# Energy Technologies from KIER for 1℃ Below

한국에너지기술연구원
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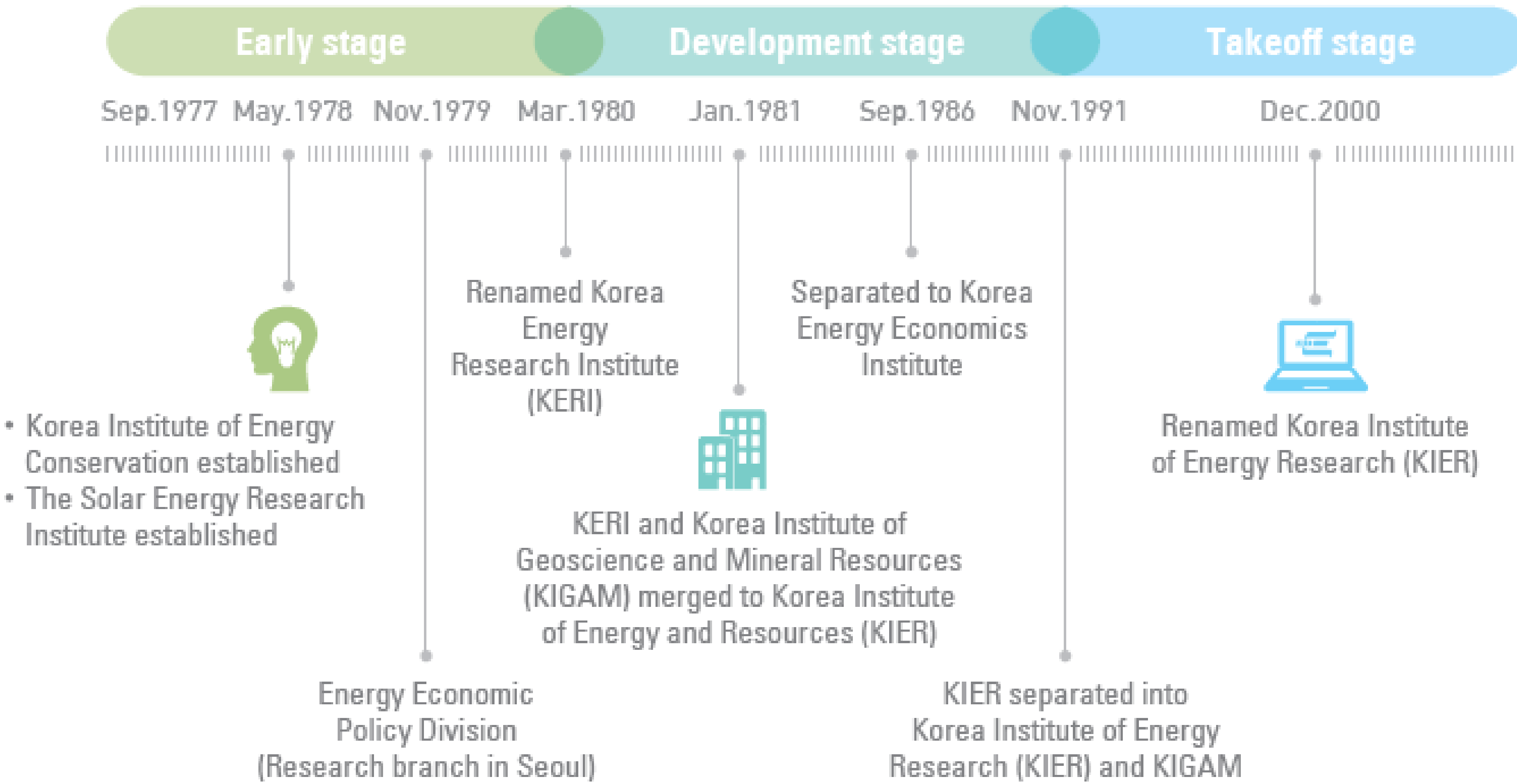
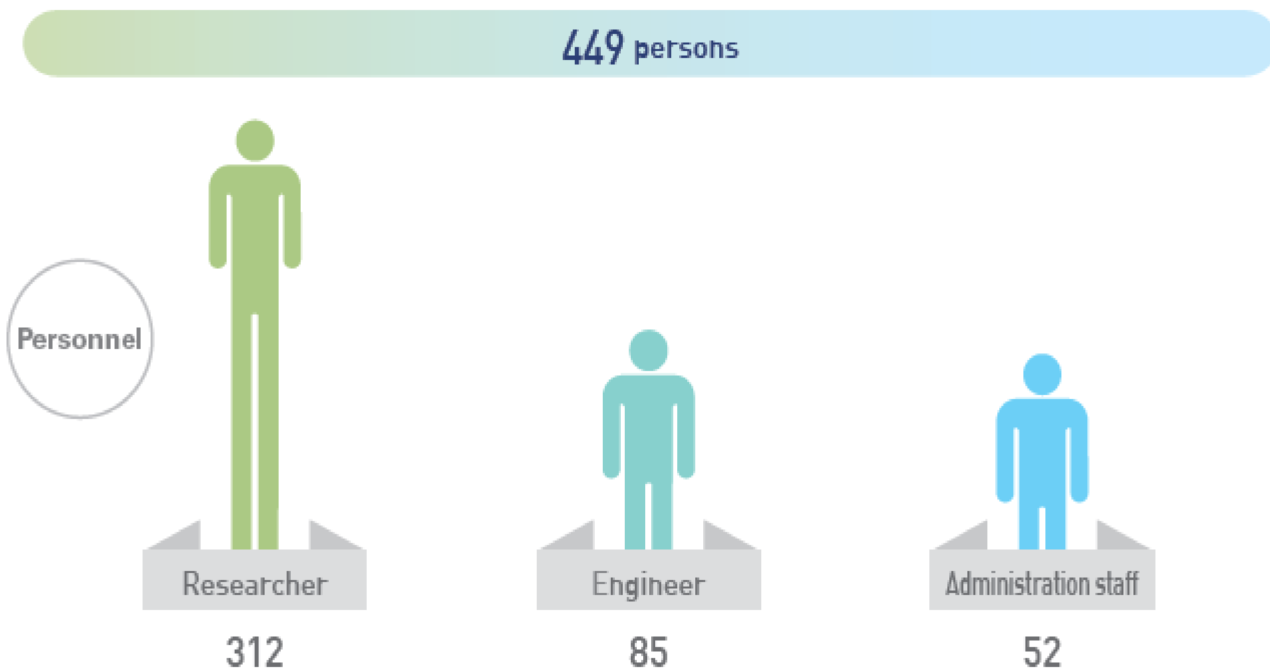
# 01

