Hydrogen Economy Roadmap of Korea

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Chinho Park

Professor/Director, Hydrogen Education & Research Consortium, Yeungnam University, Korea

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Part 1. Korea’s Energy Transition and Innovation Strategy

Paradigm Shift in Global Energy Industry

Deep Global Trends

Industrialization & Urbanization
Greater Global Connectivity
Digitalization (A ICBM)
Stronger Commitment to Environment

Shale Revolution & Climate Change

Change in Geopolitical Landscape

↕

Crisis in Global Energy Market?

Start with..

Potential "Game Changers"

Advanced Energy Acceleration
Mobility Revolution
Energy System Fragmentation

Which lead to..

*Source: McKinsey & Company, World Economic Forum White Paper, 2017

Opportunities Arising from a Revolution

DECARBONIZATION

DECENTRALIZATION

DIGITALIZATION & DEMOCRATIZATION

Destruction?

Dr. John Murton (UK's COP26 Ambassador, Feb. 20, 2020)

"Green growth and economic growth are mutually win-win. With increased investment in green growth, the transformation of the global industrial structure are taking place very rapidly. How well prepared and ready to change will determine the fate of enterprise and nation."

Basic Principles

Enhance Citizens' Wellbeing as well as Maintain Sustainable Growth through Energy Transition

Revamp Energy Consumption Pattern

Transform Towards Cleaner & Safer Energy

Expand Distributed & P2P Energy Systems

2040 Renewable Electricity Target: 30~35%

Strengthen Global Competitiveness of Energy Industry

Build New Infrastructure for Energy Transition

Innovative Growth Strategies in Energy Industry

Restructure Energy Mix Portfolios (Towards New Climate Regime)

Enhance **Energy Efficiency** & Create **New BMs** (Via Digitalization & A ICBM)

Revitalize Core Energy Industries (Via Export-oriented Market Expansion & New Industry Development)

Confront **Air Pollution & Nuclear Safety Issues** (For Citizen's Well-being)

As-Is Major Industry Supporter

To-Be New Growth Engine Industry

Soft Landing via Synergy?

Solar	⟺	Semiconductor/Display
Wind	⟺	Ship Building/Steel/Marine
Hydrogen	⟺	**Automobile/Steel/Petrochemical**
Gas Turbine	⟺	Aerospace/Nuclear/Coal
Micro-grid	⟺	Battery/Power Electronics/System IC

Part 2. Korea’s Hydrogen Economy Roadmap

I. Current Status of Hydrogen Economy in Korea

Production

- **Production (2017) : 2.2 Mton**
  - Oil refining process : 75%
  - Naphtha cracking : 13%
  - LNG reforming (SMR) : 7%, and others

- **External circulation (2017) : 0.25 Mton**
  - Pipeline : 88% (200 km*)
  - Tube trailer : 12% (500 T/T)

Utilization

- **FCEV Domestic Dissemination (2019F)**
  - Passenger cars : 5,058 units; Buses : 15 units; Taxis : 10 units
- **Hydrogen Refueling Station (2019F) : 54 Stations**
- **FCEV(passenger car) Export (May 2019) : 1,288 units**
- **Fuel Cell for Power Generation (2019F)**
  - Power Plants : 397 ㎿
  - Fuel Cell for Domestic Buildings : 7.1 ㎿

*LNG pipeline : 4,857 km

II. Hydrogen Economy Roadmap of Korea

Vision

▪ **To Become the World's Top-Class Country in Hydrogen Economy**

'18 → **'22** → **'30** → **'40**

Entering H_2 Economy

- Create H_2 industry ecosystem
- Establish infrastructure
- Establish law & institution

Developing H_2 Economy

- Enlarge H_2 utilization
- Large-scale production of H_2

Leading H_2 Economy

- Oversea H_2 production
- Water electrolysis by RE
- CO_2-free H_2 system

II. Hydrogen Economy Roadmap of Korea

Goal

	'18	'22	'30	'40
FCEV	▪ 1,800 (domestic 900)	▪ 81,000 (domestic 67,000)		▪ 6.2 mil. (domestic 2.9 mil.*)
Hydrogen Station	▪ 14	▪ 310		▪ 1,200
Fuel Cell Power Generation**	▪ 307 ㎿ (250 KRW/kWh)	▪ 1.5 ㎓ (domestic 1.0 ㎓)		▪ 15.0 ㎓ (domestic 8.0 ㎓)
Hydrogen Supply	▪ 130 kton - By-product H_2 - SMR H_2	▪ 470 kton (<6,000 KRW/kg***) - **Water electrolysis** - By-product H_2 - SMR H_2	- **Overseas import** - Water electrolysis - By-product H_2 - SMR H_2	▪ 5,260 kton (<3,000 KRW/kg)

