KOREA's Hydrogen Policy and R&D

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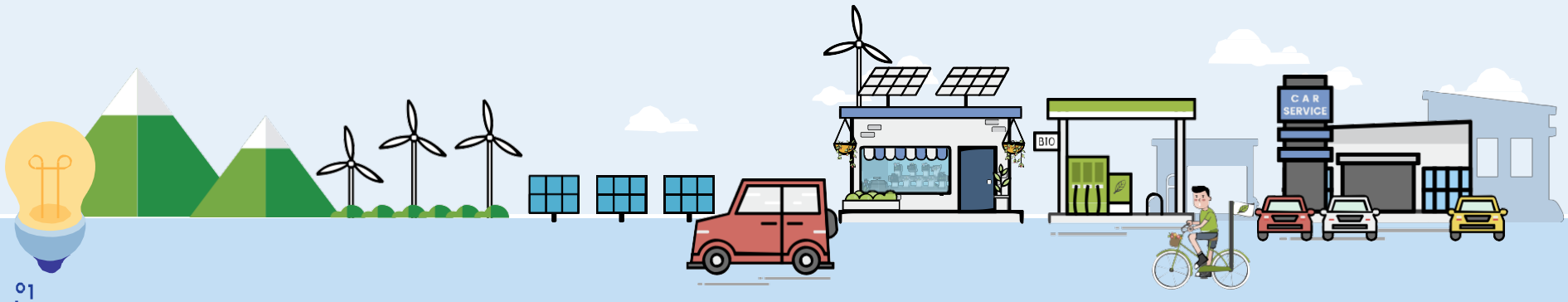
Tae-Hyun Yang
Hydrogen Energy Research Division,
Korea Institute of Energy Research (KIER)

Contents



더 맑은 지구와
더 강한 경제를
만들어가는

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1. KOREA's Hydrogen Energy Policy

KOREA's Hydrogen Policies

➢ Hydrogen Economy Roadmap was announced (Jan. 2019)

• Hydrogen Economy Promotion and Hydrogen Safety Management Law came into force (Feb. 2021)

• 11 Hydrogen-specialized companies designated based on Hydrogen Economy Law (June, 2021)

➢ Carbon Neutral Strategy by 2050 (2020)

➢ Hydrogen Economy Action Plan was announced (Nov. 2021)
• around 33% of energy needs will be powered by hydrogen fuel for carbon neutrality by 2050

➢ Revision of the law proposed on "Clean Hydrogen Energy Portfolio Standards (CHPS)" and clean hydrogen certification system (June, 2022)

• CHPS for H2 -fueled power generation (currently included in RPS)
• Standards and verification process being developed for certification system

KOREA's Carbon Neutral Strategy by 2050

Korea's 2050 Vision :
Realization of a safe and sustainable carbon-neutral society from the climate crisis

