Overview

- **A brief introduction to KIER**
  - History, personnel and budget
  - R&D Strategies and organization
- **An overview of KIER R&D on Thermal Energy Network**
  - KIER's approach to thermal energy network
  - Brief history of KIER R&D on thermal energy network

  KIER's Activities I : R&D on heat pumps for TEN
    - Sea water source heat pump for a low-temperature TEN
    - Medium- and high-temperature heat pumps for an industrial TEN

  KIER's Activities II : 3025 Project
    - Overview of 3025 Project (Demonstrative Research on TEN in KIER campus)
    - KIER Energy Center

  KIER's Activities III : R&D on EMS for TEN
    - Local EMS for uni-directional thermal energy supply system with a local source
    - EMS for bi-directional thermal energy network
- **Summary**

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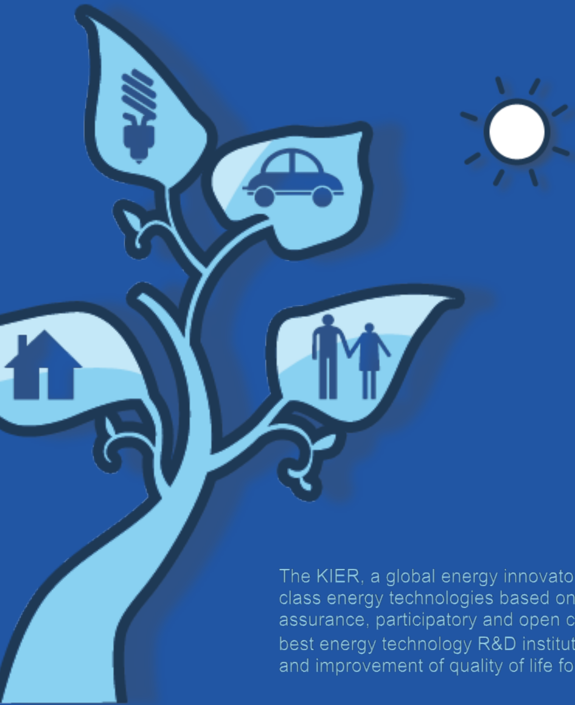
Chapter 01

A brief introduction to KIER



The KIER, a global energy innovator, does its best in pursuing its mission to invent world-class energy technologies based on open innovation, life-cycle research quality assurance, participatory and open communication. Therefore the KIER will become the best energy technology R&D institute in the world, contributing to the creation of wealth and improvement of quality of life for the people.

1.1 History

Toward a content and prosperous society, led by **KIER energy technology**

Early Stage

Sep.1977

- Korea Institute of Energy Conservation established
- The Solar Energy Research Institute established

Mar. 1980

- Renamed Korea Energy Research Institute (KERI)

Development Stage

Jan. 1981

- KERI and Korea Institute of Geoscience and Mineral Resources (KIGAM) merged to Korea Institute of Energy and Resources (KIER)

Nov. 1991

- KIER separated into Korea Institute of Energy Research(KIER) and KIGAM

Takeoff Stage

Dec. 2000

- KIER's affiliation changed to Ministry of Knowledge Economy in Mar. 2008

Mar. 2013

- KIER's affiliation changed to Ministry of Science, ICT & Future Planning(MSIP)

Energy Economic Policy Division (research branch in Seoul, Nov. 1979)