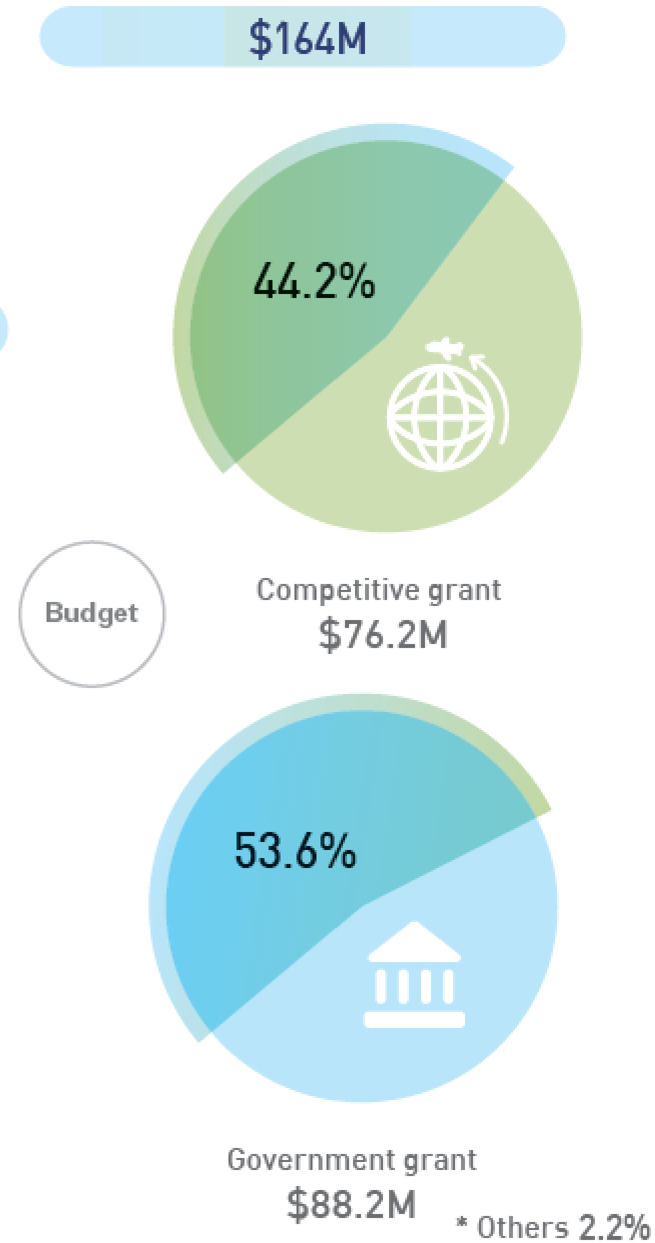
# Introduction of KIER

# History

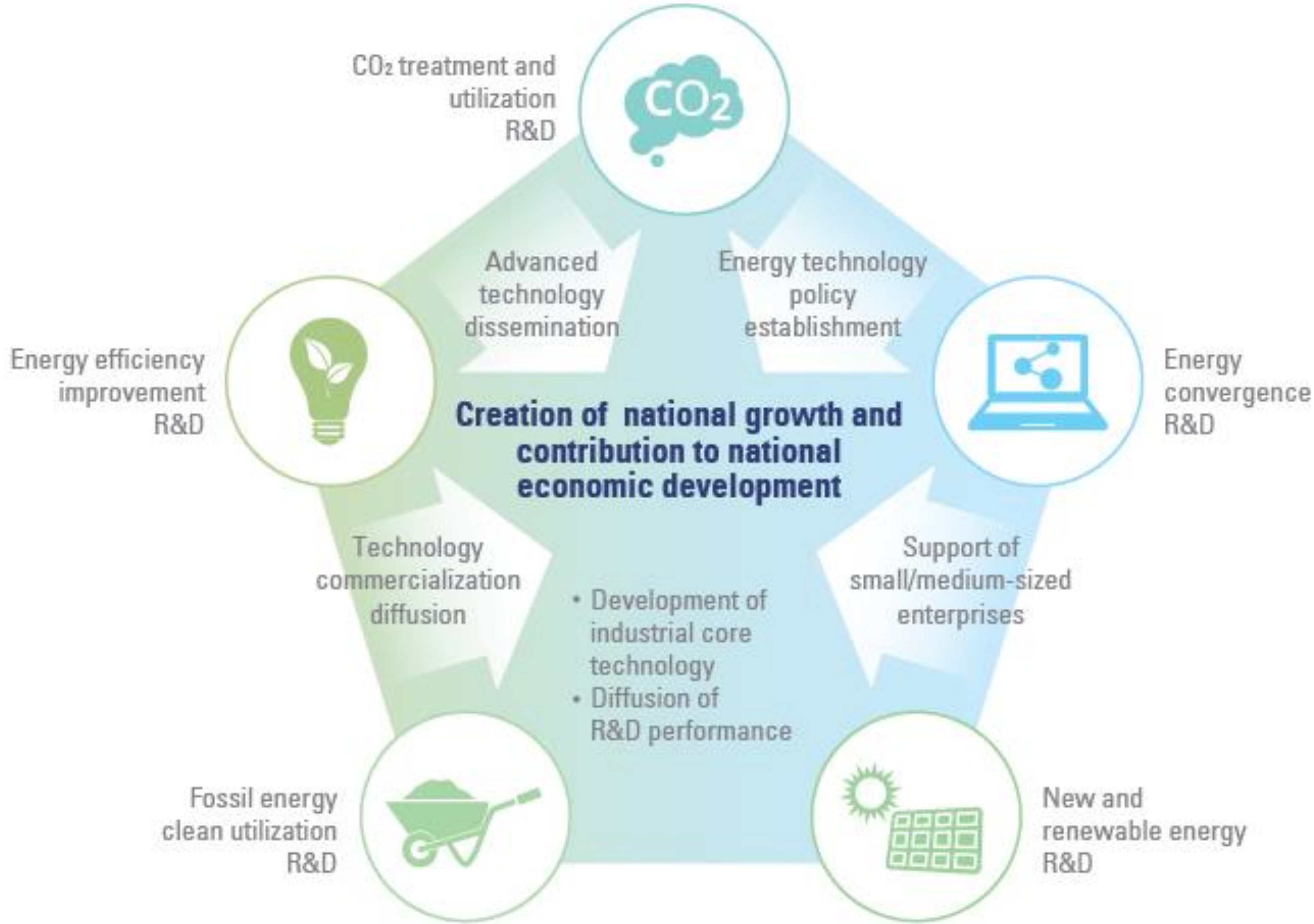

Early stage
Development stage
Takeoff stage
Sep.1977
May.1978
Nov.1979
Mar.1980
Jan.1981
Sep.1986
Nov.1991
Dec.2000
• Korea Institute of Energy Conservation established
• The Solar Energy Research Institute established
Energy Economic Policy Division (Research branch in Seoul)
Renamed Korea Energy Research Institute (KERI)
KERI and Korea Institute of Geoscience and Mineral Resources (KIGAM) merged to Korea Institute of Energy and Resources (KIER)
Separated to Korea Energy Economics Institute
KIER separated into Korea Institute of Energy Research (KIER) and KIGAM
Renamed Korea Institute of Energy Research (KIER)

# Personnel & Budget



# Main Research Areas



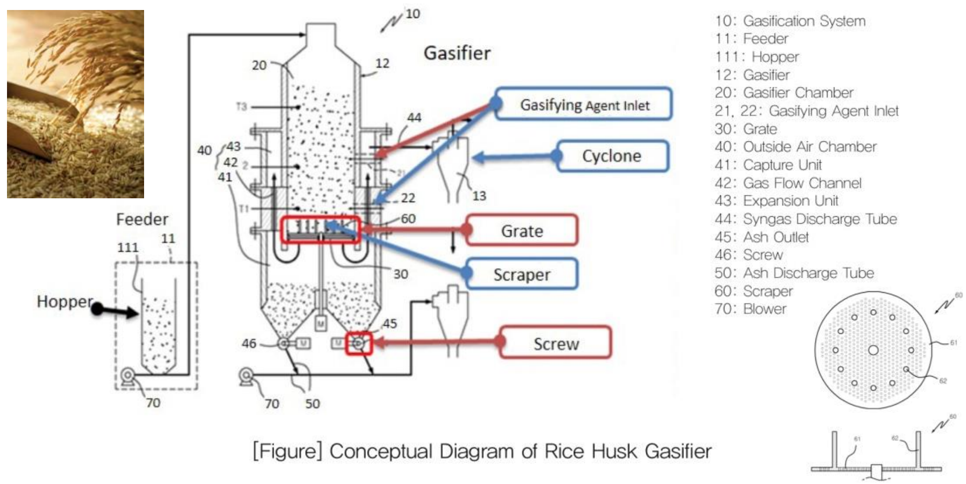
02

# Energy Technologies from KIER

# Biomass (Rice Husk) Gasifier (Lee Jae-goo, PhD.)

## ➢ Overview

The technology produces syngas by **gasifying the rice husk** which is mass-discharged in the rice processing center(RPC) and then can be utilized **to produce electricity by syngas combustion** from internal combustion(IC) engine as well as **heat generation**.




[Figure] Conceptual Diagram of Rice Husk Gasifier

## ➢ Technical Issues

- There is a problem of **gas yield fluctuation and plant durability due to the discharge of side products such as tar and ash** in addition to the syngas after rice husk gasification process.
- There is a problem of **the decrease of gas production amount**, in process of gasification **due to the tunnel in between of rice husk layer**, or **due to the entanglement of ash**.