Key Elements

❶ Expanding the use of clean power and **hydrogen** across all sectors

❷ Improving **energy efficiency** to a significant level

❸ Commercial deployment of carbon removal and other future technologies

❹ Scaling up the circular economy to improve industrial sustainability

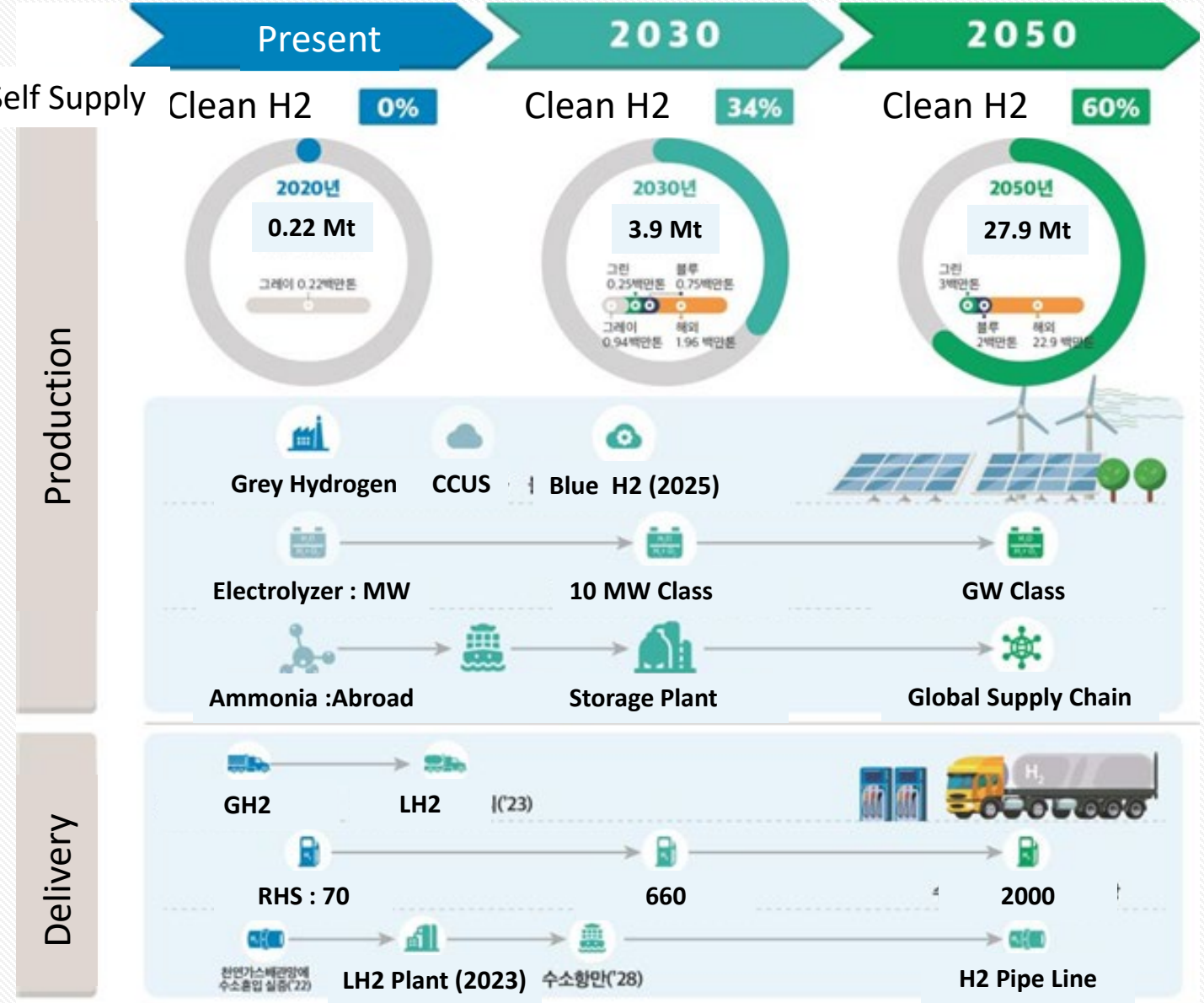
❺ Enhancing carbon sinks

Korea Hydrogen Roadmap : Turning Point of Hydrogen Tech.

	2015	2019	2022.3	2050 (Target)
Government	MOTIE MSIT	MOTIE , MSIT (R&DD) ME (HRS deployment) MOLIT(H_2-city, transportation)		
Budget (MOTIE) (US $ M)	30 - 40	60	111	
FCEV	160	3,216	20,628	51.5M
HRS	12	24	125	2,000
Stationary FC (MW)	244	350	730.6	8,000/2,100(RPG)
Bus/Truck	demo	7	150/5	110,000
Production (MMT)	<0.1	<0.2	0.47	5.26
H2 Mobility		taxi, forklift, drone, submarine	HDV, Train, Ship, Drone etc.	
Storage	Compressed Gas, Hydrogen Storage Metal	NH3, LH2, LOHC		

*Hydrogen Production: 1.9 Million Tons (2015). Most consumptions take plance in industry.