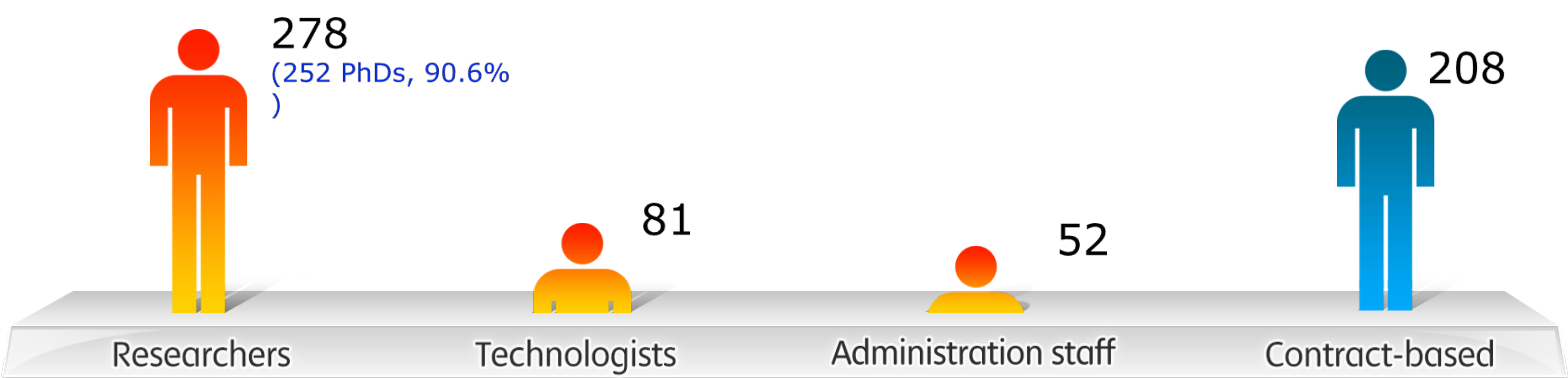
Separated to Korea Energy Economics Institute (Sep.1986)

Toward a content and prosperous society,
led by **KIER energy technology**

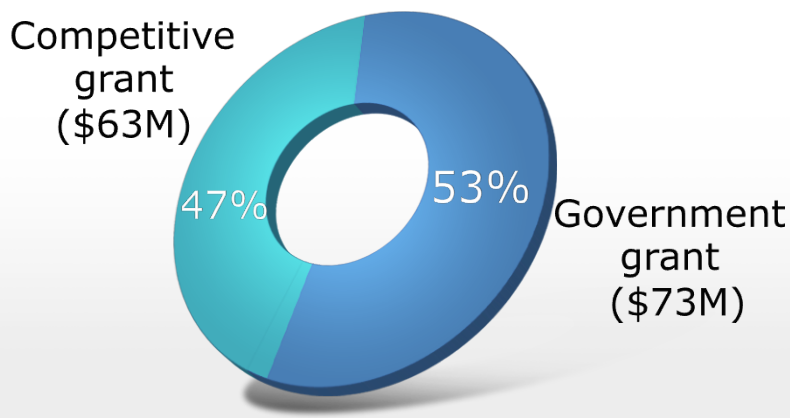
1.2 Personnel & Budget

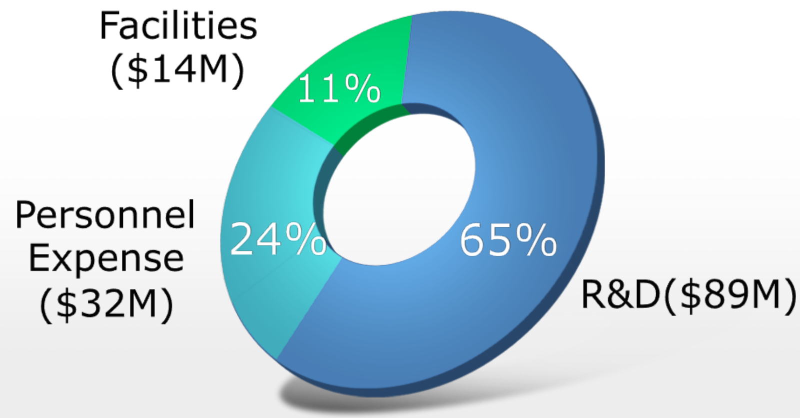
Personnel

619 employees in total with 411 of regular employees
(as of April 2015)



2015 Budget ($136M)





5.1 R&D Strategies

Toward a content and prosperous society, led by **KIER energy technology**

National Policy Goals

National Energy Master Plan	National Strategy for Green Growth	Green Energy Strategic Roadmap
Realization of energy self-sufficient society Convert to low energy consumption society Convert to low carbon society and to lower the dependency on petroleum Realization of energy society for mutual benefits	Adaptation to climate change and energy self-sufficiency Creation of new growth engine Improve the quality of life and the national status	Green energy technology as a new growth engine GHGs emission reduction Contribute to national energy security
Energy Self-sufficient	Expansion of Green Energy Supply	Expansion of Energy Efficiency
GHGs Emission Reduction	Promotion of Energy Welfare	Creation of New Growth Engine