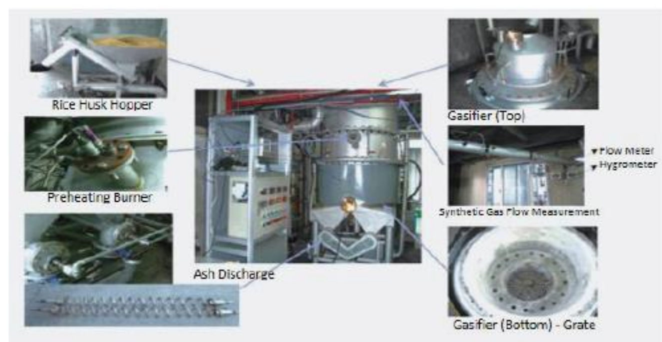
## ➢ Advantages

- There are two gasifying agent inlets, one in the middle of the gasifier and the other at the lower part of the gasifier. **The tar is combusted inside gasifier** to produce low tar syngas.
- **The scraper is mounted on the grate** installed in the gasifier to **scrap the deposited ash** so that the reacted ash can be continuously discharged without entanglement.
- The **cyclone system separates the particulate matters** from the discharged syngas.
- The **collected ash** from the gasifier can be **used as the soil fertilizer**.

## ➢ Development

(TRL 6 : Pilot-Scale and Performance Evaluation from Demo Plant)

- The combined heat and power system for RPC using the rice husk gasifier and IC engine has been developed.




[Figure] Pilot Plant for Rice Husk Gasification

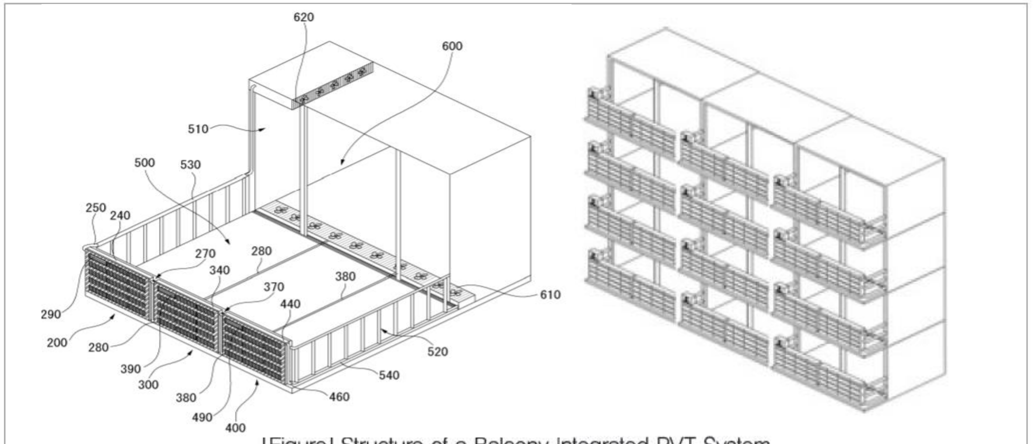
[Figure] CHP System Using Rice Husk Gasifier Combined with IC Engine System in RPC

# Building Integrated Photovoltaic-Thermal System (Kang Eun-chul, PhD.)

## ➢ Overview

• **The PVT system integrated with a building is installed on a balcony** as part of a building skin and has the **heat flowing through the frame of the system**.

• The building integrated energy production and supply system **generates electricity and thermal energy using the solar energy** and reduces the energy consumption of building through the generated energy.



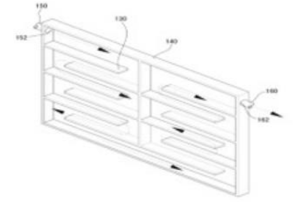

[Figure] Structure of a Balcony Integrated PVT System

## ➢ Technical Issues

- Since the flow channels of conventional PVT modules are uni-directional or single layered, **the cooling of photocell and absorption of solar energy are poor**.
- **The energy utilization is low because each module cannot be independently controlled** since the modules cannot independently use the thermal energy they acquired.
- The system has the structure that binds the modules, and thus it is a **technical issue to integrate it into the building skin.**

## ➢ Advantages

- **The stacked flow channel design** allows the heat to flow in alternate directions and layers to acquire a large amount of solar energy.
- **Each PVT module can control the thermal energy independently** so that the system can create a warm curtain using all or part of the acquired thermal energy.
- **The system installation cost and space requirements are low while the heat efficiency is higher** since the system installation can be integrated with the building and thus assured of structural integrity.