*Includes FCEVs for 80,000 taxis, 40,000 buses and 30,000 trucks
**Includes additional 2.1 GW for residential/commercial use by 2040
***~50% of the current oil price in Korea

II. Hydrogen Economy Roadmap of Korea

Strategies for Value Chains

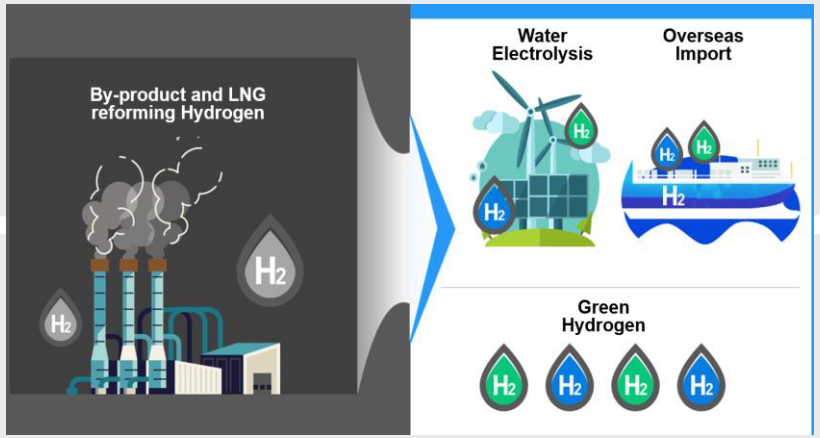
Production

Green Hydrogen

- Development of efficiency improvement technology for water electrolysis
- Development of long-term storage technology for high capacity hydrogen

Overseas Import

- Construction of H_2 receiving terminal for imported hydrogen
- Development, demonstration and commercialization of liquified H_2 Carrier



Storage and Transportation

- Development of hydrogen liquefaction technology
- Development of technology for liquefied plant, tank and related parts
- Transition from high-pressure gas transport to liquid and/or liquefied carrier transport

II. Hydrogen Economy Roadmap of Korea

Strategies for Value Chains

Utilization

FCEV	▪ Expansion of production capacity of hydrogen car (* 2025 : 100 thou. units/year) ▪ Development of technology for reducing price and improving durability of core components ▪ Increase of the supply of hydrogen taxis, buses, trucks and special vehicles
Ship	▪ Development and demonstration of fuel cell systems for ships ▪ Full-scale dissemination : (coastal ships) from 2027, (ocean liners) from 2030
Train	▪ Gradual replacement of diesel trains by hydrogen trains ▪ Demonstration after technology development until 2022
Power Generation	▪ Development of core technology and expansion of fuel cell power supply ▪ Development and commercialization of hydrogen gas turbine power generation technology in the medium to long term
Hydrogen City	▪ Construction of hydrogen city by applying technology, products and systems using hydrogen

III. Promotion Plan

Enacting Hydrogen Law (passed, January 9th, 2020)

- Preparing Promotion System and Comprehensive Planning System
- Establishing Hydrogen Safety Management System

Preparing Roadmap for Technology Development

- Green Hydrogen Production, Liquification, Carbon Dioxide Capture and Use
- Fuel Cell, Hydrogen Utilization

Infrastructure Building

- Building Hydrogen Filling Station and Hydrogen Production Base
- Building Hydrogen Acquisition Base
- Constructing Hydrogen Industry Clusters and Hydrogen Cities

IV. Representative Applications in Korea

National Assembly
Hydrogen Station

Hyundai Hydrogen-Powered Car
Nexo

IV. Representative Applications in Korea

Seoul Noel Park (near World Cup Park)
LNG Fuel Cell PJT (POSCO Energy)

Daesan Hanwha Total Petrochemical
Hydrogen Fuel Cell PJT (Doosan)

2020 Plan of Ministry of Trade, Industry & Energy on Hydrogen

- **(Commercial Vehicle) Small-size Electric Truck, Mid to Large-size Hydrogen Truck**
  - **10 ton Hydrogen Truck Manufacturing & Export** (2020~2025, 1,600 Trucks for Switzerland),
    Cargo Truck for Postal Service (2020, 1,000 Trucks)
  - Initiate Tech Development for Manufacturing Sweeping Vehicles, Special Vehicles, etc.