4 Strategic Goals of KIER R&D

Strategic Goal 1	Strategic Goal 2	Strategic Goal 3	Strategic Goal 4
Expansion of renewable energy	*GHGs emission reduction*	*Energy efficiency improvement*	*Decrease in oil dependency*

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Organization

President

- Auditor
  - Audit Division
    - Anti-corruption & Integrity

Vice President

- Energy Efficiency
  - Energy Saving
  - Energy ICT
  - Advanced Combustion
  - Thermal Energy Conv.
  - Energy Network
  - Energy Storage
- Energy System Integration
- ...ewable Energy
  - ICT-based EMS on electric grid
  - Adv. Ctr. for Energy
  - Solar Thermal
  - New & ...
  - Heat pumps on thermal grid
  - CHP on thermal grid
  - ... Ctr. for Ind-Acad-lab
  - Hydrogen
  - Center for Eco-Friendly Zero Energy Town
- Climate Change
  - Clean Fuel
  - Petroleum
  - Renewable-hybrid and TES
  - Waste Energy
  - Green Energy Process
  - Low Carbon Process
- Energy Materials & Process
  - Advanced Materials & Devices
  - Energy Materials
- Jeju Global Res. Ctr.
  - Marine Energy Convergence & Integration
  - Wind Energy
  - Operation & Management
- Technology Transfer & Commercialization
  - Technology Commercialization
  - SMEs Support
  - Quality Management
- Convergence Research

- Partnerships, Strategy & Policy
  - Energy Policy Research
  - Public Relations
  - International Cooperation
- Planning & Coordination
  - Planning
  - Budget
  - R&D Project Management
  - Knowledge & Information
- Administrative Management
  - Personnel Management
  - General Affairs
  - Accounting & Finance
  - Procurement & Asset
  - Maintenance
  - Safety Supervision
- KIER Overseas Branch
- R&D Center for Reduction of Non-CO_2 Greenhouse Gases

1 vice president, 9 divisions, 20 laboratories, 11 offices, 7 teams, 6 centers, 1 branch

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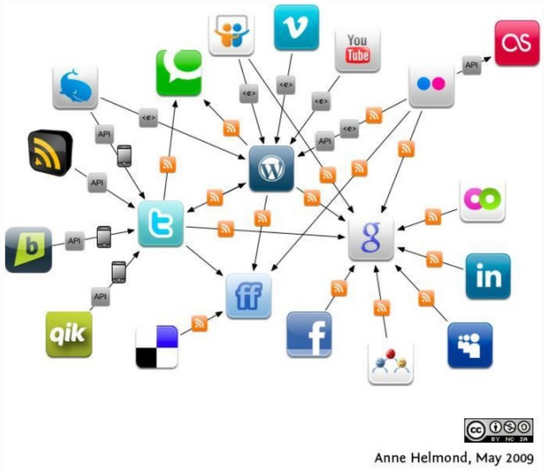
Chapter 02

An overview of KIER R&D on Thermal Energy Network

The KIER, a global energy innovator, does its best in pursuing its mission to invent world-class energy technologies based on open innovation, life-cycle research quality assurance, participatory and open communication. Therefore the KIER will become the best energy technology R&D institute in the world, contributing to the creation of wealth and improvement of quality of life for the people.

Where is a network or grid ?