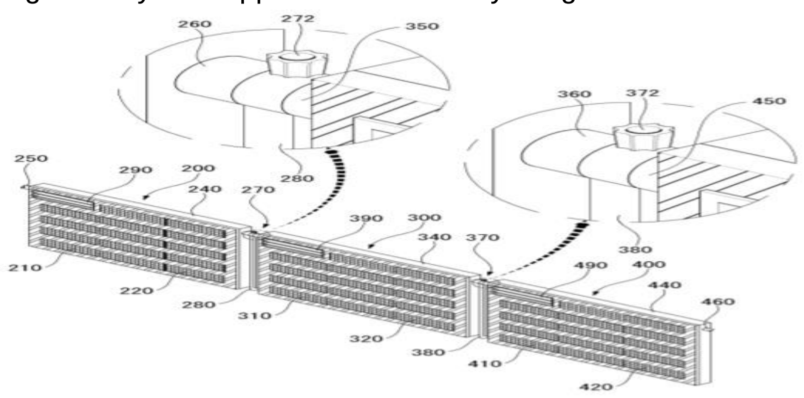
[Figure] Stack Design Concept of Module

[Figure] PVT Module Prototype

## ➢ Development

(TRL 5: System Prototype Manufacturing and Performance Evaluation)

- Development and testing of PVT modules in similar environments
- Improvement of PVT heat-electricity performance
- Design and system application of balcony integrated PVT module



# $CO_2$ Capture Technology – KIERSOL™ (Yoon Yeo-il, PhD.)

## ➢ Overview

- **The cost of capturing $CO_2$ takes up 70% of total CCS** (Carbon Capture and Storage) **cost**, and it is mainly determined by the reboiler heat duty for regenerating of the absorbent. The technology intends to improve the process to reduce the operation cost.

  - **Material**: Development of material with improved physical and chemical resistance for $O_2/SO_2/NO_X$/side reaction by heat and cost for make up.

  - **Application**: This technology can be applied to capture $CO_2$ for various industries such as a pulverized coal power plant, an ironworks, an cement factory and petrochemicals.

  - **Construction**: Optimized construction will ensure and verify the performance.

## ➢ Technical Issues

- The commercial absorbents have the problem of poor resistance to $O_2$, $SO_X$, $NO_X$, and heat.
  → Physical and chemical resistance problem

- The reboiler in the existing process generates excessive regeneration heat. Dissociation or side reaction of absorbent occurs by reacting with $O_2$, $SO_2$ and nitrosamine is made by reaction with $NO_X$.
  → Unstable and difficult to control

- There is the need to improve the $CO_2$ separation capacity of existing absorbent and to lower the operating cost.

## ➢ Advantages

- The absorbent material with better performance of $CO_2$ capturing than existing commercial products has been developed.

- Low volatile, nontoxic, and naturally decomposing material

- Strong resistance to side reaction by $O_2$, $SO_X$, $NO_X$, and heat

- Low operating cost compared to the amine process
  → **\$ 27/ton $CO_2$ or \$ 23/ton $CO_2$ with waste heat recovery**

- The performance is realized through the process development and construction of 10 ton $CO_2$/d in cement factory.

| Type | Leading Existing Technology | | Proposed Technology (KIERSOL) |
|---|---|---|---|
| | Alkanolamine (KS-1) | Benfield Method | |
| Main Component | 3° Amine/1~2° amines mixture + (Water) | Alkaline-carbonate + (Water) + Inorganic acid | Alkaline-carbonate + (Water) + Sterically hindered cyclic amine |
| Generation of salt | △ | O | X |
| Regeneration energy (GJ/t$CO_2$) | 2.6 – 2.8 | 3.8 | 2.2 |
| Absorbent loss (kg/t$CO_2$) | 0.35 – 0.40 | 2.4 | 0.01 or less |

[Table] Comparison of Liquid Absorption Process to Capture $CO_2$

## ➢ Development

(TRL 6: Pilot-Scale Prototype Manufacturing and Evaluation)