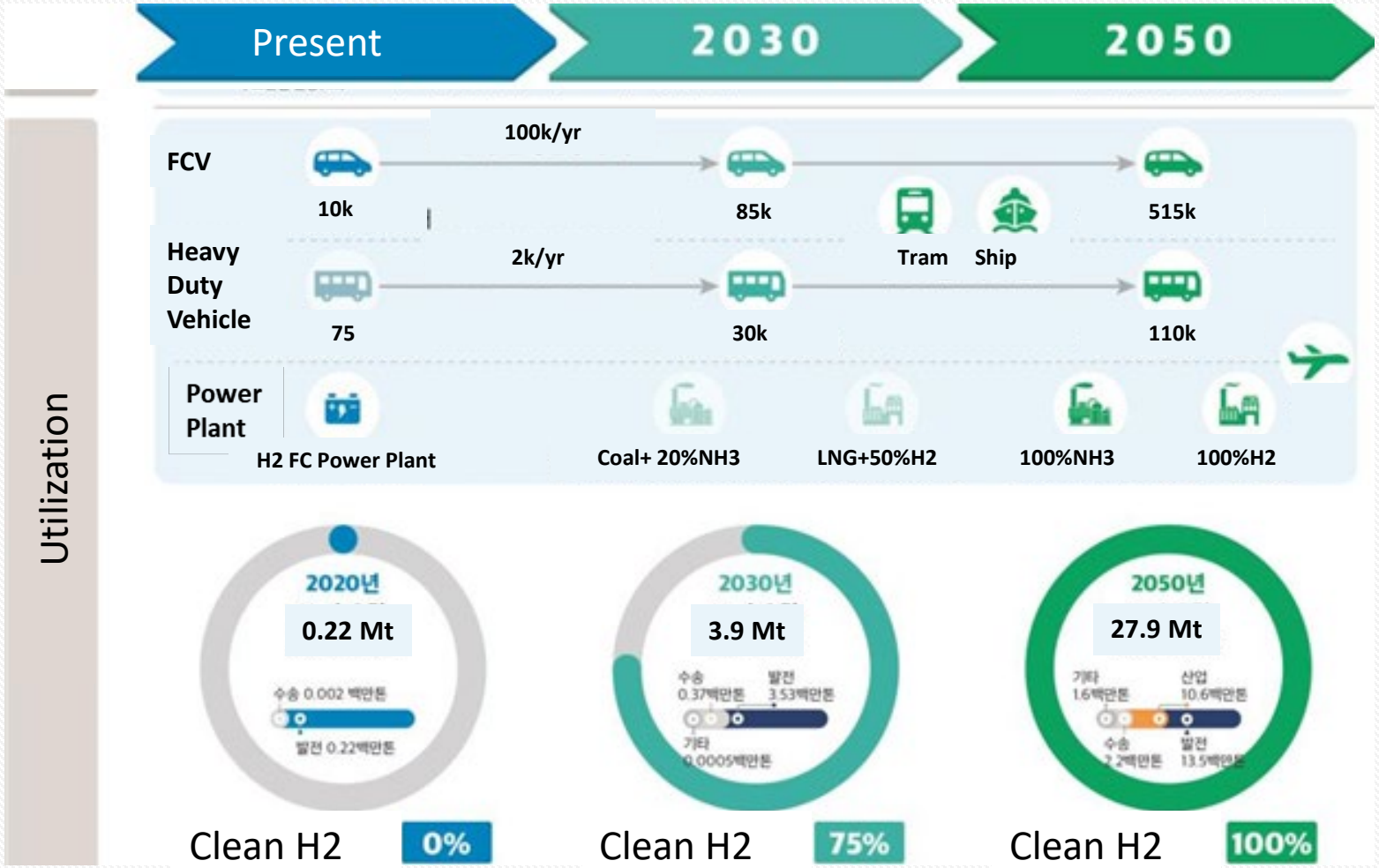
KOREA's Hydrogen Roadmap Action Plan (2021)



(Unit: M ton CO_2eq)

Green H2 Production/Cost :
(2030) 250k ton / ₩3,500/kg
(2050) 3M ton / ₩2,500/kg

KOREA's Hydrogen Action Plan



Hydrogen Demand & Supply Plan

		2050
Hydrogen Demand (MMt/yr)	Conversion (GT, Fuel Cell)	13.5
	Industry (Steel, Petrochemical, Cement etc)	10.6
	Transport	2.2
	CCUS	1.6
	Total	27.9

