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Status and Development Plan for Hydrogen Energy in Korea

- ECO-MOBILITY 2021 -

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Backgorund

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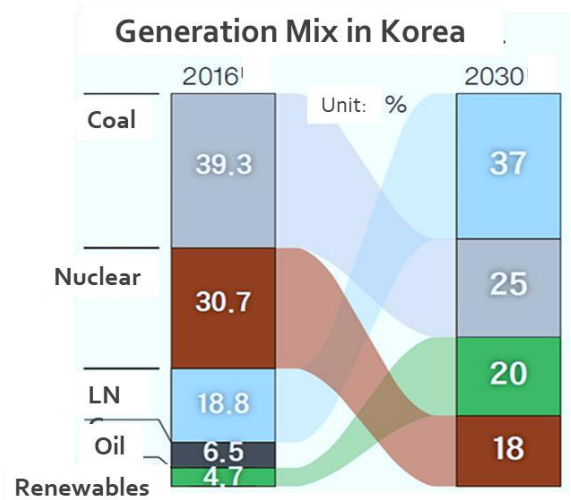
Energy Issues and Strategies in Korea

Issues

- Korea is the 8th largest energy consuming country in the world.
- Korea imports more than 95% of primary energy from abroad.
- Korea is the world's 7th largest GHG emitter in 2016.

Strategies

- Renewable Energy 3020 Implementation Plan : Increase Renewable energy's share of the energy mix from 7% to 20% by 2030.
- Reduction of GHG Emission : Carbon Neutrality by 2050
- Invest R&D and Deployment of Hydrogen Energy : Leading Hydrogen Economy in 2040



Policies in Hydrogen Energy

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Hydrogen Economy Roadmap (2019)

			2018	2022	2040
Goal	FCEVs		1.8K	81K	6.2M
	FC power generation	Com. & Utility	307MW	1.5GW	15GW
		Res. & Building	7MW	50MW	2.1GW
	H2 supply (ton/year)		130K	470K	5.26M
	H2 price (KRW/kg)			6,000	3,000
	Preparation (2018~2022)		Expansion (2023~2030)		Leading (2030~2040)
Strategy	• Ecosystem buildup • Infrastructure investment • Legislative support		• Build-up and scale-up of H2 supply-demand system		• Overseas H2 production • C-free H2 supply system

- Technology development is necessary to reach the goal successfully.
- H_2 Technology Development Roadmap is published

