

District heating and Cooling Research Activities based on IoT technology in Korea

[Session#4 : Smart Cities, Districts and Buildings]

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History of District Heating in Korea

Current status of KDHC

Research Activities in KDHC

Research Activities of IoT Technology in KDHC

Summary

History of District Heating in Korea(1978 & 1985)

- ***In 1978(After the oil crisis) : The Korea government considered to introduce DHC as politically***
 - ***For the purpose of energy conservation & greenhouse gas reduction***
- ***In 1985 : Established Korea District Heating Corp. (as a government founded corporation)***

• ***The Korea government considered to introduce DHC***

• ***Established Korea District Heating Corp.***

▼ 1978

▼ 1985

▼ 1991

▼ 2001

▼ 2030

History of District Heating in Korea(1991)

- ***In 1991 : Development of new cities of metropolitan area***
 - ***Increasing requirement of electricity and district heat***
 - ***Adopting “The Act of District Heating and Cooling”***
 - ***The new city must be provided DHC(if the city exceed certain scale)***
 - ***Over 5,000 households are constructed***
 - ***Over 600,000m² are developed***

•Development of new cities of metropolitan are

a



▼ 1978

▼ 1985

▼ 1991

▼ 2001

▼ 2030

History of District Heating in Korea(Recent)

- After this act are introduced, then the Propagation rate of DHC are increased more than twice (**5.5 → 12.7%**)
- The trend of DHC in Korea
 - 36 district heating companies
 - 2.43 million households are provided DHC
 - ※ **KDHC : 1.3million households and 2,100 buildings**

<The Annual trend of district heating propagation in Korea>

| | '95 | '00 | '05 | '10 | '11 | '12 | '13 | '14 |
|------------------------|-------|--------|--------|--------|--------|--------|--------|--------|
| Total (thousand) | 9,570 | 11,472 | 13,222 | 14,677 | 15,007 | 18,551 | 18,884 | 19,217 |
| Supply (thousand) | 525 | 980 | 1,390 | 2,008 | 2,178 | 2,220 | 2,323 | 2,436 |
| Supply rate(%) | 5.5 | 8.5 | 10.5 | 13.7 | 14.5 | 12.1 | 12.3 | 12.7 |
| Number of Companies | 2 | 8 | 15 | 26 | 28 | 33 | 34 | 36 |

History of District Heating in Korea(2001)

- ***The Korea government Establishing the master plan for national DHC (every 5 years)***
 - ***For pushing ahead with the DHC enlargement policy***
- ***In 2001 : Structure reforming of electric power industry***
 - ⇒ ***DHC companies entering the electric power market***

• ***DHC companies entering the electric power market***



▼ 1978

▼ 1985

▼ 1991

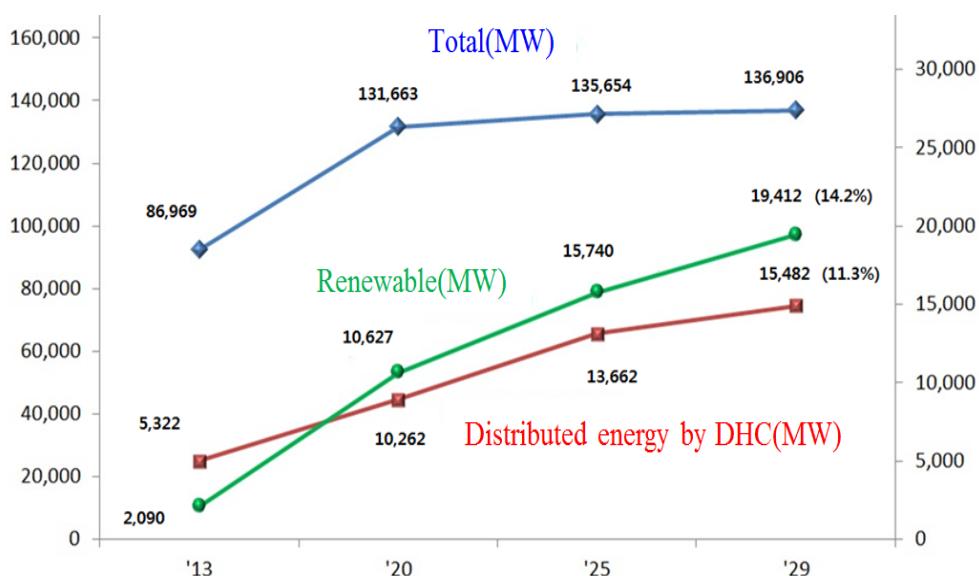
▼ 2001

▼ 2030

History of District Heating in Korea(2030, Future plan)

● *Future Plan of Distributed power generation in 2030*

- *by DHC : more than 11% (of entire power generation)*
- *by Renewable energy : more than 14% (of entire power generation)*



| | '13 | ~'20 | ~'25 | ~'29 |
|----------------------------------|---------------|----------------|----------------|-----------------------|
| Total | 86,969 | 131,663 | 135,654 | 136,906 |
| Distributed Energy by DHC | 5,322 | 10,262 | 13,662 | 15,482 (11.3%) |

<The plan for distributed power generation in Korea>

History of District Heating in Korea(2030, Future plan)

- ***Under 500MW scale CHP is appropriate method(in Korea) for the integrated energy business model for the metropolitan area***
 - *Because the electricity and district heating demands are focused on the metropolitan area*
 - *Metropolitan area required approximately 40% of total electrical demands but 23% plant are existed around*
- ***And under 500MW scale CHP should be constructed neighboring the metropolitan area***

Distributed power generation by DHC will supply more than 11% of entire power generation