http://blog.skenergy.com/1707

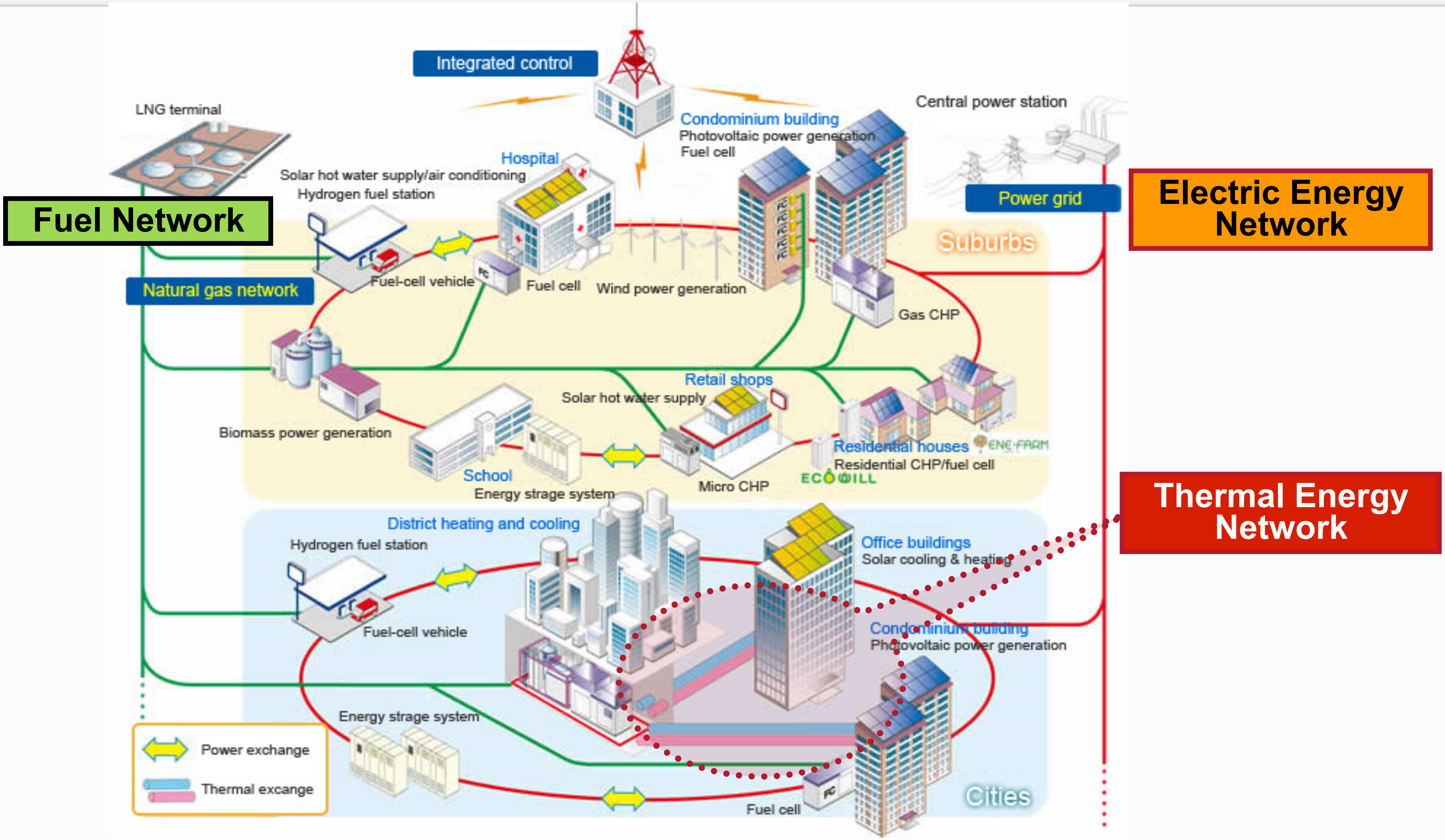


http://pcgladiator.blogspot.kr/2009/01/crazy-highway-intersections.html

http://kamerican.com/GNC/new/secondary_contents.php?article_no=8&no=1201

http://cfile21.uf.tistory.com/image/22662E3B54D44EB1301038

Energy Networks



http://www.tokyo-gas.co.jp/techno/challenge/002_e.html

KIER's approach to thermal energy network

Electric Energy Network

- Driving potential : Electric potential difference
- Transmission loss : relatively low (estimated by 4% in Korea)

Fuel Network

- Driving potential : Pressure difference between the ends of supply and demand
- Transmission loss : relatively low (∵energy density is high)