- **(Win-Win Cooperation) Mobility Alliance → Vitalization of Future Mobility Service Industry**
  * Participants : Automaker, Parts Supplier, IT Company, Insurance Company, Telecom Company, Game Company
  - **Cooperative Manufacturing of Hydrogen Buses by Large Companies and SMEs** → Market Penetration

- **(Infrastructure Building) Mobility Alliance → Hydrogen Industry Clusters, Hydrogen Cities**
  - **Hydrogen Industry Clusters :** Regions to foster R&D cooperation between knowledge institutes, companies and organizations. These regions will be testbeds for demonstrating newest technologies.
    (Planned by Ministry of Trade, Industry and Energy, and selected 5 candidate regions on Dec. 15, 2019)
  - **Hydrogen Cities :** Cities using hydrogen as the fuel for cooling, heating, electricity and transportation
    (Planned by Ministry of Land, Infrastructure and Transport, and selected 4 cities on Dec. 29, 2019)


First Mass-production
Exported to Switzerland
34 ton; 7 H_2 tanks (32 kg H_2);
190 kW fuel cell; 476 hp;
8 min charging time for 400 km
First 10 Hyundai XCIENT Hydrogen Trucks
YTN
NEWS

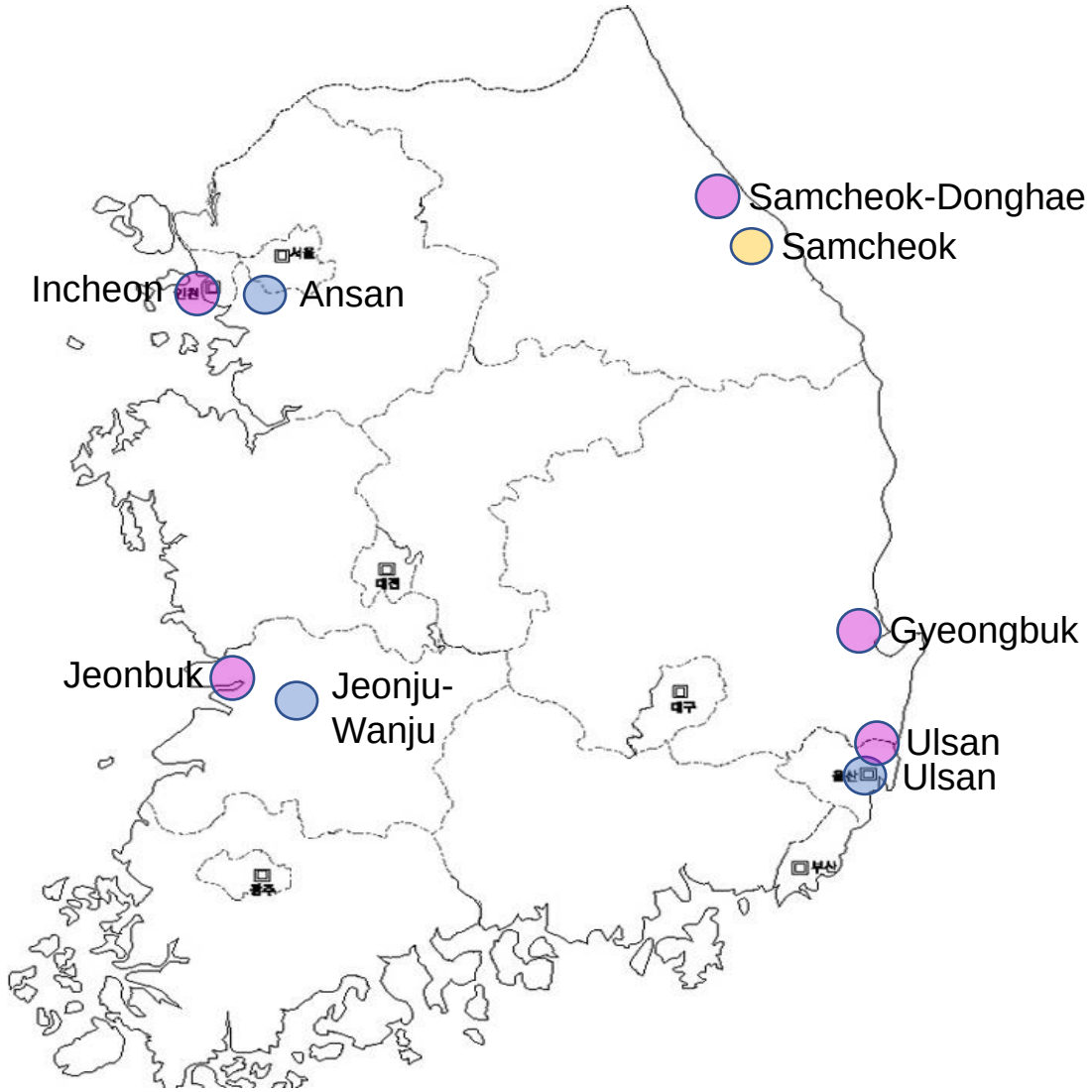
New Concept Hydrogen Truck - Neptune

VI. Hydrogen Cities and Hydrogen Industry Clusters in Korea

Hydrogen Pilot City by 2022

Hydrogen R&D Specialty City by 2022

Hydrogen Industry Clusters from 2021
- Incheon : Hydrogen Production
- Jeonbuk : Hydrogen Production
- Samcheok : Hydrogen Storage/Transport
- Ulsan : Hydrogen Mobility
- Gyeongbuk : FC Power Generation/H_2 Terminal