▼ 1978

▼ 1985

▼ 1991

▼ 2001

▼ 2030

History of District Heating in Korea

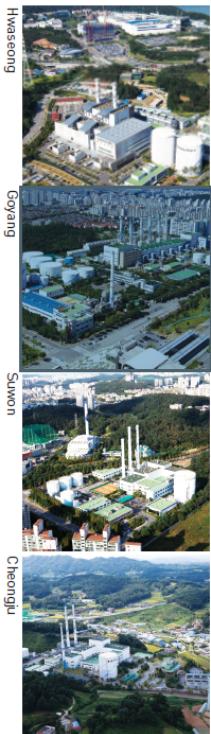
Current status of KDHC

Research Activities in KDHC

Research Activities of IoT Technology in KDHC

Summary

Current status of KDHC



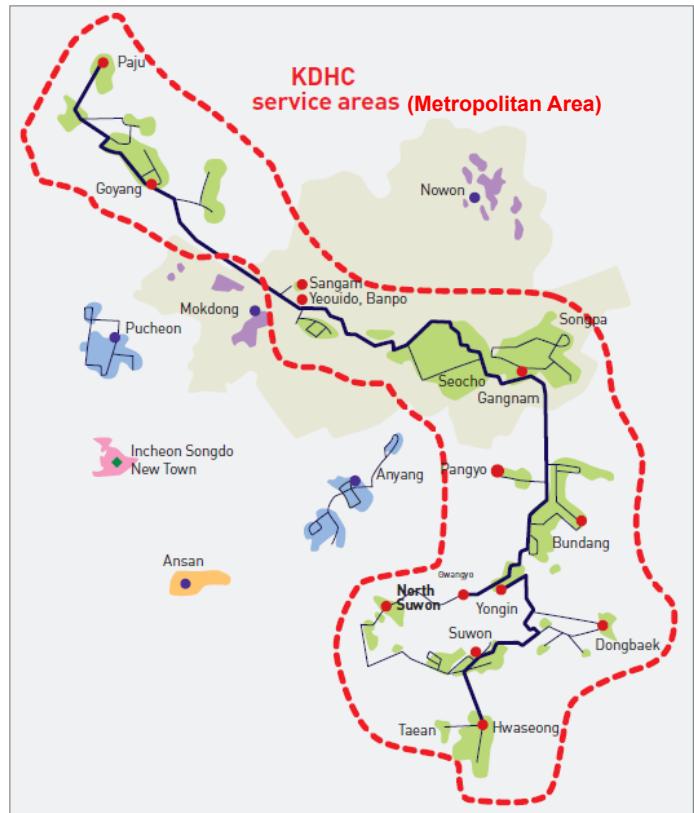
Status of Branches

| Name | Heat supply started | Main service area | Telephone |
|---------------------|---------------------|---------------------------------------|----------------|
| Mapo (Danggindong) | 1987. 11 | Yeouido, Ichon, Banpo etc. | 82-2-305-2488 |
| Bundang | 1991. 9 | Bundang etc. | 82-31-702-2295 |
| Gangnam | 1991. 10 | Gangnam, Seocho, Songpa etc. | 82-2-459-2488 |
| Goyang | 1992. 8 | Ilson, Hwajeon, Haengsin etc. | 82-31-900-2488 |
| Yongin | 1994. 12 | Suji, Jukjeon, Dongback etc. | 82-31-262-2488 |
| Daegu | 1995. 4 | Seongseo, Daegok etc. | 82-53-589-4114 |
| Suwon | 1995. 10 | Youngtong, Gweonseon, Cheoncheon etc. | 82-31-201-0114 |
| Cheonju | 1997. 5 | Bunpyeong, Habokdae etc. | 82-43-234-2488 |
| Gyeongnam (Yangsan) | 1999. 11 | Mulgem etc. | 82-55-388-2477 |
| Gyeongnam (Gimhae) | 2000. 7 | Jangyu etc. | |
| Mapo (Sangamdong) | 2001. 7 | Worldcup stadium, Sangam New Town | 82-2-305-2488 |
| Hwaseong | 2004. 3 | Dongtan, Taean, Byeongjeom etc. | 82-31-374-2188 |
| Paju | 2005. 10 | Gyoha, Unjeong etc. | 82-31-957-2961 |
| Pangyo | 2008. 11 | Pangyo | 82-31-706-2488 |
| Gwangyo | 2011.10 (scheduled) | Gwangyo etc. | 82-31-693-8588 |
| Samsong | 2011.11 (scheduled) | Samsong, Eunpyeong New Town etc. | 82-2-356-2488 |



Status of Subsidiary Companies

| Company | Established date | Main business | Telephone |
|----------------------------------------------|------------------|----------------------------------------------------------|----------------|
| Korea District Heating Engineering Co., Ltd. | 1991. 11. 1 | Integrated energy engineering business | 82-31-776-8888 |
| Incheon Total Energy Service Co., Ltd. | 2004. 6. 10 | District heating supply to Songdo New Town, Incheon City | 82-1577-1079 |



Current Status of KDHC (2014)

- 18 district branches
(Sejong & Naju are under constructing)
- 1.3 million households
- 2,100 buildings

Current status of KDHC

New-Town development

population density of Seoul in late 1980s

- Seoul : 9.9m('87) ⇒ 10.0m('00) ⇒ 10.0m('12)
- Gyeonggi : 5.2m('87) ⇒ 9.1m('00) ⇒ 11.2m('12)
- Incheon : 1.6m('87) ⇒ 2.5m('00) ⇒ 2.6m('12)

1st New-town development plan ('89~'96)

- 5 new-cities development in Gyeonggi province
(for 1,100,000 persons, by 300,000 new APT)
- 4 new CHPs(KEPCO) & DH plant(KDHC)