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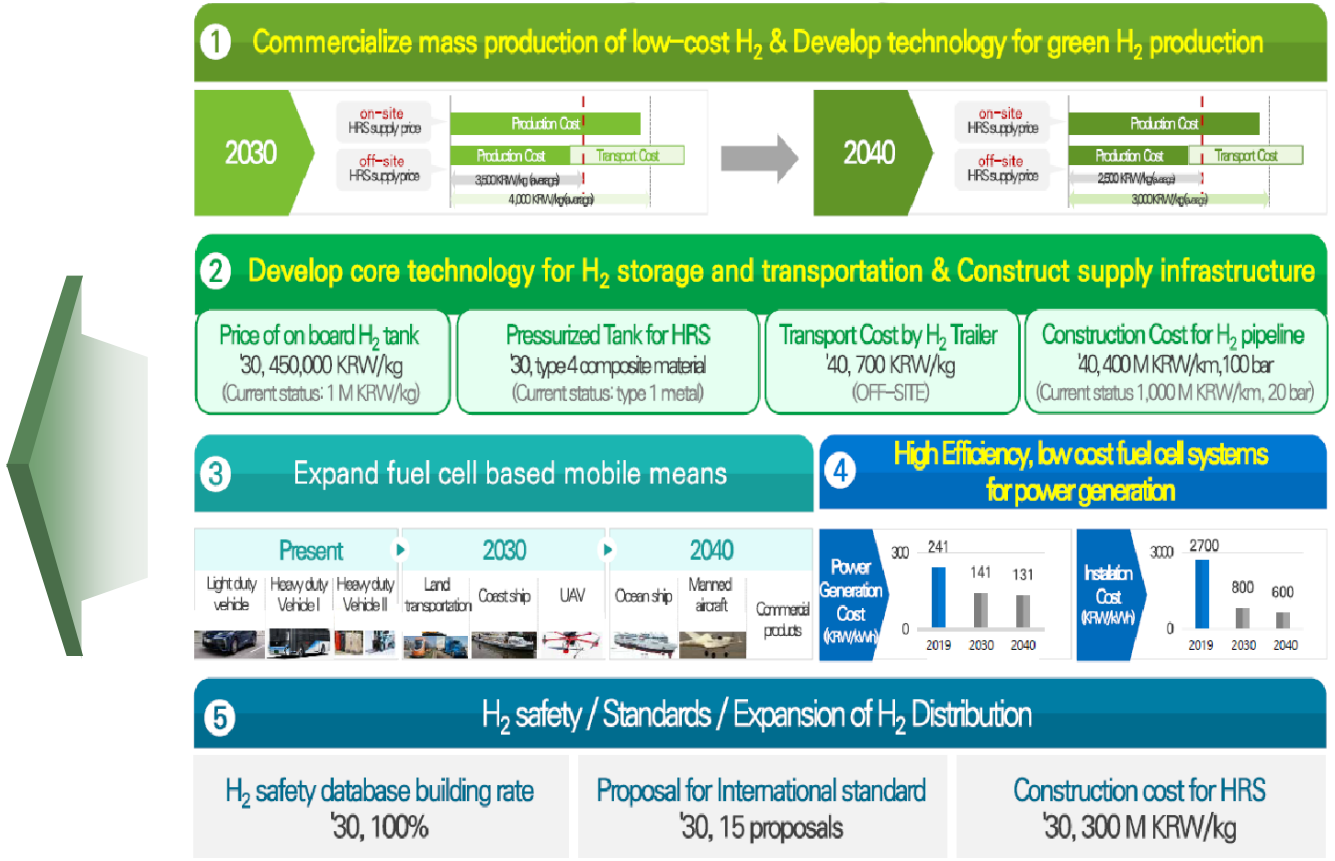
Hydrogen Technology Roadmap (2019)

- Leading "Hydrogen Economy " driven by Innovative Scienc e and Technology.
- Development strategies are prepared for selected 5 core technical fields for "Hydroge n Economy"
  - Production, Storage & Trans portation, Mobility Utilizatio n, Stationary Utilization, Saf ety & Infrastructure



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NDC and Carbon Neutrality Scenario

	NDC (Nationally Determined Contribution)	SCENARIO (Carbon Neutrality Scenario)	
Aiming Year	2030	2050	
		Plan A	Plan B
Target of Hydrogen	- CO2: 40% Reduction (~291Mton CO2) - Amount of H2 : 194 Mton ・Electricity : 157 Mton ・Mobility : 37 Mton ・Electrolysis : 24 Mton ・Reform : 77 Mton ・Import : 93 Mton	- CO2: Neutral - Amount of H2 : 2,740 Mton ・Electricity : 1,420 Mton ・Industrial : 1,060 Mton ・Mobility : 150 Mton ・Electrolysis : 550 Mton ・Reform : - ・Import : 2,190 Mton	- CO2: Neutral - Amount of H2 : 2,790 Mton ・Electricity : 1,350 Mton ・Industrial : 1,060 Mton ・Mobility : 150 Mton ・Electrolysis : 300 Mton ・Reform : 100 Mton ・Import : 2,290 Mton

[출처: 국립 환경과학원]