The 4th Energy Technology Development Plan_(December, 2019)

New Industry in Energy

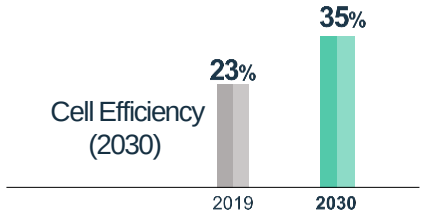
Renewable Energy (PV & Wind) and Hydrogen Economy Development

Materials & Parts Development for Global Value Chain Risk Management

< R&D Strategies >

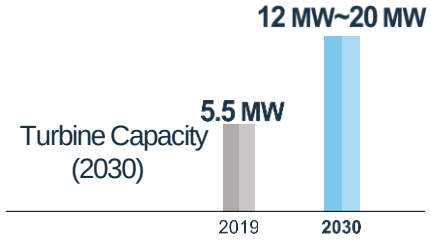
PV

Cost Reduction & High Efficiency (Crystalline Si);
Ultra-high Efficiency (Next Gen PV)

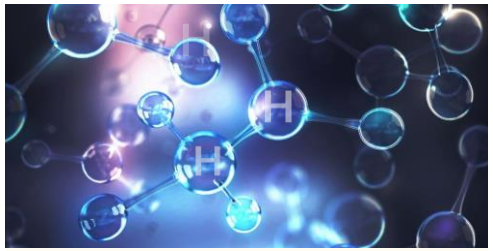


Wind

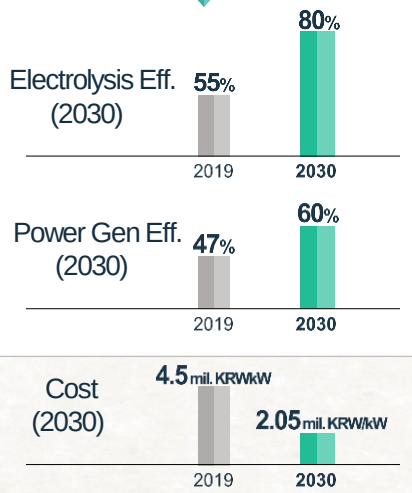
Core Parts Localization; Ultra-high Cap. Off-shore Wind Development;
Turbine & Floating Wind Development



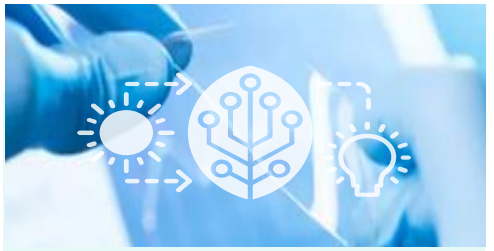
Hydrogen



Green H_2 Production; Large Cap. Storage &Transport; Efficiency & Durability Improvement



New Materials



Localization of Core Materials;
Enlargement of Industry Applications

*(Localization Items)

- Fuel Cell MEA, Separator
- Catalyst & Electrode Materials
- Metals for Gas Turbine
- Nuclear Shielding Materials

*(Next Generation Items)

- Post-Li Materials
- Materials for Secondary Battery
- Materials for Electrolysis
- Light-weight Materials for PV

Korean New Deal Plan was announced on July 14th 2020, and included,

Total 160 Bill. USD will be invested till 2025, and 1.9 million jobs will be created in three major areas: Digital New Deal; Digital-Green Convergence; Green New Deal.

Green New Deal projects include **1) Green Remodeling, 2) Green Energy, and 3) Eco-friendly Future Mobility – 73 Bill. USD, 650,000 jobs**

Digital-Green Convergence projects include **1) Green & Smart School,** 2) Digital Twin, 3) Digitalized SOC for Safety, and **4) Smart & Green Industrial Complex.**

International Energy Agency's General Secretary, Dr. Faith Birol, stated,

"Hydrogen is today enjoying unprecedented momentum, driven by governments that both import and export energy, as well as the renewables industry, electricity and gas utilities, automakers, oil and gas companies, major technology firms and big cities."

"The world should not miss this unique chance to make hydrogen an important part of our clean and secure energy future."