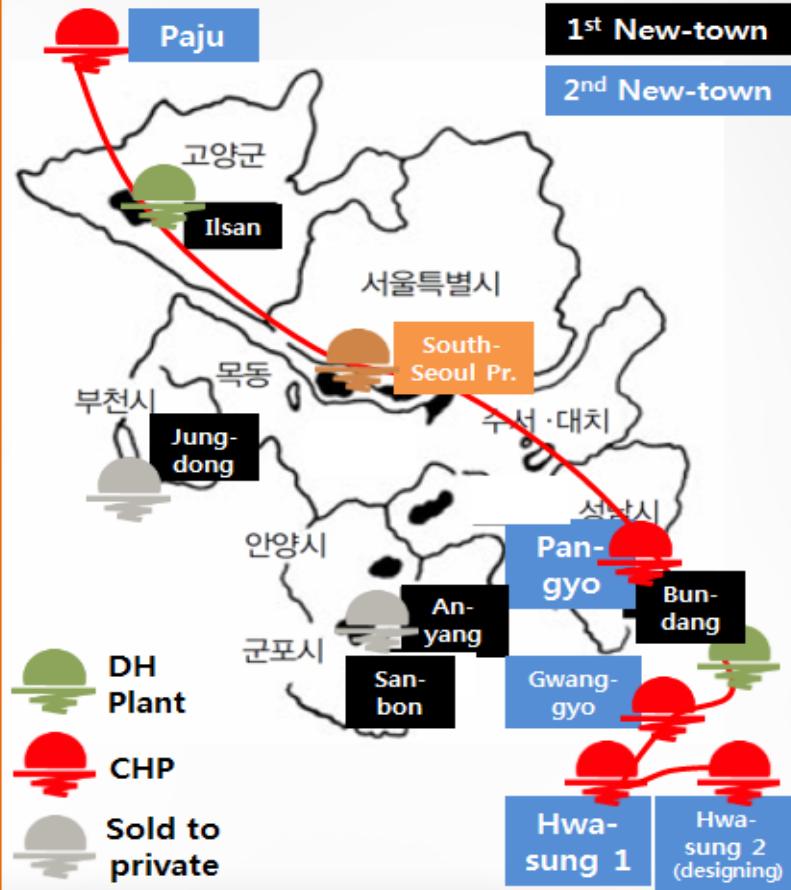
2nd New-town development plan ('01~'15)

- 10 new-cities development in metropolitan area
(for 1,484,000 persons, by 592,000 new APT)
- 5 CHPs(including DH system)(KDHC)



< Bird view of Paju CHP, 2010 >

Expansion of KDHC Plants



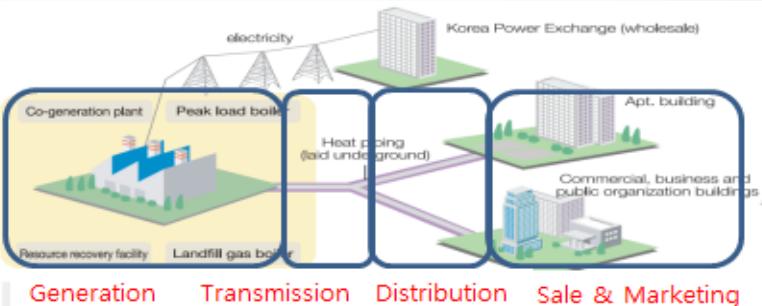
Current status of KDHC

Comparison table('87 vs '12)

| Items | Beginning (‘87) | Present (as of ‘12) | Note |
|------------------------------------|-----------------------------|-------------------------------|-----------------------|
| Assets (m\$) | 50 | 4,500 | X 90↑ |
| Sales (m\$) | 1.6 | 2,600 | X 1,625↑ |
| Consumers (residents) | 39,491 households | 1,211,858 households | X 30↑ |
| Consumers (commercial, etc) | 38 places | 2,336 places | X 60↑ |
| Heat supply (Total capacity) | 0.1 Gcal/yr (387 Gcal/h) | 12 mGcal/yr (7,398 Gcal/h) | X 120m↑ (X 19) |
| Power supply (Total capacity) | 0 (0) | 9 GWh/yr (3,812 MW) | |
| Employee No. (Branches) | 111 (1) | 1,312 (16) | X 10↑ (Nationwide) |

Current status of KDHC

< District heating business field of KDHC >



Generation : economical fuel and type

- Various Fuel : Incinerator heat, Solar Energy, LFG, Woodchip, RDF, biogas, LNG, Oil
- Type : GT, ST, PLB, Gas engine, PV, Incinerator



< Hwasung CCPP, 512MW + 397Gcal/h >

Transmission : Water(Hot/Cold), Steam

- District heating/cooling network(120~85 °C/3 °C)
- Steam network : Industrial complex(North Korea)



Distribution : Residents, commercial

- Residents : APT, single/multi family house
- Commercial : Office, stadium, shopping mall, IT server data center