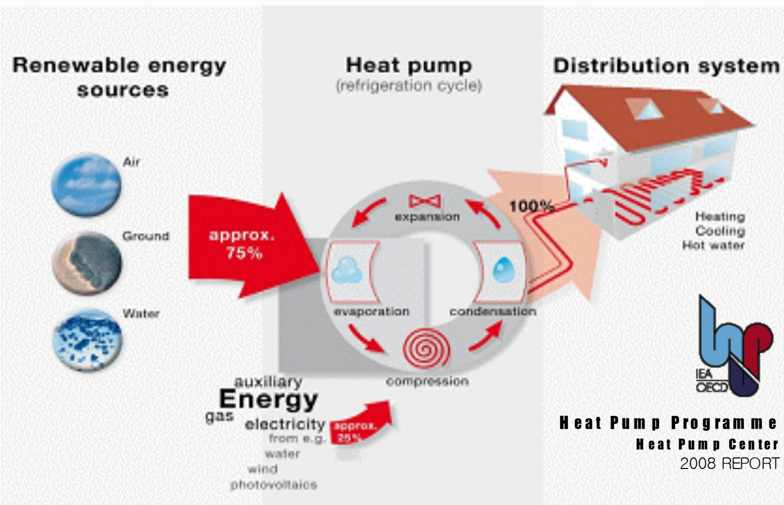
Thermal Energy Network

- Driving potential : External work by pump to secure pressure difference
- Transmission loss : high
  - Increased pumping power for long distance supply
  - Large portion of heat rejected during transmission

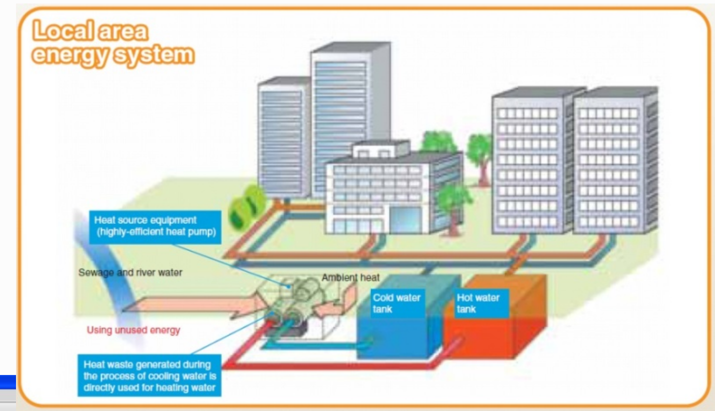
- Therefore, thermal energy must be generated near demand site and transmitted.
- KIER's approach : introducing a concept of heat pump-based thermal energy supply system near demand site, which is called "THERMAL STATION"

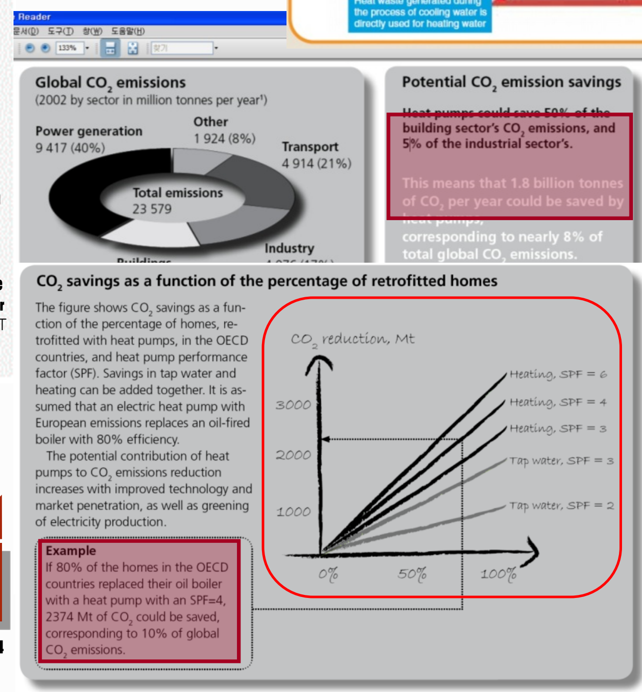
Why heat pump?

- Minimization of energy consumption to produce thermal energy



Heat Pump Programme
Heat Pump Center
2008 REPORT





Global CO_2 emissions

(2002 by sector in million tonnes per year[1])

Power generation 9 417 (40%)

Other 1 924 (8%)

Transport 4 914 (21%)

Total emissions 23 579

Industry

Potential CO_2 emission savings

Heat pumps could save 50% of the building sector's CO_2 emissions, and 5% of the industrial sector's.

This means that 1.8 billion tonnes of CO_2 per year could be saved by heat pumps, corresponding to nearly 8% of total global CO_2 emissions.

CO_2 savings as a function of the percentage of retrofitted homes

The figure shows CO_2 savings as a function of the percentage of homes, retrofitted with heat pumps, in the OECD countries, and heat pump performance factor (SPF). Savings in tap water and heating can be added together. It is assumed that an electric heat pump with European emissions replaces an oil-fired boiler with 80% efficiency.