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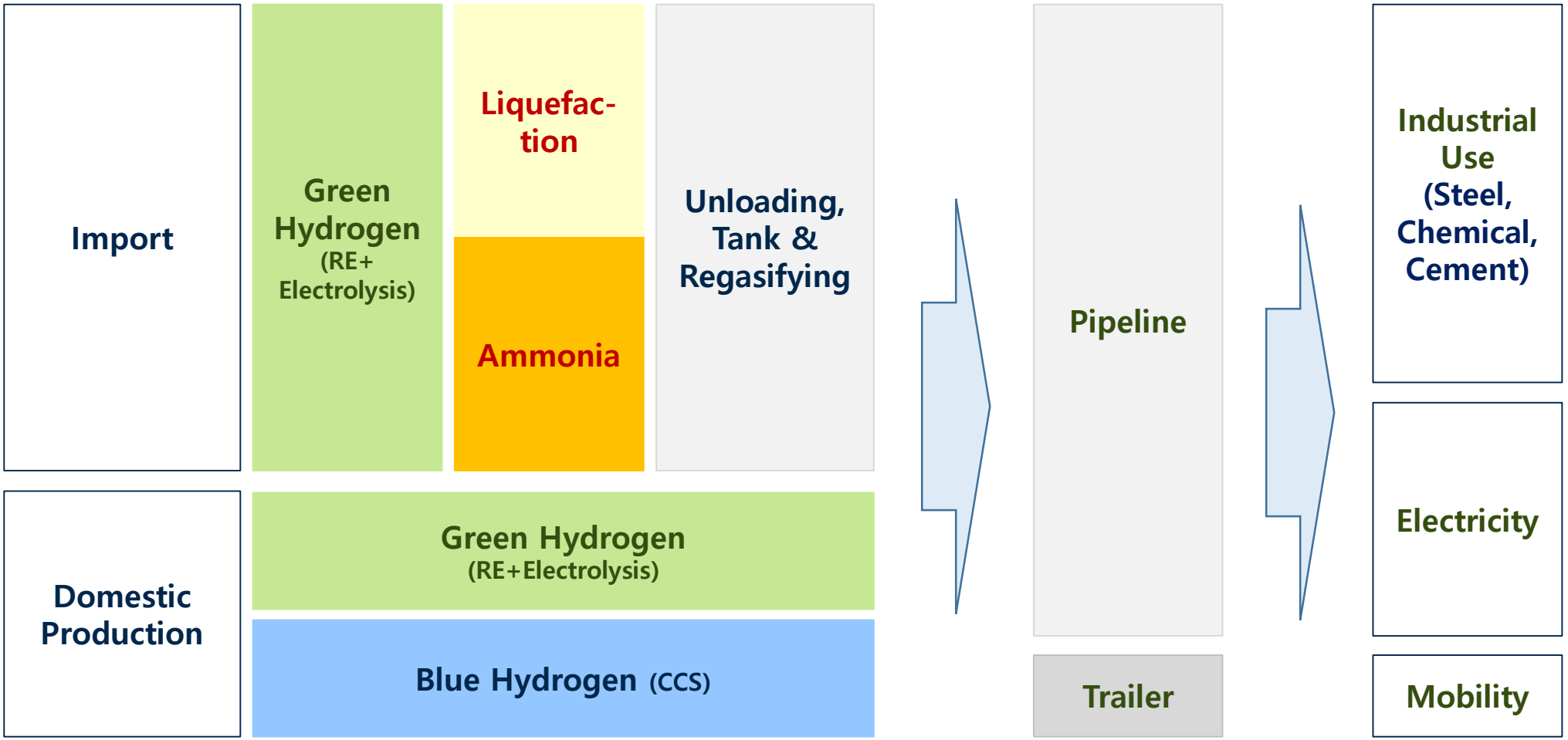
Future Hydrogen Supply Chain