		2022	2030	2040	2050
Hydrogen Supply (MMt/yr)	Import (Clean H2)	0	1.96		22.9
	Green H2	0	0.25		3
	Grey H2 By Product	0.22	0.94		0
	Blue H2	0	0.75		2
	Total	0.22	3.9		27.9
Delivery	Domestic	Tube Trailer	LH2 trailer Tube Trailer	Pipe Line Trailer (GH2, LH2)	Pipe Line
	Overseas	-	Ship (H2 tanker)	Ship (H2 tanker)	Ship (H2 tanker)

2. Current Status of Hydrogen Energy in KOREA

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Strategy of Hydrogen R&D

- Hydrogen Production (Low TRL)
  - Cost competitiveness with fossil fuel : cost, efficiency, electricity, utilization, etc.
  - Clean hydrogen (grey → blue →green) : electrolysis, NG reformer with CCUS etc.,
- Hydrogen Storage and Transport (Low TRL)
  - Increase hydrogen storage density
  - Gas H2 : high pressure tank ($900/kg → $400/kg), pipe line (20 → 100 bar), tube trailer (200 → 450 bar)
  - Liquid H2 : liquid hydrogen plant, storage tank, tank lorry and tanker
  - LOHC, NH3 : hydrogenation and dehydrogenation catalyst and process
- Hydrogen Refueling Station (Low TRL)
  - Safety, Cost, Standard, Demonstration
  - Localization of core materials and components

Strategy of Hydrogen R&D

- Hydrogen Mobility (High TRL)
  - Cost, Durability (LDV, LDT, HDV)
  - Localization of core materials and components

- Conversion (stationary fuel cell, hydrogen turbine) (Low and High TRL)
  - LCOE (system cost, efficiency, etc.)
  - Localization of core materials and components

1. Energy Conversion : Fuel Cell Power Plant

20MW distributed power in Seoul(2017)

- E: 160 M kWh/year, Heat : 6.5 T Cal/year
- Fuel : NG

50MW Plant in Daesan Industry Complex(2020)

- Fuel : By product hydrogen

1. Energy Conversion : Fuel Cell Power Plant

KOWEPO, 77MW FC Power Plant

2021
Doosan Fuel Cell (PAFC)
Electricity Supply for 237,300 home in Incheon

KOSPO, 78MW FC Power Plant

2017-2021
Doosan Fuel Cell (PAFC), Posco Energy (MCFC),
Electricity Supply for 250,000 home in Incheon
Hot Water Supply for 44,000 home

1. Energy Conversion : Coal & Gas Fired Power Plant

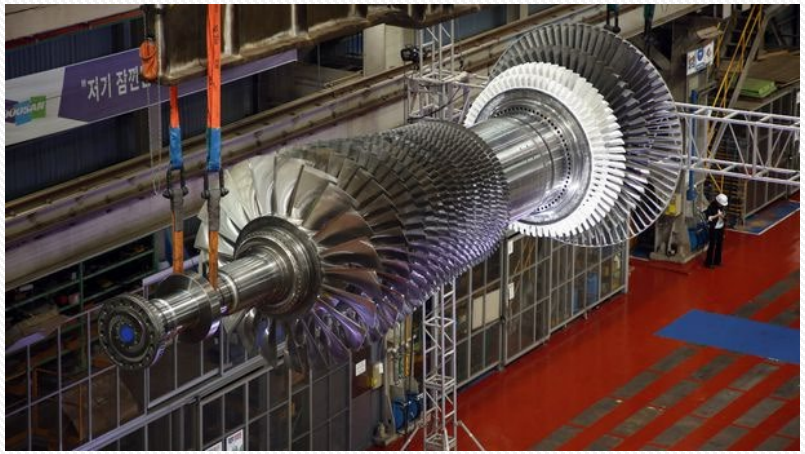
Fuel Transition from Coal and LNG to green H_2 and NH_3