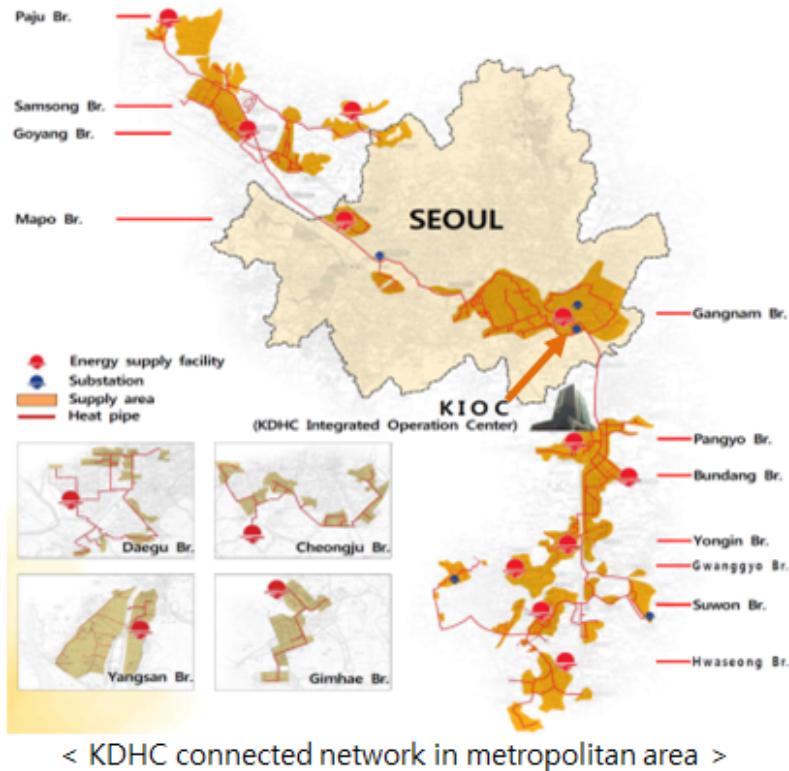
< Seoul worldcup stadium >

Current status of KDHC

Plants integrated Operation

KIOC(KDHC Integrated Operating Center)

- Control tower of Operation
- Considering real-time information on control board
- Help all plants cooperate each other
- Real-time analysis & Real-time Control
-



Advantage

- Maximizing efficiency of whole plants
- Unification of independent operation of branches
- Improvement of efficiency and stability
 - < From independent operation to integrated operation >



History of District Heating in Korea

Current status of KDHC

Research Activities in KDHC

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Summary

Research Activities in KDHC

Development of commercial process for CO₂ reduction and bioconversion of high-valued biomaterials using micro-algae

1. Research Summary

- Duration : 2012. 6. ~ 2017. 5. (Total of 5 years [1 Step(3 years), 2 Step(2 years)])
- Research expense : Total of 12.4 billion Won (Government grants: 9.3 billion Won)
- Performance Method : The R&D project supported by Ministry of Trade, Industry & Energy
 - Subjective participation: Korea District Heating Corporation(KDHC),
 - Collaborative participation: Korea University, Korea institute of Energy Research (KIER), GnG, Huons

2. Technology overview and research contents

- **Fundamental of technology :** A green technology that uses photosynthetic microalgae to deplete CO₂ and produce high-valued products.
- **Business purpose :** South Korea's first commercialized microalgae technology that reduces the amount of CO₂ in the atmosphere and produce high-value products in 10 ton scale.
- **Performance system :**

| Institution | Performance contents | Institution | Performance contents |
|-------------|--------------------------------------------------------------|-------------|------------------------------------|
| KDHC | General operation and commercial plant Installation | Huons | Production of High-valued products |
| Korea Univ. | Microalgae and photoreactor development | GnG | Maintenance of plant |
| KIER | Extraction of biomass, transformation and diesel productions | | |

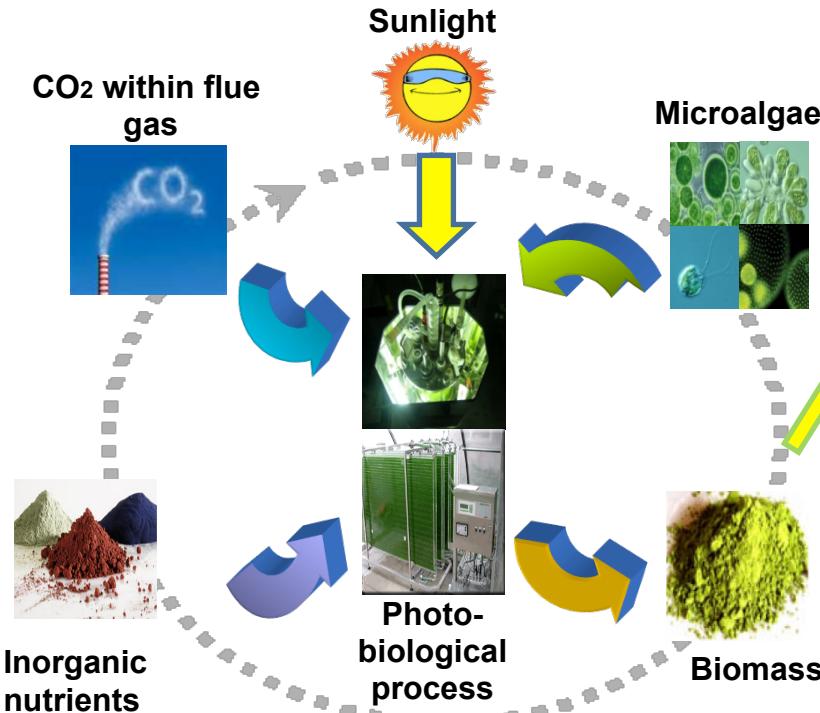
Research Activities in KDHC

Development of commercial process for CO₂ reduction and bioconversion of high-valued biomaterials using microalgae

Reduction of CO₂ using microalgae

Environment-friendly efficient bioprocess

Microalgal photoculturing for field applications



Best process for the mass production of microalgae in use to produce useful substances

Production of useful material converted from CO₂ by using microalgae

Integrated multidisciplinary process

Production process of useful materials from biomass (downstream)

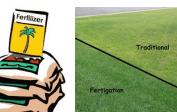
Functional food, feedstuff, aquaculture feed