* 2018년 국내 Energy Balance Flow (교본 중 '탄소중립과 수소경제'에 '우리나라의 에너지 소비' 내) 참고

Highlight in Deployment

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Mobility

- Passenger Cars : 10,100
- Buses : 180
- HRS : 100

Stationary

- Large (>100kW) : 584 MW
- Small (<100kW) : 25.2 MW

Highlight in R&D

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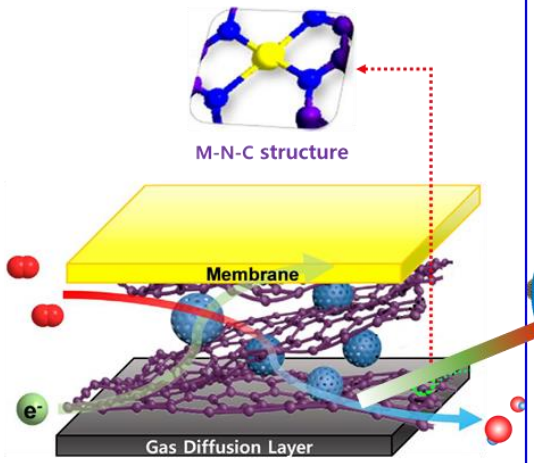
Materials Development - Catalysts

1 Improvement of MEA electrode structure



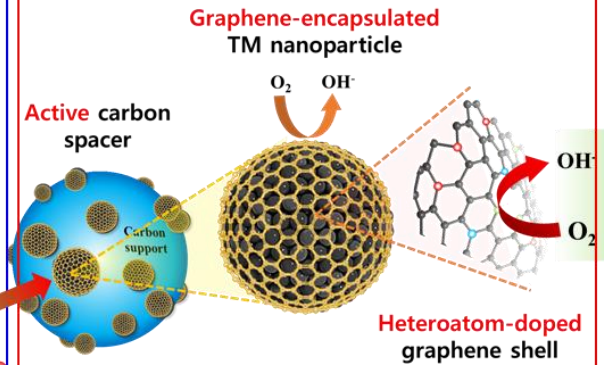
Overcoming the limitation of MEA electrode structure composed of M-N-C catalyst

(1) Insufficient active points & excess catalyst usage (increased thickness)

(2) Form catalyst layer densely on Planar catalyst structure

Nano Energy, **2016**, 26, 496.
Advanced Energy Materials, **2018**, 8, 1801002.
Chemistry of Materials, **2018**, 30(1), 2.
Small, **2019**, 15(36), 1902090.

2 Development of nano graphene spacer with high activity and high specific surface are



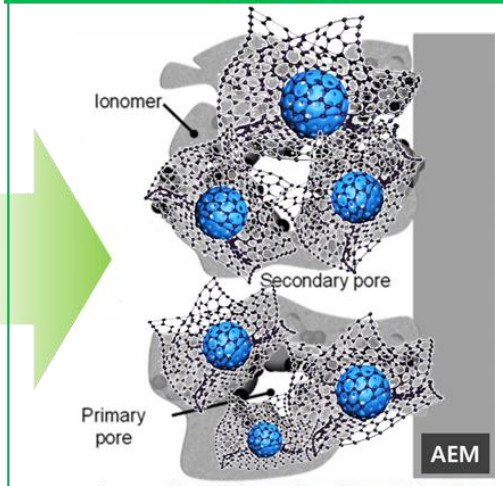
Hybrid of highly active nano-graphene coated non-noble metal nanoparticles and high surface area carbon support

(1) Development of highly active n-type nano-graphene catalyst structure

(2) Formation of electrode layer pore structure utilizing porous carbon structure

Energy & Environmental Science, **2019**, 12, 2200.
Applied Catalysis B: Environmental, **2020**, 260, 118192.
ACS Catalysis, **2017**, 7(9), 5796.

