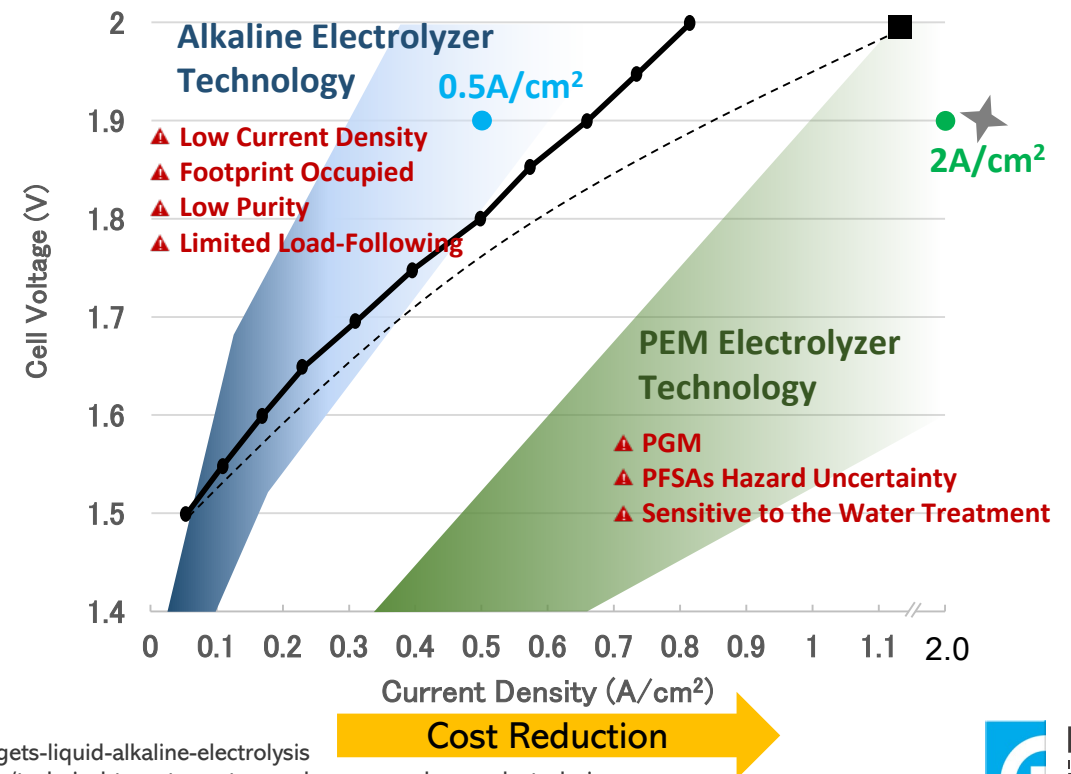
Electrolyzer Current Accomplishment

- Utilize in/ex-situ characterization techniques to evaluate materials and components for identifying the performance and sourcing material. Develop reproducible analysis pathways to keep the progress rolling
- Stack, Cells, PTLs, Electrodes development are in scope of the optimization research.



Study phenomena at interfaces, coatings, materials and operating conditions to characterization the impact of performance

- 2023 ITRI-GEL | High Pressure AEM Accomplishment
- 2024 ITRI-GEL | High Pressure AEM Developing
- Alkaline Status (DOE 2023) ● PEM Status (DOE 2023)



Reference:

DOE (2023). Technical targets for liquid alkaline electrolysis. Available at: <https://www.energy.gov/eere/fuelcells/technical-targets-liquid-alkaline-electrolysis>

DOE (2023). Technical targets for proton exchange membrane electrolysis. Available at: <https://www.energy.gov/eere/fuelcells/technical-targets-proton-exchange-membrane-electrolysis>

IV. Conclusion - Opportunity and Challenge

- ITRI-GEL has established key technical capabilities of the **water electrolyzer on cost reduction**. GEL will assist domestic industries to introduce hydrogen energy applications in order to provide **distributed power** and **carbon reduction** benefits.

Gradual and Orderly toward Hydrogen

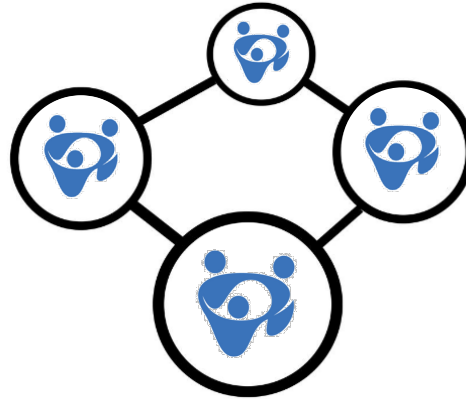
Pilot Project



Example

- Hydrogen Energy Demonstration Site

Minimum Viable Ecosystem



Example

- Hydrogen Industrial Cluster

Mature Ecosystem



An example of what a hydrogen cycle could look like, including possible end uses. (Source: FCHEA)

Thank You.