The potential contribution of heat pumps to CO_2 emissions reduction increases with improved technology and market penetration, as well as greening of electricity production.

Example

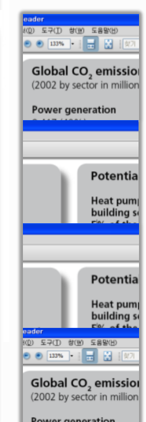
If 80% of the homes in the OECD countries replaced their oil boiler with a heat pump with an SPF=4, 2374 Mt of CO_2 could be saved, corresponding to 10% of global CO_2 emissions.

Cut 8 % of total global CO_2 emission

100% replace with SPF=3

CO_2 cut increases to 10 %

80% replace with SPF=4



2446W급 화력발전소

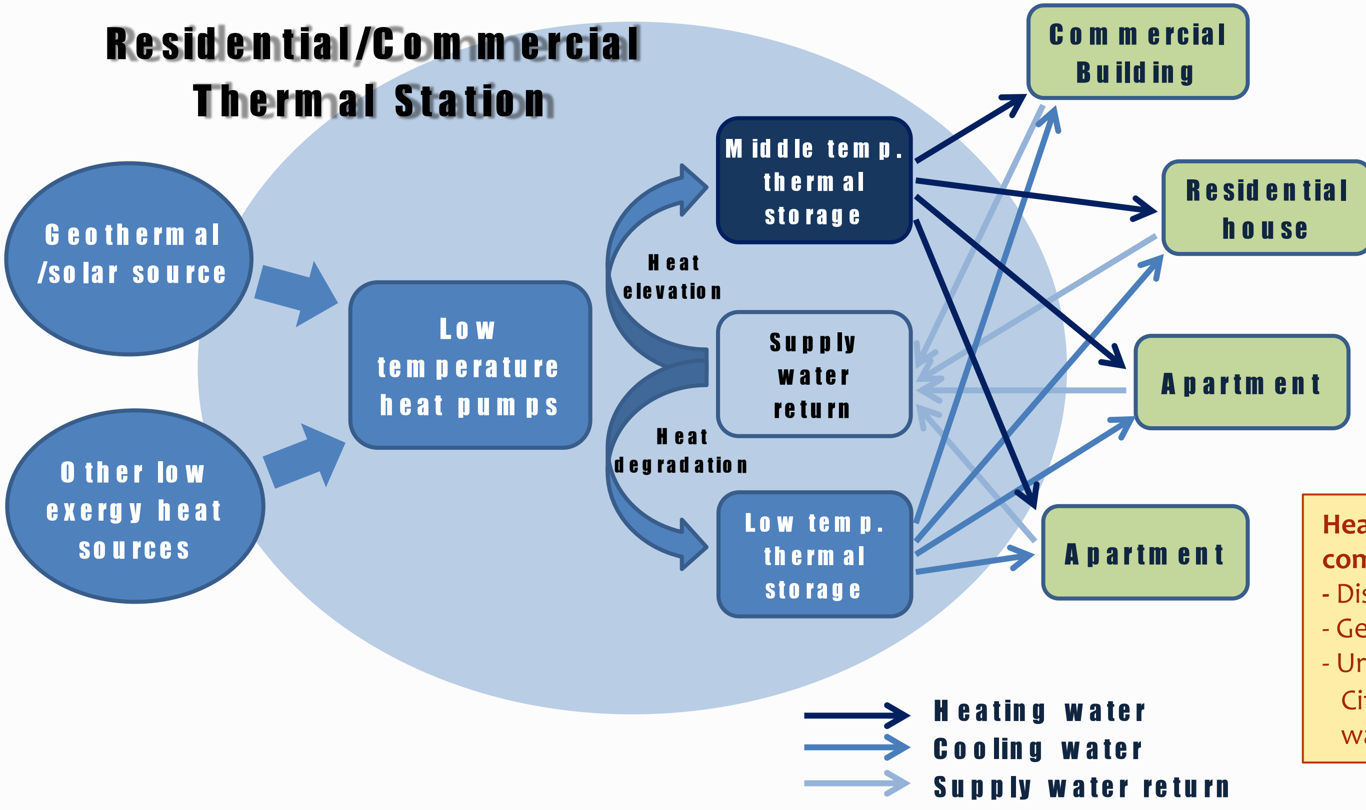
나무 5천만 ha

자동차 5,200만대

원유 7천8백억 리터

Thermal station for a residential application

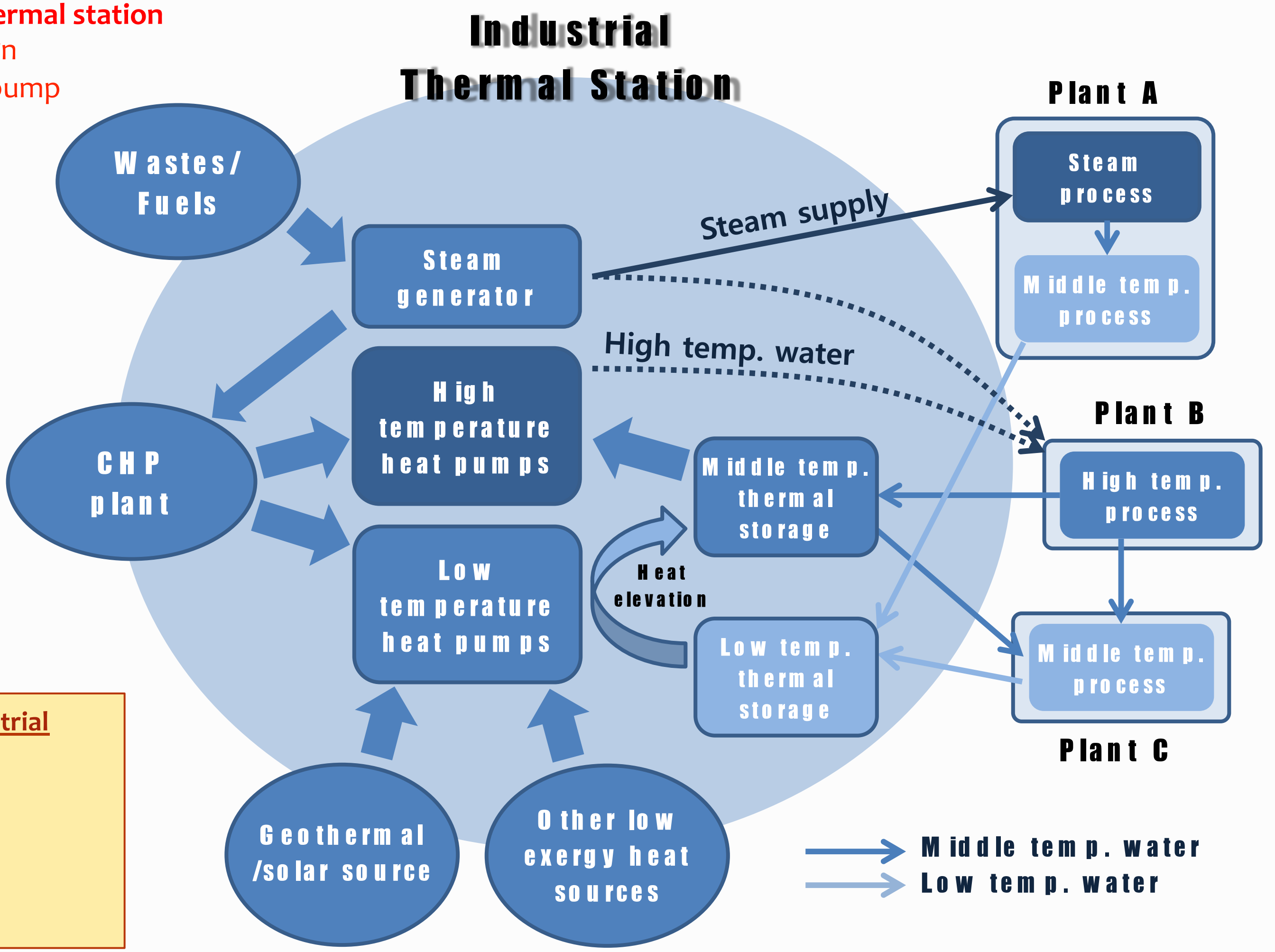
- **Low temperature thermal network**
- Minimization of combustive heat production facilities
- Short-distance network using heat pump systems