3 Development of high performance and high durability multi-scale electrode layer structure



Design of multi-scale electrode layer composed of M-N-C & nano-graphene spacer

(1) M-N-C/spacer/Ionomer binding optimization

(2) Optimized electrode layer pore structure and ink composition

⇒ Performance improvement by controlling the structure of the electrode layer
⇒ Improved durability through strengthened combination of components
⇒ Maximize MEA performance and durability

ACS Applied Materials & Interfaces, **2019**, 11(31), 27735.
ACS Sustainable Chemistry & Engineering, **2019**, 7, 15487.

Highlight in R&D

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Cells and Components

- Water generation at anode of anion exchage membrane fuel cell
- Water generation at cathode of cation exchage membrane fuel cell
- Simutaneous water formation at anode and cathode during fuel cell operation
- Fuel cell operation under non-humidified condition

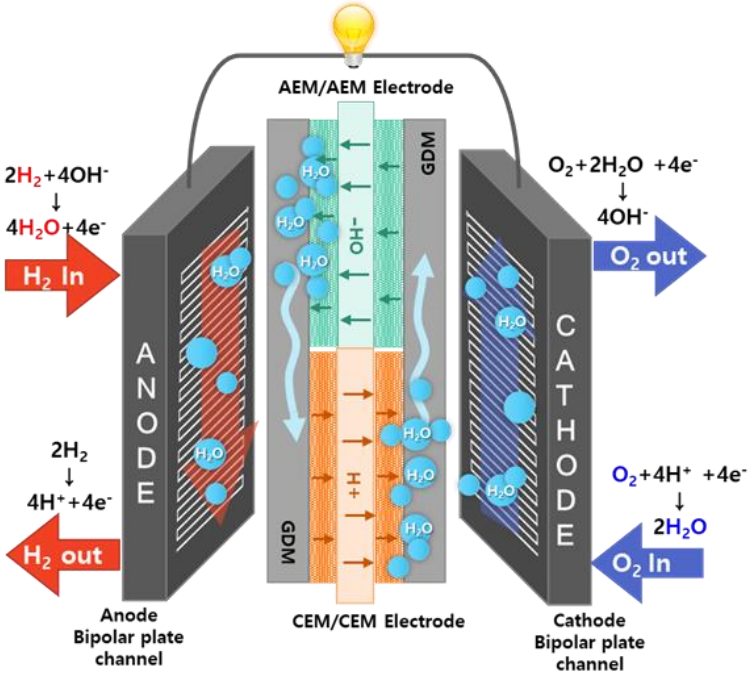

Fig. Schematic diagram of the DEMFC (C50A50)