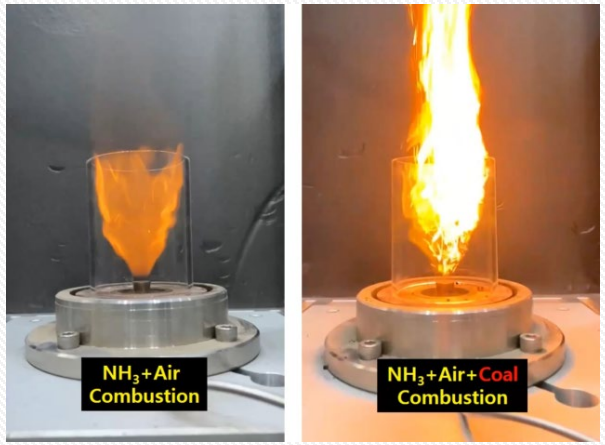
Coal

LNG

Green Hydrogen and Green Ammonia

1. Energy Conversion : Thermal Power Plant





Doosan Enerbility: 270W LNG GT
R&D of Fuel Transition from LNG to Hydrogen and Ammonia

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R&D of Ammonia and Coal Cofiring

2. Building and Home : m-CHP Fuel Cell

Solar (Incheon International Airport)

Geothermal (Lotte World Tower)

Fuel cell (Eulji Twin Tower)

Heat recovery from treated wastewater (Seonam Water Recycling Center)

3. Transportation: Fuel Cell Vehicle

NEXO (Hyundai Motors)

◈ 성능

- 최대 출력 : 135kW(9%⇧, 124kW)
  - 연료전지 스택 95kW + 배터리 40kW(1.5kWh 추정)
- 최고속도 : 177km/h(11%⇧, 160km/h)
  - 모터 최대출력 : 113kW(154ps)
- 복합연비 : 96.2km/kg H_2(25%⇧, 76.8km/h)
- 1충전 주행거리 : 609km(47%⇧, 415km/h)
  - 수소저장용량 : 6.33kg(700기압)
- 연료전지 스택 내구성 : 20만km(E) (100%⇧, 10만km)
  - 연료전지부품 품질보증 : 10년 16만km(투산ix 8만km)

◈ 차량가격

- 모던(Modem) : 6,890만원
- 프리미엄(Premium) : 7,220만원

◈ 색상(5종)

: 화이트크림, 코쿤실버, 카퍼메탈릭,
티타늄그레이(무광), 더스크 블루

완성차, 부품업체 노력과 기초부터, 부품, 시스템, 차량실증까지 정부의 적극적인 R&D 지원으로 함께 이루어진 세계최고의 수소차

3. Transportation: Fuel Cell Heavy Duty Vehicle

Hydrogen BUS : ELEC CITY Fuel Cell in 11 districts (Seoul, Pusan etc)

PEMFC : 90kW stack x 2
Motor : 180kW (240 hp)
H2 Tank : 845 liter (5 ea)
Driving Range : 474km

3. Transportation: Fuel Cell Heavy Duty Vehicle

H2 Truck :XCIENT Fuel Cell Truck

PEMFC : 95kW stack x 2
Motor : 350kW (476 hp)
H2 Tank : 31kg (350 bar)
Driving Range : 400km
Charging Time : 20 min

3. Transportation : zero emission ship

KSOE KOREA SHIPBUILDING & OFFSHORE ENGINEERING

- Commercialization of ammonia powered ship by 2025
- Commercialization of hydrogen powered ship by 2030

DSME

- Commercialization of ammonia powered ship by 2025
- Development of SOFC powered ship with Bloom Energy

SAMSUNG HEAVY INDUSTRIES

- Commercialization of ammonia powered ship by 2024
- Development of fuel cell core technologies

Carbon-Free Fuel : Liquid H2 or Ammonia ???