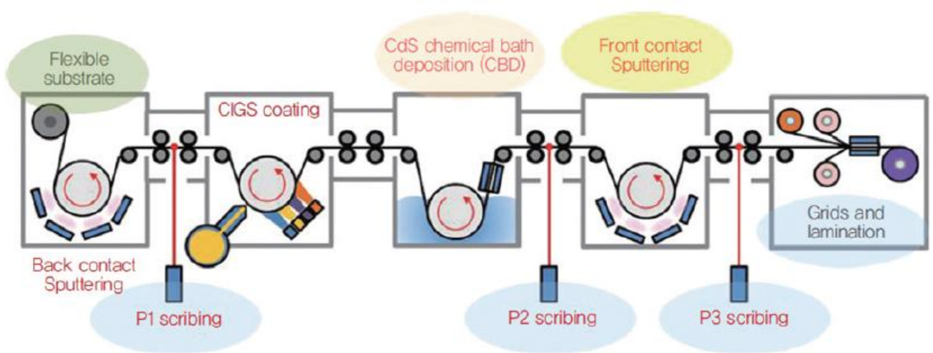
- The pilot process (10 ton $CO_2$/d) Has been completed at a cement factory in Danyang at the middle region of Korea.


※ The novel technology to generate electric energy using the capture process is at TRL 4 (performance evaluation of lab-scale system).

# Flexible CIGS Thin Film Solar Cell (Ahn Seung-gyu, PhD.)

## ➢ Overview

- This technology is related to manufacturing and mass production of CIGS thin film solar cell on a metal foil or polymer film using the non-vacuum roll-to-roll processes.




[Figure] Conceptual Diagram of Roll–to–Roll Process

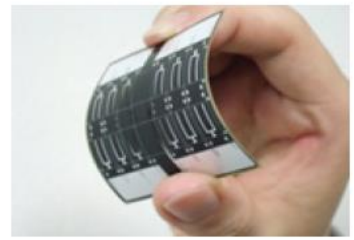
- The flexible substrate CIGS solar cell uses the rear-side electrode consisting of the single metallic electrode layer containing Na to improve the Na supply to the light absorber.

## ➢ Technical Issues

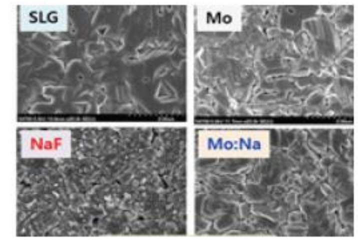
- **The photo conversion efficiency of the flexible CIGS solar cell is relatively lower** than a conventional crystalline silicon solar cell.
- Hence, a relatively **larger area** than the crystalline silicon solar cell **is necessary** for the same power generation.
- **It is difficult to produce a large area cell** with high conversion efficiency since **the process is complex and requires precise controls.**

## ➢ Advantages

- The technology applies Na-added Mo electrode layer that shows about 1/10 specific resistance than the existing Na-added Mo electrode layer.
- The high efficiency flexible CIGS thin-film solar cell is developed.
  - Conversion efficiency η≥ 18% (~1cm$^2$) and degradation rate ≤ 7%



[Figure] Flexible CIGS Thin Film Solar Cell SUS




[Figure] CIGS Micro Structure

**Development**

(TRL 4: Key lab–scale material, part, and system performance evaluation)

