

Current Status of Clean Energy Technologies in KIER

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1. Introduction

Korea has seen rapid economic and technological advancements over the last three decades. At the same time, the country has found itself struggling with the implementation of eco-friendly energy policies. In the year 2017, the country's share of renewable energy was only 7%. However, with the 3rd National Basic Energy Plan announced in June 2019, directions for clean energy policy have been formulated, such as increasing the share of renewable energy to 35 percent by 2040.

The 3rd National Basic Energy Plan involves the five goals of 1) Innovation in the energy consumption structure, 2) Transition to a clean and safe energy mix, 3) Building a decentralized and participatory energy system, 4) Strengthening the global competitiveness of the energy industry, and 5) Building a foundation for the energy transition. As a country with high R&D expenditures, Korea has the potential to accelerate its own clean energy technologies while staying competitive in an increasingly global market. And as a government research institute conducting energy and environment R&D, the Korea Institute of Energy Research (KIER) has been at the forefront of energy technology innovation as it proactively addresses climate change and sustainable environment issues through its MTP (Massive Transformative Purpose), 'Below 1°C to Keep the Earth Livable!'.

2. R&D activities related to clean energy technology

As a member country of the Mission Innovation (MI) that was initiated at COP21 on November 30, 2015 to double public R&D investment in clean energy technology within five years, Korean government ministries organized the MI Committee and jointly announced a strategy for the development of clean energy technologies in the following year. It has chosen new and renewable energy, efficiency improvement, energy storage system, carbon capture utilization and storage, nuclear safety, and smart grid as its six primary technology fields. Since its establishment in 1977, KIER has been conducting R&D in all of these fields except nuclear and has played a very important role as a hub for energy and environment R&D and demonstration projects as a leader in the energy transition.

In July of 2019, KIER re-established its three main R&Rs (Roles and Responsibilities) after year-long meetings with all employees in order to realize its MTP. The three main R&Rs are: 1) Building a clean and safe energy world by developing new and innovative renewable energy technology innovations, 2) Constructing a smart energy society by developing a high-efficiency energy system and innovative energy materials, and 3) Reducing fine particle pollution and greenhouse gas emissions by developing integrated clean energy technologies.

KIER has the nation's largest scale R&D infrastructure for hydrogen fuel cell technology demonstrations at its Buan campus, and Jeju Global Research Center (JGRC) has been developing convergence technologies in the fields of on/off shore wind turbines, micro-grids, and salinity gradient power generation, all of which take advantage of the local characteristics of the carbon free island, Jeju.

Jeju Global Research Center, KIER (JGRC)



3. Specific research activities in hydrogen, CCUS, and related technologies

CO₂ capture and utilization (CCU) technologies have been in development ever since KIER was established. Today, KIER demonstrates its CO₂ capture technology (KIERSOL) to 200 Nm³/h in a coal-fired thermal power plant in Montana, USA with a CO₂ recovery rate of over 90% and a reboiler heat capacity of 2.0 GJ/tCO₂, and then full-chain CO₂ capture and storage (CCS) will be done in Montana. KIER is also engaged in the development of key technologies for the production of associated fuels and chemicals using captured CO₂. Methanol, DMC or formic acid may be the most advantageous alternatives in terms of energy density, transport and marketability. KIER is currently developing catalysts for both that have high activity and selectivity, systems with dehydration during the reaction for the synthesis of C₂ to C₄ alcohols including methanol and DMC, and is developing a low-power catholyte-free CO₂ conversion system for the production of highly-concentrated formic acid.

- CCS Overseas Demonstration and Development of Core Technology Upgrading CO₂ Conversion Efficiency Project / 1.0 ton-CO₂/day full chain CCS Demonstration / Low-power catholyte-free electrochemical conversion / Development of future innovative CO₂ capture sorbent (2017-2021)

Each country is trying to develop clean coal technology (CCT) since it has become more significant to convert coal into clean energy and higher added value products with lower emissions of environmental pollutants. Coal gasification technology is one of the most important platforms for CCT utilization. It provides an opportunity to add value to coal by converting it into higher value-added materials (e.g., Hydrogen, electricity, chemicals, and liquid fuel).