Industrial material



Fertilizer



Remaining biomass

Molecular bio-material



Biofuel

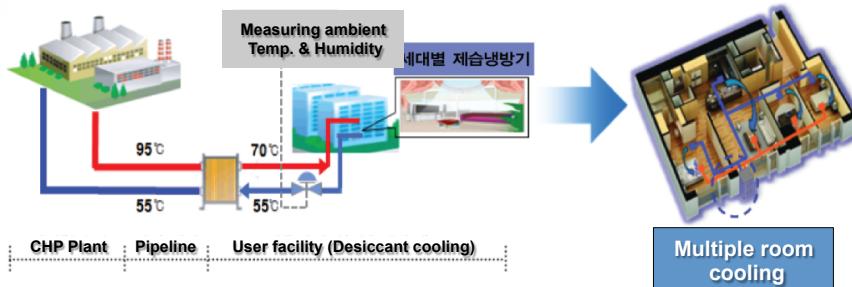


Research Activities in KDHC

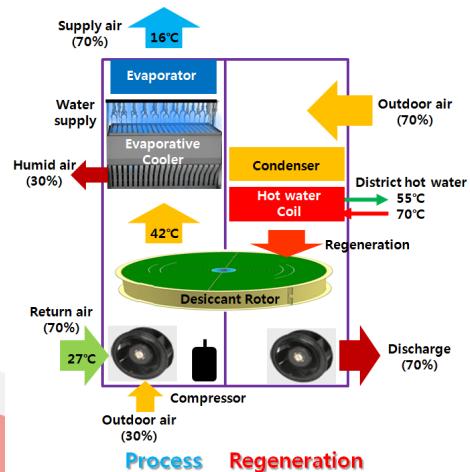
Development of desiccant cooling system

Desiccant cooling concept

Don't need additional pipes for chilled water. Supply cooling energy through the hot water line already existed



Desiccant cooling principle



Development progress

Exchange rate 1,100(kRW/US\$)

- 4kW Mock-up build ('06.09 ~ '07.11, budget : 363K US\$)
 - KIST(Korea Institute of Science and Technology)
- 7kW Prototype build ('08.12 ~ '09.12, budget : 909K US\$)
 - Kiturami(product maker)
- National project('10.06 ~ '13.10, budget : 6,545K US\$)
 - Government subsidies : 4,909K US\$
 - 7kW, multi-room control, COP 0.9, field trial test for 40 units
 - KDHC, Kiturami, KIST and 6 companies
- Joint research ('14.05 ~ '17.05, budget : 909K US\$)
 - Development of residential product for 7kW, 9kW and 11kW
 - KDHC & Kiturami(product maker)

Pilot project

- Place : Yongin-city LIGA apartment
- Target : type 126m², 40 houses(total 533)
 - '11.01 : Design for user's facilities
 - '12.01 : Installation of heat supply facilities
 - '12.03 : Installation of Desiccant cooling
 - '12.05 : Commissioning test
 - '13.07~ : Field test for summer season

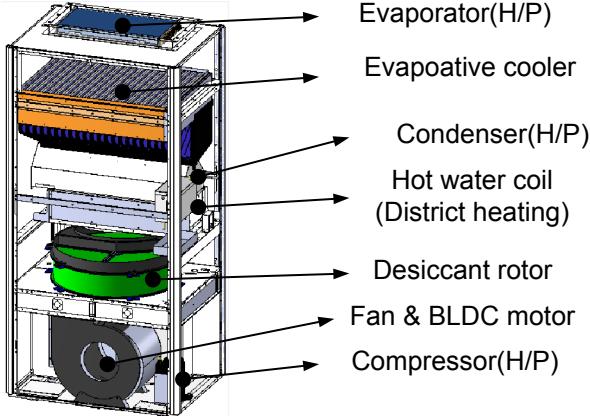


Research Activities in KDHC

Development of desiccant cooling system

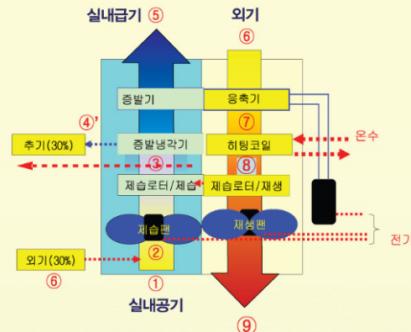
Characteristics of Desiccant cooling

Product and Component

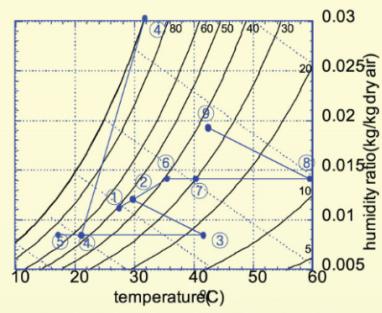


System diagram & Psychrometric chart

Hybrid desiccant cooling system

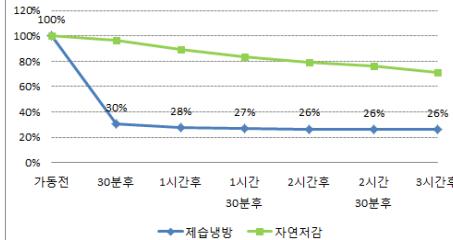


Psychrometric Chart

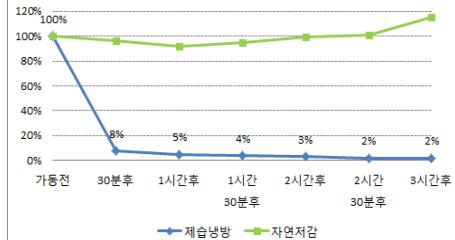


Effect of eliminating indoor pollutant

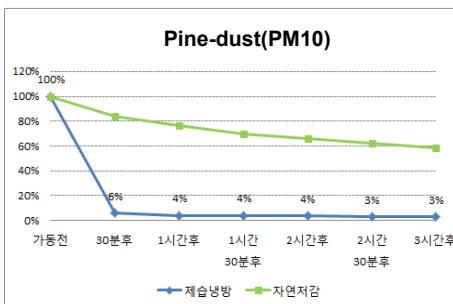
TVOG (Total Volatile Organic Compound)