**Applications**

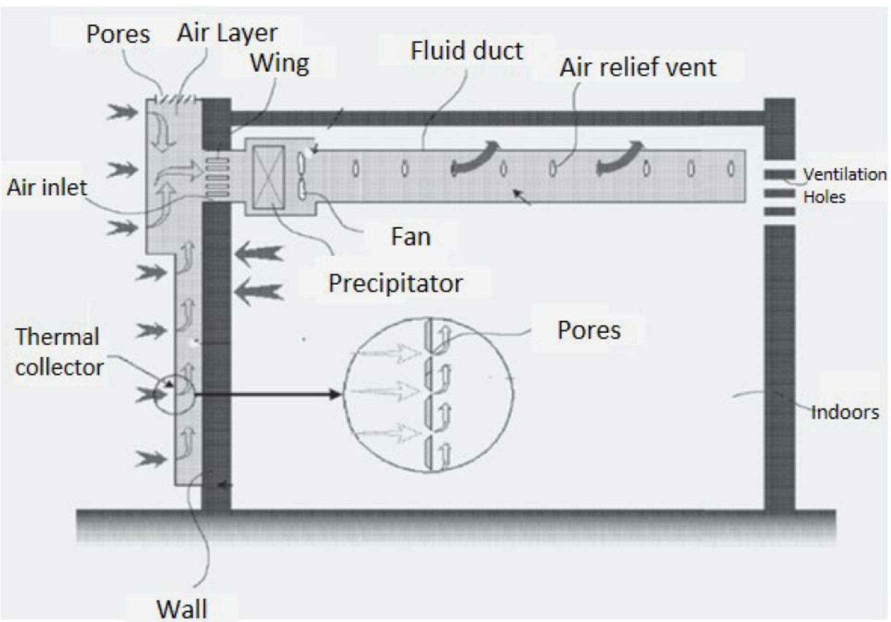

[Figure] Flexible CIGS Solar Cell Application

# Integrated Solar Air Heating with Electrostatic Precipitation Purification System(Lee Euy-Joon,PhD.)

## ➢ Overview

- The integrated solar air electrostatic purification system having the **thermal collection and dust collection function** consist **electrostatic solar thermal collector** to heat fresh air on the outer wall of the building and the precipitator that filters the outside dust air.

- This innovative system can eliminate the dust from outside effectively using an electrostatic precipitator and solar fresh air heating by the solar filtration.




[Figure] Conceptual Diagram of Solar Fresh air heating and Electrostatic Precipitation Purification System

## ➢ Technical Issue

- The increased ventilation while collecting the solar heat brings in the relatively cold or hot outside air to change the indoor temperature and increases the dust to cause overloading of air purifier.

- The conventional thermal collector requires the separate air purifier to purify the outside air and thus increases the system volume.

- The technical issues on smog and dust free solar fresh air heating to purify the smog and dust air.

## ➢ Advantages

- The thermal collector **uses the material that contains many small holes with high absorption rate** to act as the filter and heater.

- The thermal collector installed on the outer wall of the building and the air circulation path installed on the inner wall flow the warm air indoor to decrease the heating load and thus lowers the CO2 and dust concentration.

- **Using the dust filter** lowers the PM concentration in the outside air with a temperature of 18ºC or less to 20mg/m$^3$.

- The measurement showed that the temperature of the outside air flowing indoor was 22- 24ºC, the PM concentration was 150 $\mu$g/m$^3$ or less, and $CO_2$ concentration was less than 1,000ppm.

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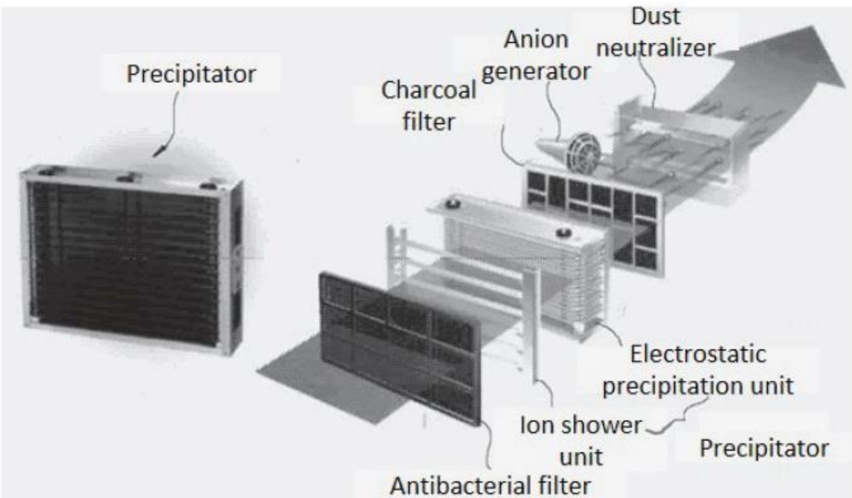
# Integrated Solar Air Heating with Electrostatic Precipitation Purification System(Lee Euy-Joon,PhD.)




[Figure] Precipitation System Diagram

## Development

**(TRL Level 4: Development of lab-scale prototype)**

- Mass production simulation process
- Building of semi-pilot level facility and manufacturing of prototype

KIER SAH-EPP Test Bed

3CMM Class SAH-EPP System

## Applications

- Dust free Solar Fresh Air/Water Heating

Solar Thermal Collection and Water Heating System

Photovoltaic Power Generation for Residential Power Supply

# 03

# Contact Information

# Contact Us

## Global KIER

## Below 1°C to keep the Earth livable.

| | | | |
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# Thank you!