- Development of Clean Fuel and High Value-Added Technology Using Low-Grade Fuels (2017-2021)

Hydrogen and fuel cells are also KIER's main R&D areas over the last few decades. For hydrogen production R&D, natural gas reforming, ammonia cracking and water electrolysis are the sub-areas of KIER involved in the production of high purity hydrogen. Solid hydrogen storage materials using metal alloys and complex metal hybrids are also R&D areas for hydrogen storage. For fuel cell R&D, the sub-areas are developing core materials and building

all types of systems such as distributed power generation, fuel cell vehicles, IT/portable power and APUs.

- Design of a cost-effective and highly efficient pressurized modular hydrogen production unit for on-site hydrogen supply (2017-2022)
- Development of large-scale alkaline water electrolysis cells and stack under dynamic operation (2019-2021)

4. International collaboration

4-1 International alliance/networking development

KIER has designed a global R&D strategy process to enhance co-beneficial international R&D projects. The fundamental approach for the process is to build up networks with international R&D institutions through collaborative agreements, workshops and personal exchanges. The accumulated experiences, information, lessons learned from these collaborations strengthen the strategic relationships between global communities and eventually enable us to develop the world's best energy technologies.

International Collaboration Strategy Concept



4-2 International joint R&D activities

According to the global R&D strategy process, KIER has categorized and supported global R&D projects in three phases. The building networks phase is to hold international conferences for exchanging expertise and personnel, thereby laying a foundation for global cooperation. The planning phase is a level of preparation prior to the R&D phase, and involves things such as the development of R&D concepts and feasibility studies for projects. The joint R&D phase consists of matching fund R&D financed by each entity, and demand oriented R&D where KIER supports both entities.

(Building networks phase)

- The 12th Korea-China Clean Energy Workshop (Jeju Island, 2018)

- The 9th KIER-GIEC, CAS New and Renewable Energy Workshop (Jeju Island, 2018)

(Planning phase)

- KIER-NETL Joint International R&D Plan for Global Project Development

(Joint R&D phase)

- KIER-CSIRO joint R&D for development of porous carbon-supported catalysts
- Thin single crystalline Si wafers by multi-wire sawing using electric discharge (Fraunhofer CSP)
- Model electrode study for electrochemical energy systems by combining theoretical and experimental insights (Harvard University)
- Functionalized Biomass Materials for Advanced Energy Conversion and Storage Application (University of Oxford)

5. Future perspectives

Korea will continue to work hard to achieve the goals of the 3rd National Basic Energy Plan. Continuous interest and cooperation from G20 members are expected. KIER is now developing a long-term development strategy to achieve the MTP by 2050. KIER would like to have the opportunity to listening to the opinions of our RD20 partners on establishing an R&D strategy in the near future. Global R&D strategizing may help each partner institution respond to future challenges by providing a platform or place for knowledge sharing. KIER welcomes international collaboration with the RD20.

Profile of Vice President of KIER

Dr. Yong-Seog Seo



Education

1983 Bachelor in Mechanical Engineering, Ajou University

1984 Master in Mechanical Engineering, KAIST¹⁾

1993 Doctorate in Mechanical Engineering, KAIST

1) KAIST : Korea Advanced Institute of Science and Technology

Career

2018-2019 Vice President, Korea Institute of Energy Research

2018-2019 Advisory Board of Energy Technologies, Ministry of Trade Industry and Energy

2016-2018 Director of Energy Efficiency Technologies and Materials Science Division,
Korea Institute of Energy Research

2011-2015 Director of New and Renewable Energy Division,
Korea Institute of Energy Research

2012-2013 Advisory Board, Daejeon Science & Technology Commission

¹ Korea Advanced Institute of Science and Technology