4. Green Hydrogen Production R&D

- Power to Gas Project in Jeju Island

- In Jeju, renewable energy-based power generation more than 42 percent
- Curtailment of solar and wind power
- Needs of ESS (Li ion Battery and Hydrogen Storage)
- One of solutions : Power-to-gas green hydrogen production technology

- 1st Phase : 500kW Water Electrolysis
- 2nd Phase : 3MW Water Electrolysis
- 3rd Phase : > 10MW Water Electrolysis

4. Green Hydrogen Production R&D
Electrolysis R&D (Alkaline EC)

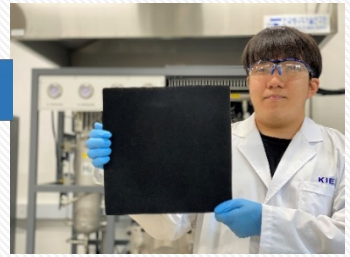
Alkaline electrolysis (KIER)

- Water electrolysis (Low-temperature)
  - 0.1 MW, Stack efficiency 82%(HHV)
  - Partial load range : 5~110%

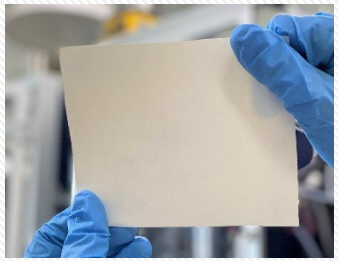
Alkaline water electrolysis

Company	Stack module	System capacity	Efficiency (HHV)
EM solution	0.5MW	1MW	
Suso Energen	0.25MW		
KIER	0.1 MW		82%

Electrolyser for dynamic operation



KIER NiAl electrode



KIER composite Separator

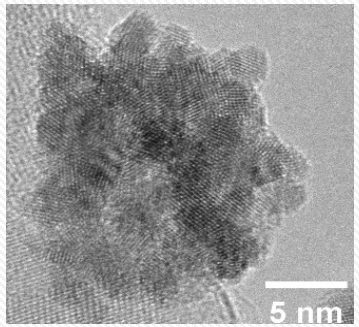
Electrolysis R&D (PEM electrolysis)

PEM electrolysis

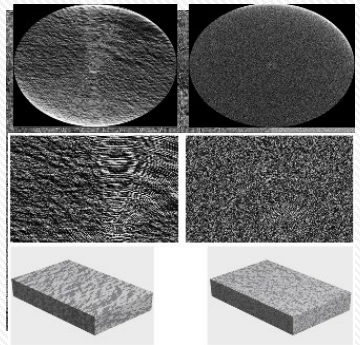
- Water electrolysis (Low-temperature)
  - Scale Up stack and system
  - Durability improvements on PEMWEs
  - AST testing protocols development
  - Supported Ir catalyst for OER
  - Porous sintered Ti sheet for PTL

PEM electrolysis

Company	Stack module	Stack capacity	Efficiency (HHV)
Elchemtech (KR)	1 MW (3000 cm^2)	Scalable	-
KIER, KIST (KR)	N.A.		82%



Supported Ir catalyst


Ti sintered PTL


MEA

Electrolysis R&D (SOEC)

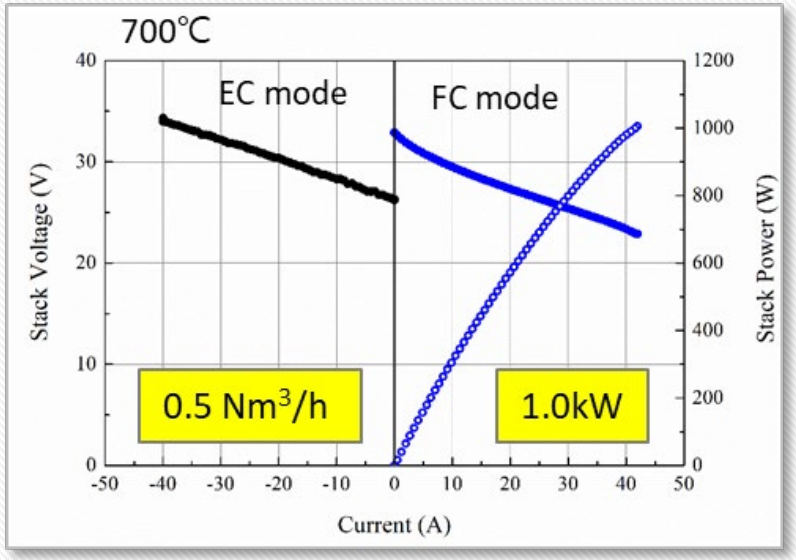
SOEC electrolysis (KIER)