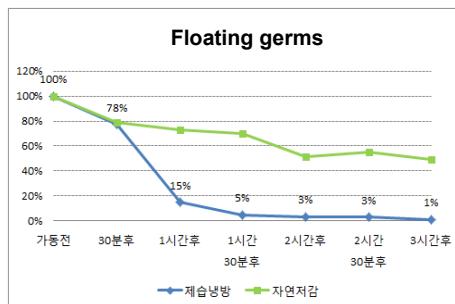
Formaldehyde



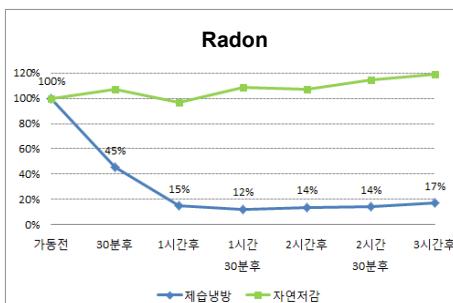
Pine-dust(PM10)



Floating germs



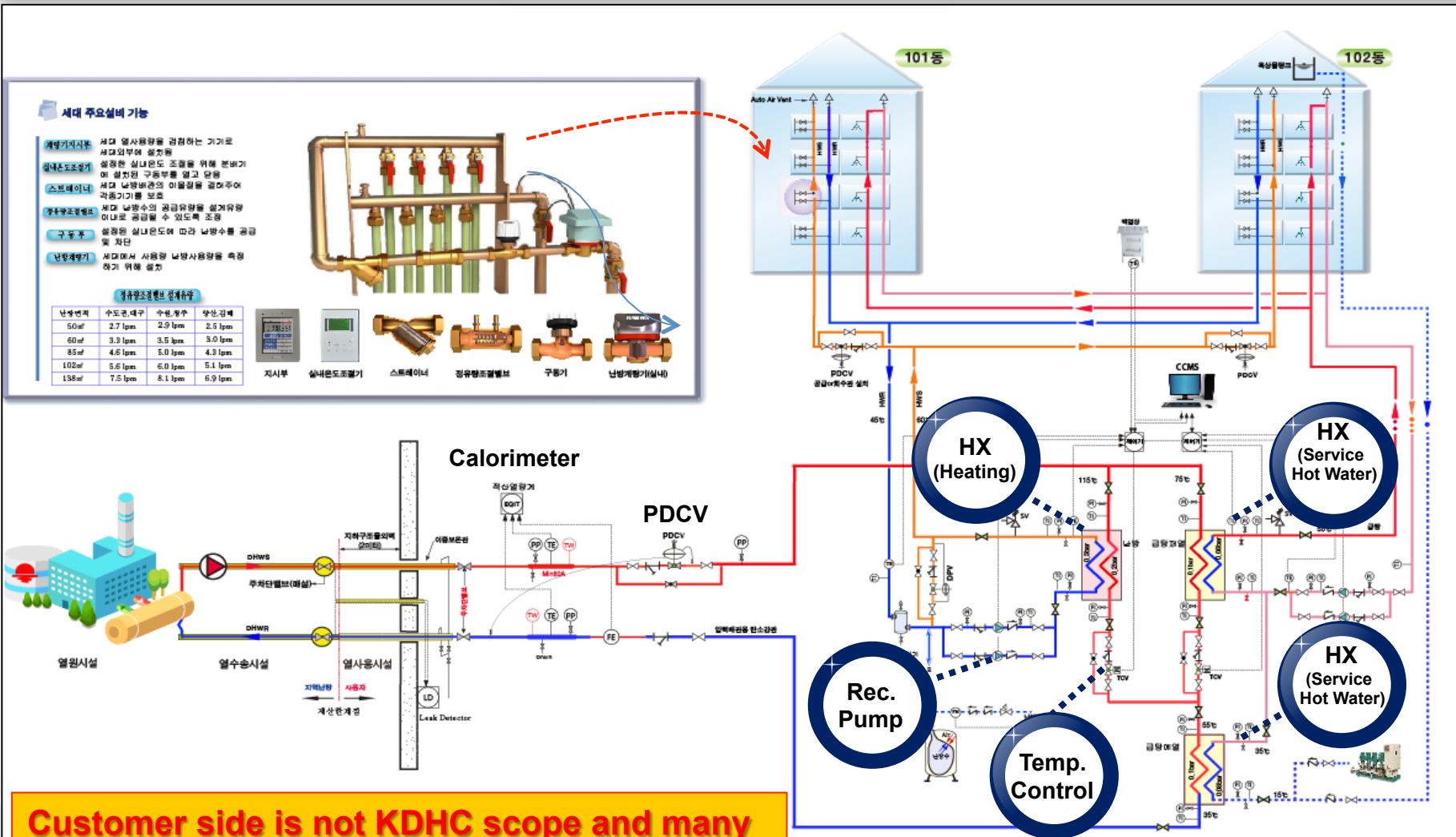
Radon



- ♠ *History of KDHC*
- ♠ *Current status of KDHC*
- ♠ *Research Activities in KDHC*
- ♠ ***Research Activities of IoT Technology in KDHC***
- ♠ *Summary*