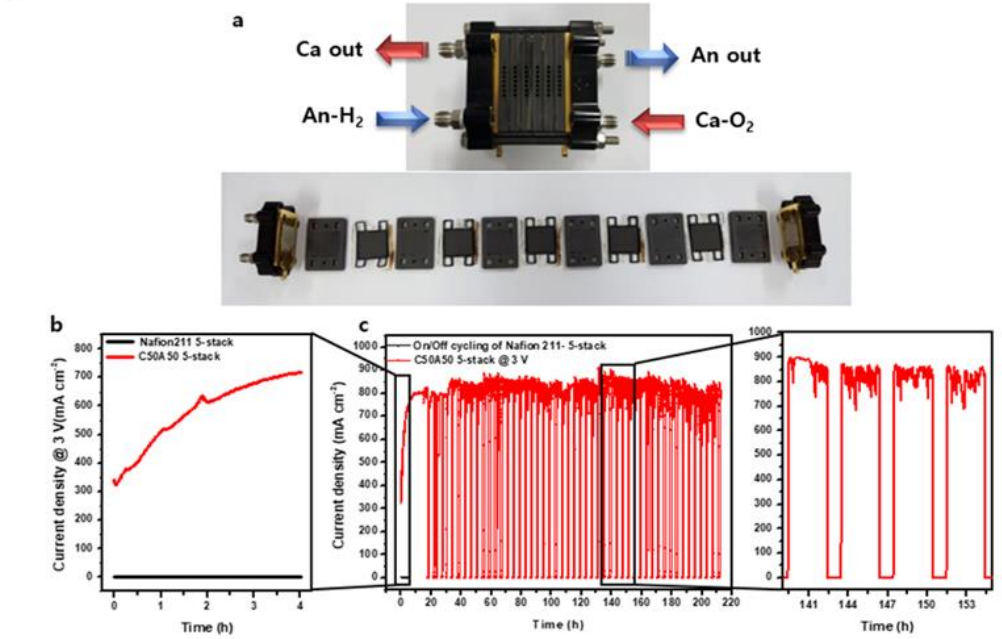

Fig. (a) Image of the five-cell stack. (b) Performance comparison of C50A50 and Nafion® 211 five-cell stacks, and (c) Accelerated on/off durability test of the C50A50 stack using dry H_2/O_2 (on: constant operation at 3 V for 3 h) and dry N_2/N_2 (off: 1 h).

Highlight in Demonstrations

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Taxies and Trucks

- 20 Taxies in Seoul area (2020)
- Target :
  - 100,000km (2020) → 500,000 km(2025)
- 50 Trucks in preparation (2020)

Highlight in Demonstrations

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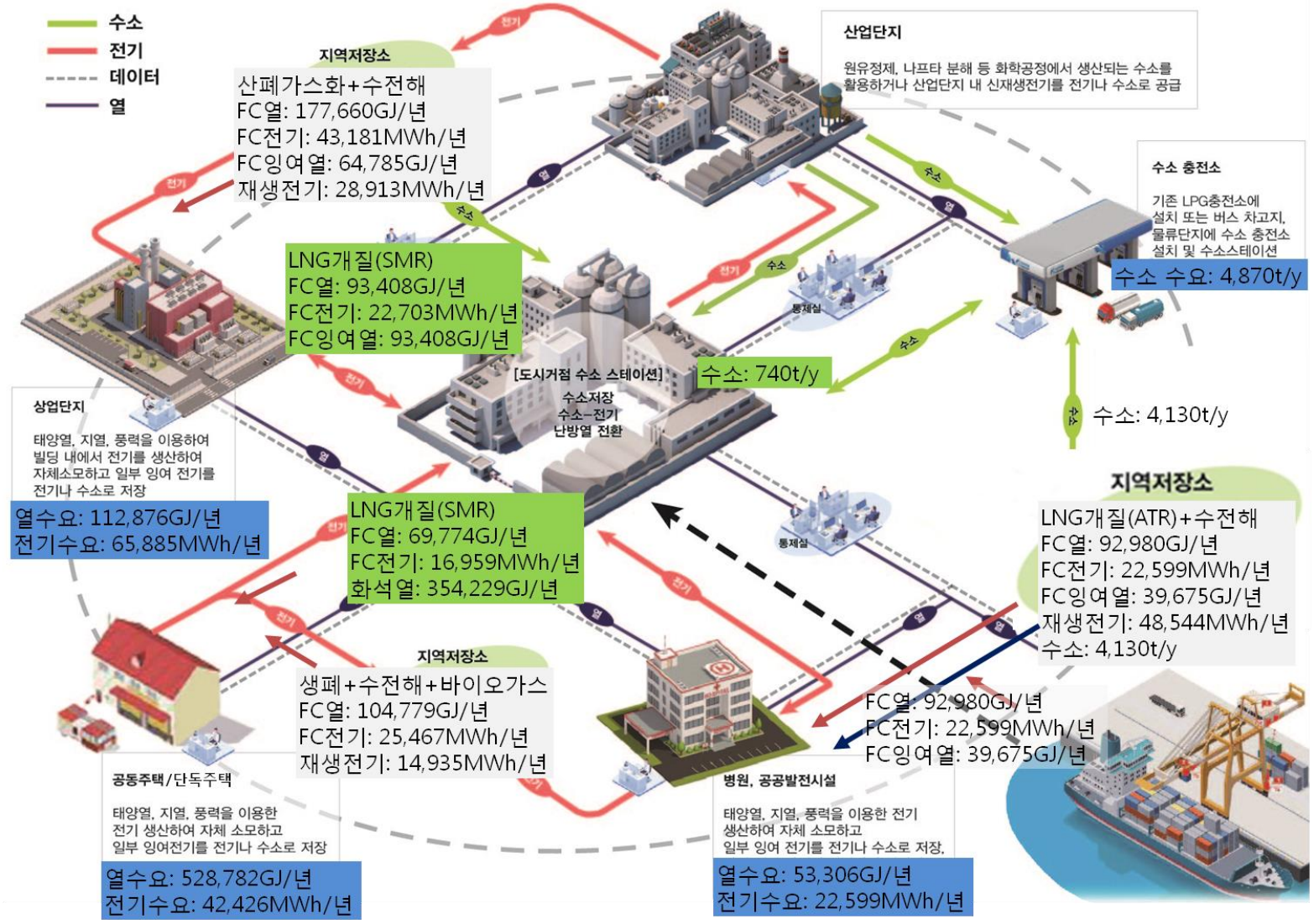
Hydrogen Cities