- High-temperature electrolysis
  - Durability improvements on SOEC
  - Flat tubular type in-house cells/stack
  - Hybrid renewable energy system for energy storage system (unitized SOFC&SOEC)

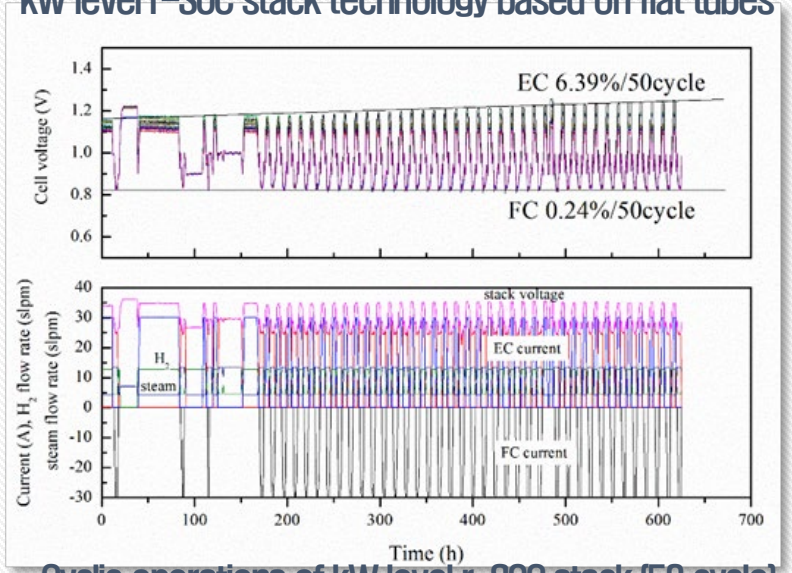
Flat tubular SOCs

30-cell stack

kW level r-SOC stack technology based on flat tubes



I-V curves of kW level r-SOC stack



Cyclic operations of kW level r-SOC stack (50 cycle)

Grey Hydrogen Production R&D
Engineering Design & Fabrication of Test Unit (KIER)

- Production capacities : 643 kg/day (300 N㎥/hr)
- Installation space : 7.0m(L)x3.0m(W)x3.5m(H)

[3D-modeling for skid unit]

[Prototype unit of 643 kg/day class]

Blue H2 Production : Reformer + CCS (KIER)

- Reformer : H_2, 〉200,000 Nm^3/h
  - scale up R&D

- CCS:
  - scale-up

KIERSOL wet-absorption

MAB absorbent process

0.5 MW scale demonstration
At Coal Power Plant

- H2 PSA : commercialized

1995~1998

99.99% H_2
150Nm^3/h
(Hyundai Oilbank)

2012

99.999% H_2
10,000 Nm^3/h
(Hyosung)