Research Activities of IoT Technology in KDHC

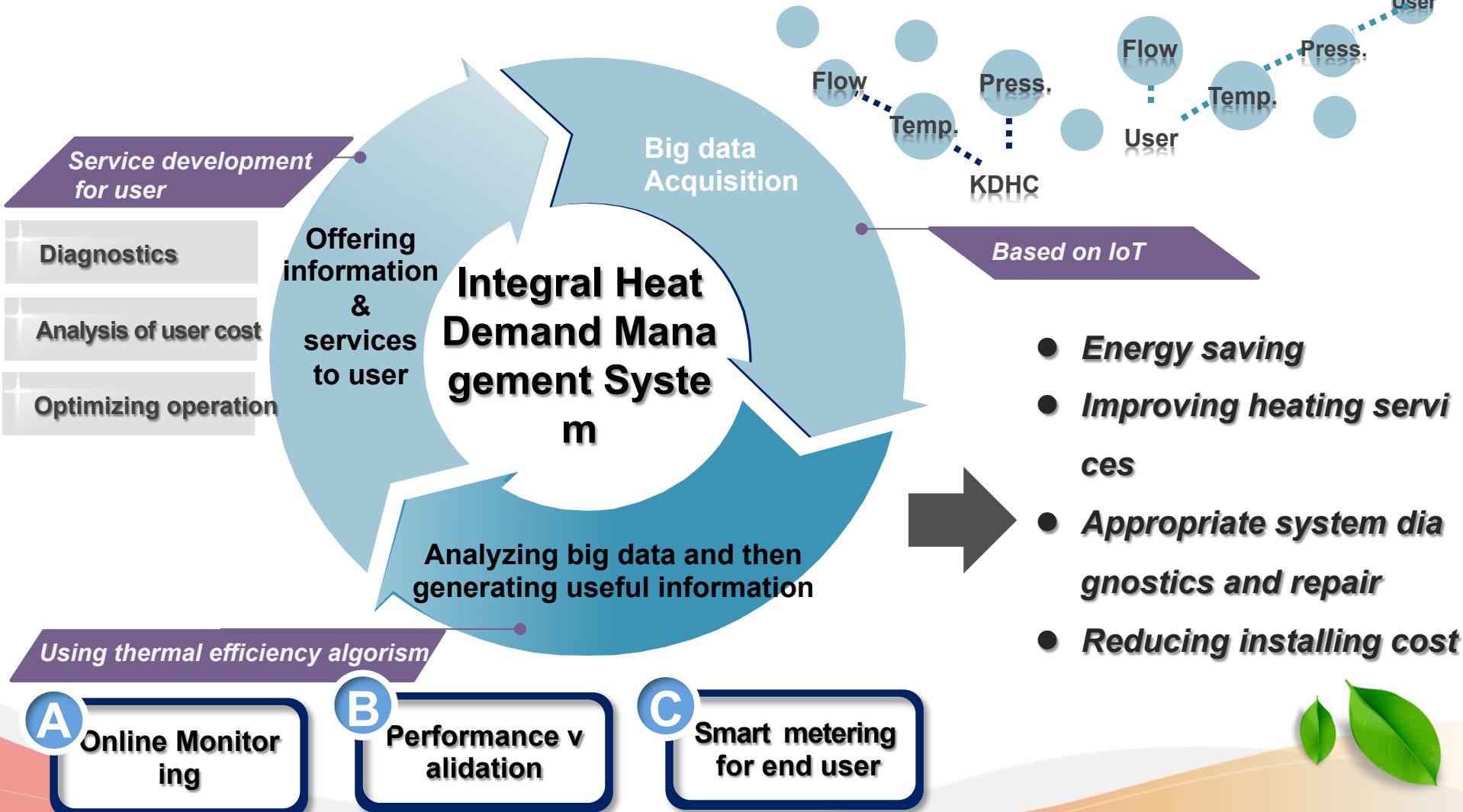
Technical Development of Integral Heat Demand Management System for District Heating Users based on IoT



Research Activities of IoT Technology in KDHC

Technical Development of Integral Heat Demand Management System for District Heating Users based on IoT

24,000 points of data are acquired while an hour



Research Activities of IoT Technology in KDHC

Technical Development of Integral Heat Demand Management System for District Heating Users based on IoT

Research Target

Development of feedback service that the DHC supplier gives real time information of heating for effective self managing as DHC customers.

Development of Interlock system for conventional units

Development of CCMS(Central Control Management System) based on standard reference model

Development of Integral heat demand management system based on big data

Development of performance monitoring and diagnostics system

Development of standard SW and MV for heat demand management based on ISO

Pilot test of integral heat demand management system

Research Activities of IoT Technology in KDHC

Field safety management system for Plant operator using IoT technology

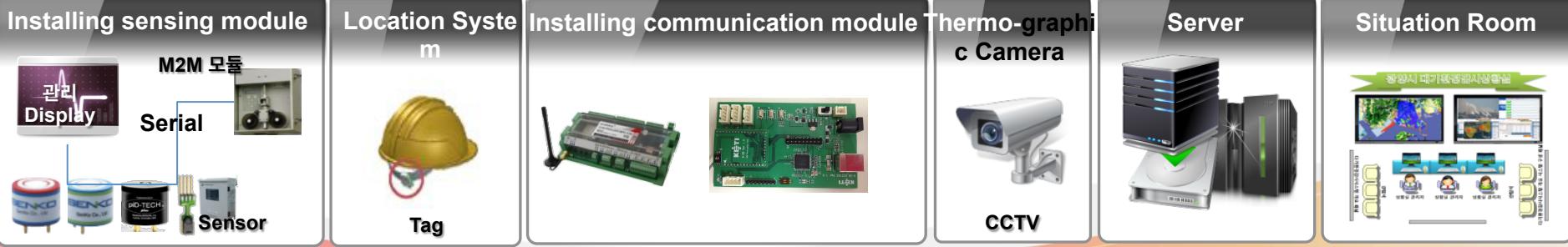
• Development of field safety management system

- Increasing a industrial accident in the plant
- Need monitoring dangerous situation and informing to operator
- Must considering security issues