송도 신도시급 규모, 수소E 대체율: 20%, FC총괄효율: 90%(전기42%, 열48%), 수전해 O_2: O_2 8톤/ H_2 1톤, 미활용 전력: 10.4%



Highlight of New Products

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LH2 Mobile HRS

- Mobile HRS using LH2 (Hyrium)
  - Storage Capacity :1,500-7,500L (3atm)
  - 800 atm pump system

Drones

- Doosan, Hyrium
  - 69km (1hr43min.) flight
  - 10.8L, 7L compressed H_2, or LH

Activities in Private Sector

Plans for Hydrogen

	Plans
SK	• Luiqefaction Plant, Fuel Cells Power Generation
Hyundai Motors	• FCV Production Facility, HRS
POSCO	• Ammonia Terminal, Hydrogen Reduction Steelmaking
Hanhwa	• Electrolysis, H2 Turbines
Hyosung	• Luiqefaction Plant, HRS
Small Others	• Electrolysis, Reforming, Materials for Hydrogen

Possible Collaboration Topics

R&D Collaboration

- Universities and National Labs. Focuses on Basic R&D, on Materials, Cells and Components for Hydrogen Production-Storages-Applications.
- Private Sector Invests Large Resources on Building Infrastructure such as Liquefaction Plant, Ammonia Combustions, Loading Ship for LH2 and Ammonia, New Applications such as mobilities.

Collaboration in Demonstration

- Hydrogen Import Process : Production (Green) – Liquefaction – Loading- Ship- Unloading- Regasfying-Delivery-Application
- Analysis of Sector-Coupling