2015

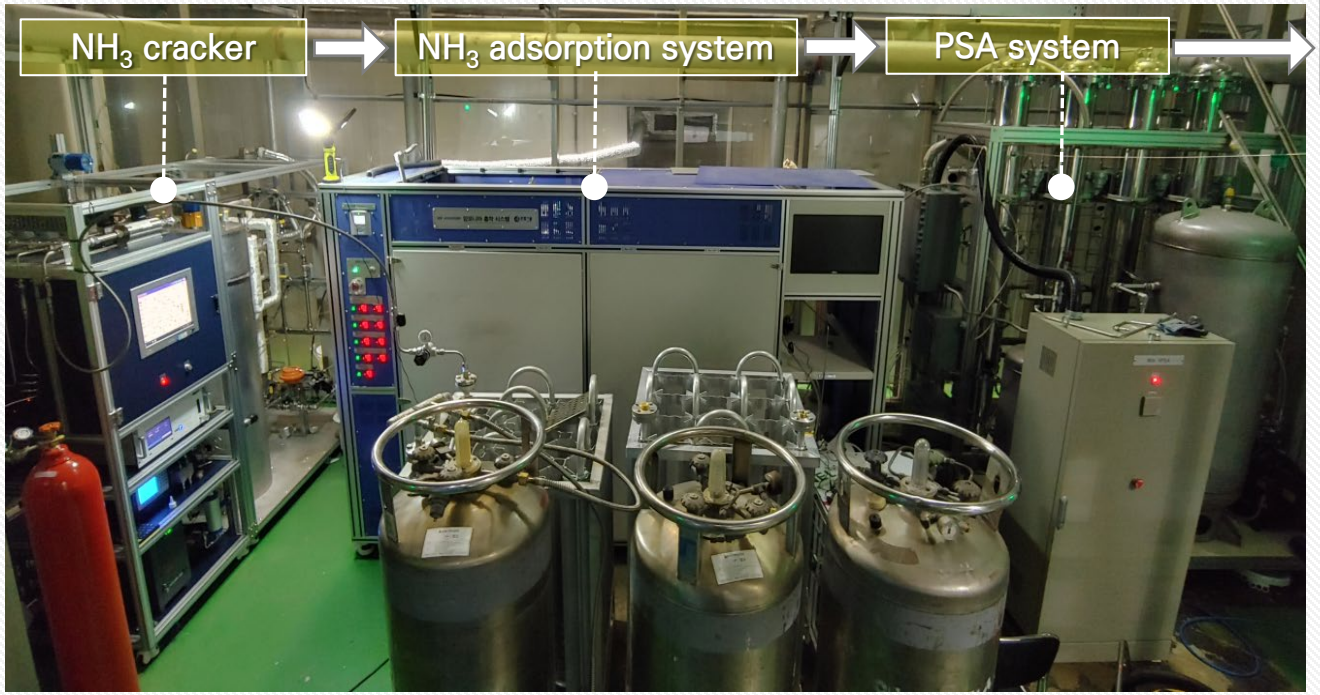
99.5% H_2
54,000 Nm^3/h
(India, HPCL)

Hydrogen Production by NH_3 Cracking

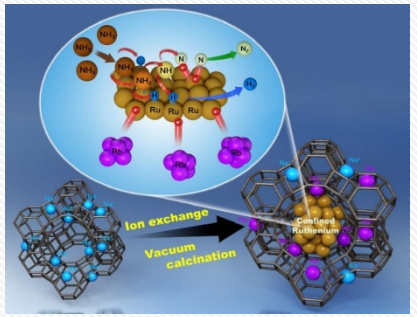
➢ Development of high purity hydrogen production unit

✓ A high-purity hydrogen production system with 20 Nm^3/hThe purity of produced hydrogen was 99.999% or more, and the concentration of residual ammonia was 0.1ppm or less.

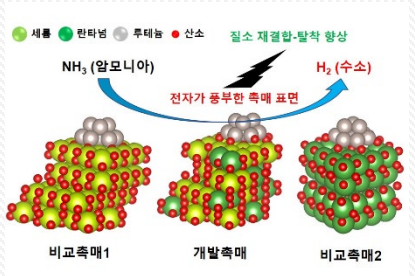
(주)씨이에스 | KIER KOREA INSTITUTE OF ENERGY RESEARCH 한국에너지기술연구원 | HYUNDAI | GENS ENGINEERING Green Energy and Sustainable Engineering | KIST Korea Institute of Science and Technology



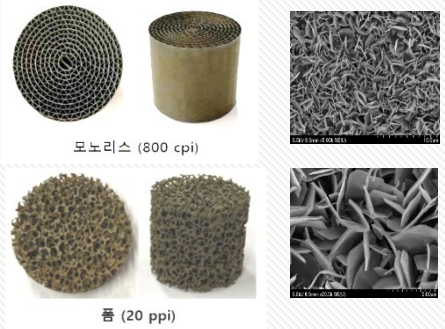
Catalyst



Supporter



NH3 Cracker



What will we do after 2030?

Thank You for Your Attention!
감사합니다.