Software

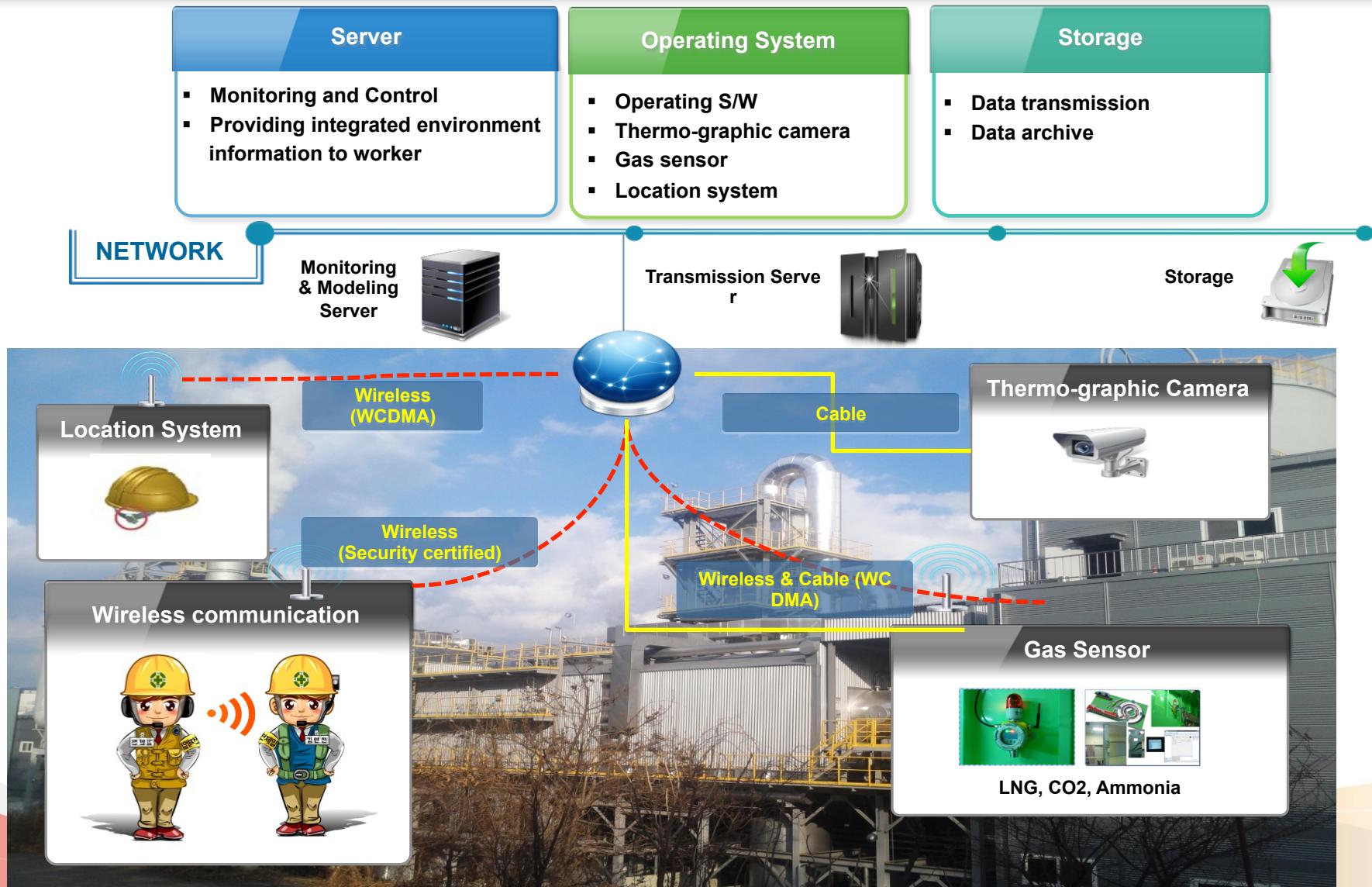


Infrastructure



Research Activities of IoT Technology in KDHC

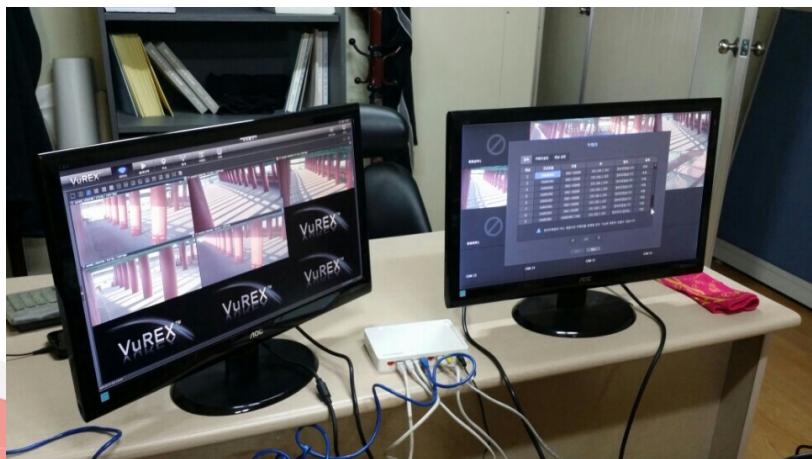
Field safety management system for Plant operator using IoT technology



Research Activities of IoT Technology in KDHC

Field safety management system for Plant operator using IoT technology

Wi-Fi test for security certification



Wi-Fi module

Wireless bridge (7Km)



CCTV
(Cable)

21th~22nd, Oct., 2015, DaeJeon, Korea

ICT Enabling Thermal Energy Flexibility in Integrated Energy Systems

- ♠ *History of KDHC*
- ♠ *Current status of KDHC*
- ♠ *Research Activities in KDHC*
- ♠ *Research Activities of IoT Technology in KDHC*
- ♠ **Summary**

Summary

- **In 1985, KDHC was established as a Government founded corporation and now KDHC having 18 district branches and covering 1.3million households & 2,100 buildings**
- **Many research activities are executed in many DHC field especially**
 - **Development of commercial process for CO₂ reduction and bioconversion of high-valued biomaterials using micro-algae**
 - **Development of desiccant cooling system**
 - **And many others**
- **Research Activities of IoT Technology in KDHC are**
 - **Technical Development of Integral Heat Demand Management System for District Heating Users based on IoT**
 - **Field safety management system for Plant operator using IoT technology**
- **KDHC will researching to make valuable things for customer and national energy**

Thank You for Your Attention



감사합니다.

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