Newly Founded KENTECH

Energy Specialized College

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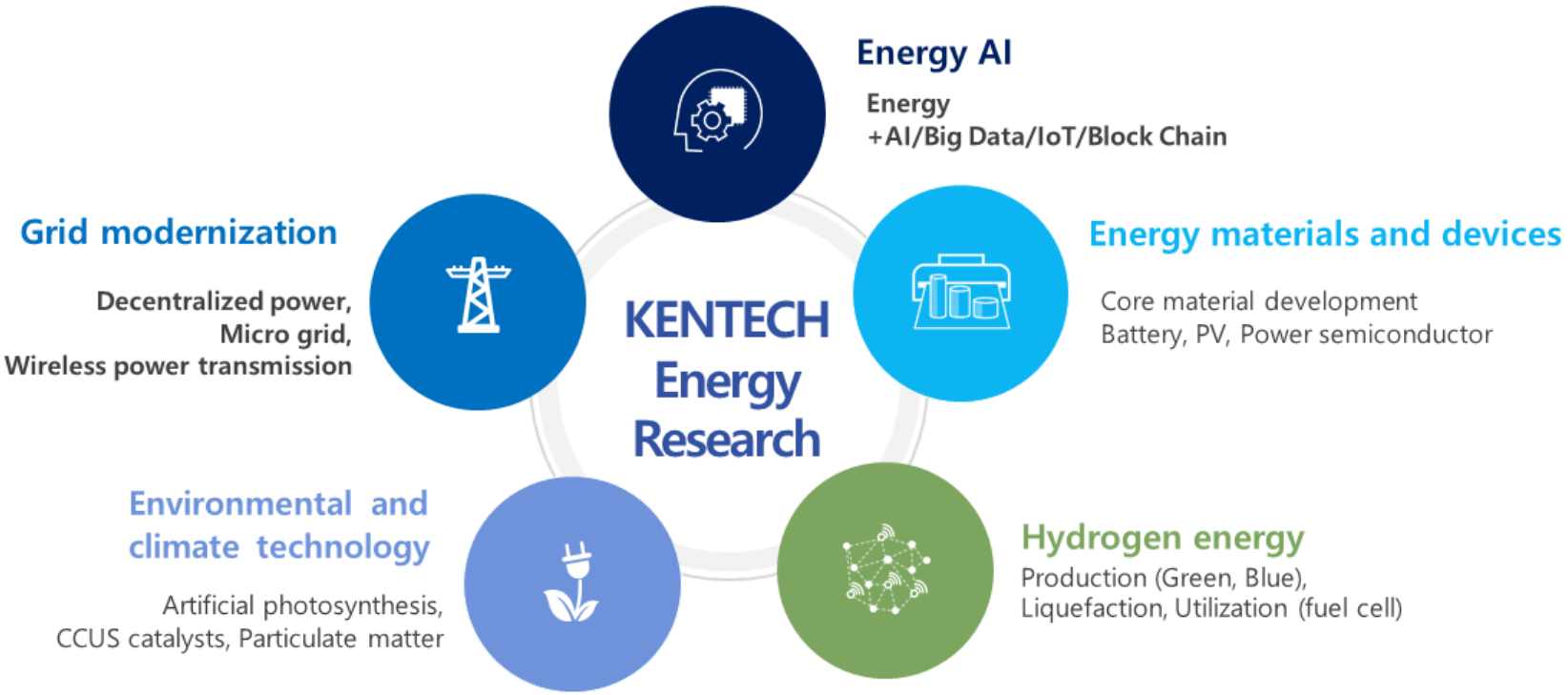
Five research area of KENTECH



Newly Founded KENTECH

Hydrogen Energy Institute

Faculty members and expertise

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Prof. Chinho PARK

- Photoelectrochemical (PEC) Systems
- Green Hydrogen Production
- Thin Film Solar Cells
- Electronic Materials Processing
- Inorganic Thermodynamics
- Computational Fluid Dynamics

Prof. Jonghee HAN (Director)

- Molten Carbonate Fuel Cells (MCFC)
- Molten Carbonate Electrolysis (MCEC)
- Hydrogen Purification Metallic Membranes
- Membrane Reactors

Prof. Chang Hee KIM

- Green Hydrogen Production
- Alkaline & PEM Electrolysis
- Electrochemical Engineering

Prof. Jihyun HWANG

- Hydrogen Liquefaction
- Hydrogen Synthesis (Ammonia, Methanol)
- LOHC
- Hydrogen Supply Chain Optimization
- Process & Mechanical Development & Engineering
- Simulation - Lab-Scale - Pilot Scale

Prof. Young Duk Lee

- SOFC based hybrid power generation
- Methane decomposition (Turquoise H_2)
- System and reactor design using process simulation and optimization
- Economic analysis, Life cycle assessment

New faculty members

- Material development for polymer, membrane, ceramic powder, catalyst, electrode, etc.
- Scientific computing
- Sector coupling and optimization

Thanks for Your Attention!