Heat source for residential/ commercial thermal station
- Distributed heat source supply
- Geothermal/solar heat
- Urban low exergy heat sources : City water, apartment sewage water, underground water

Thermal station for an industrial application

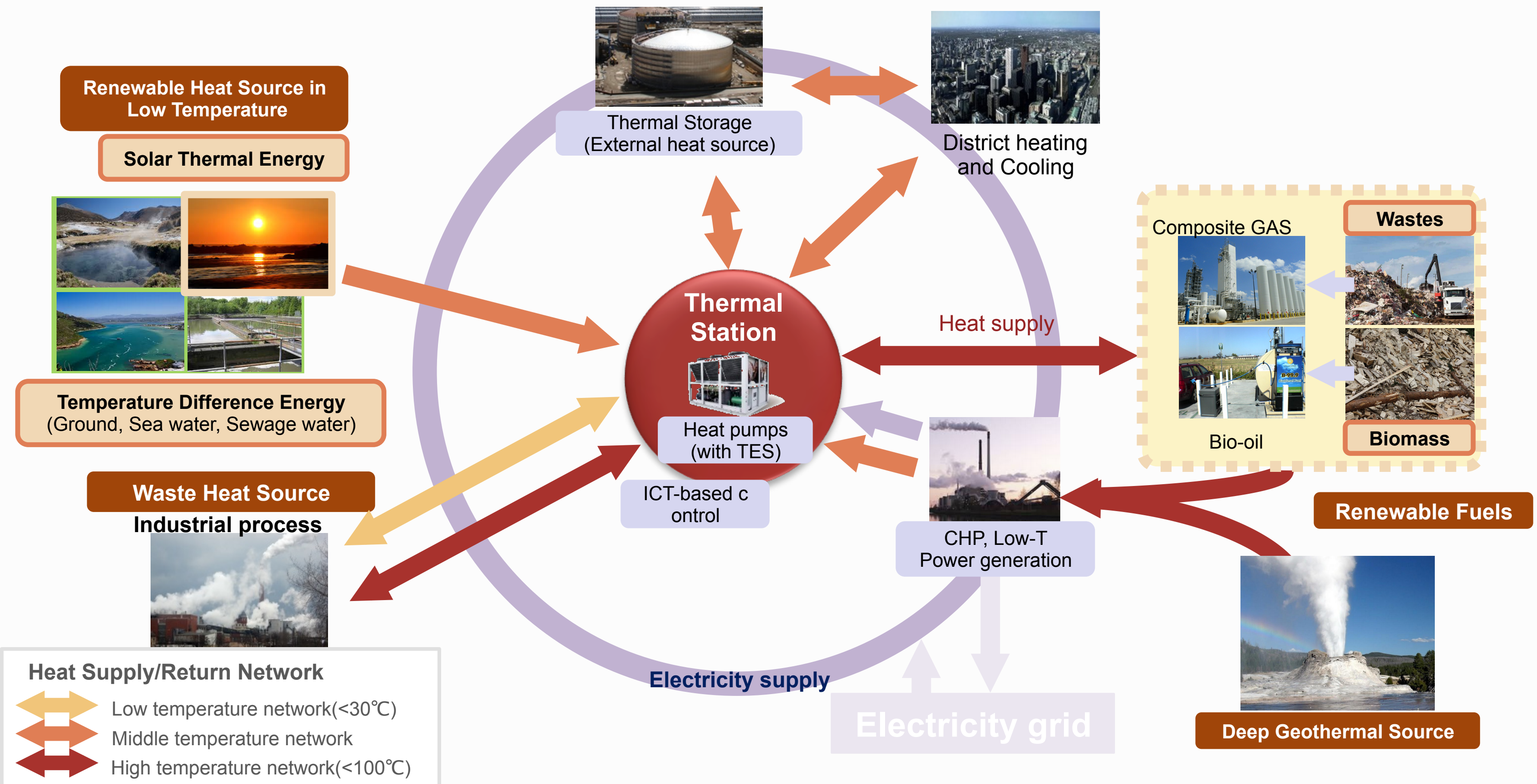
- **Combustive energy from biomass/waste fuels to produce high temperature supply for industrial thermal station**
  - Heat exchange network design
  - Ultra high temperature heat pump
  - Waste heat storage



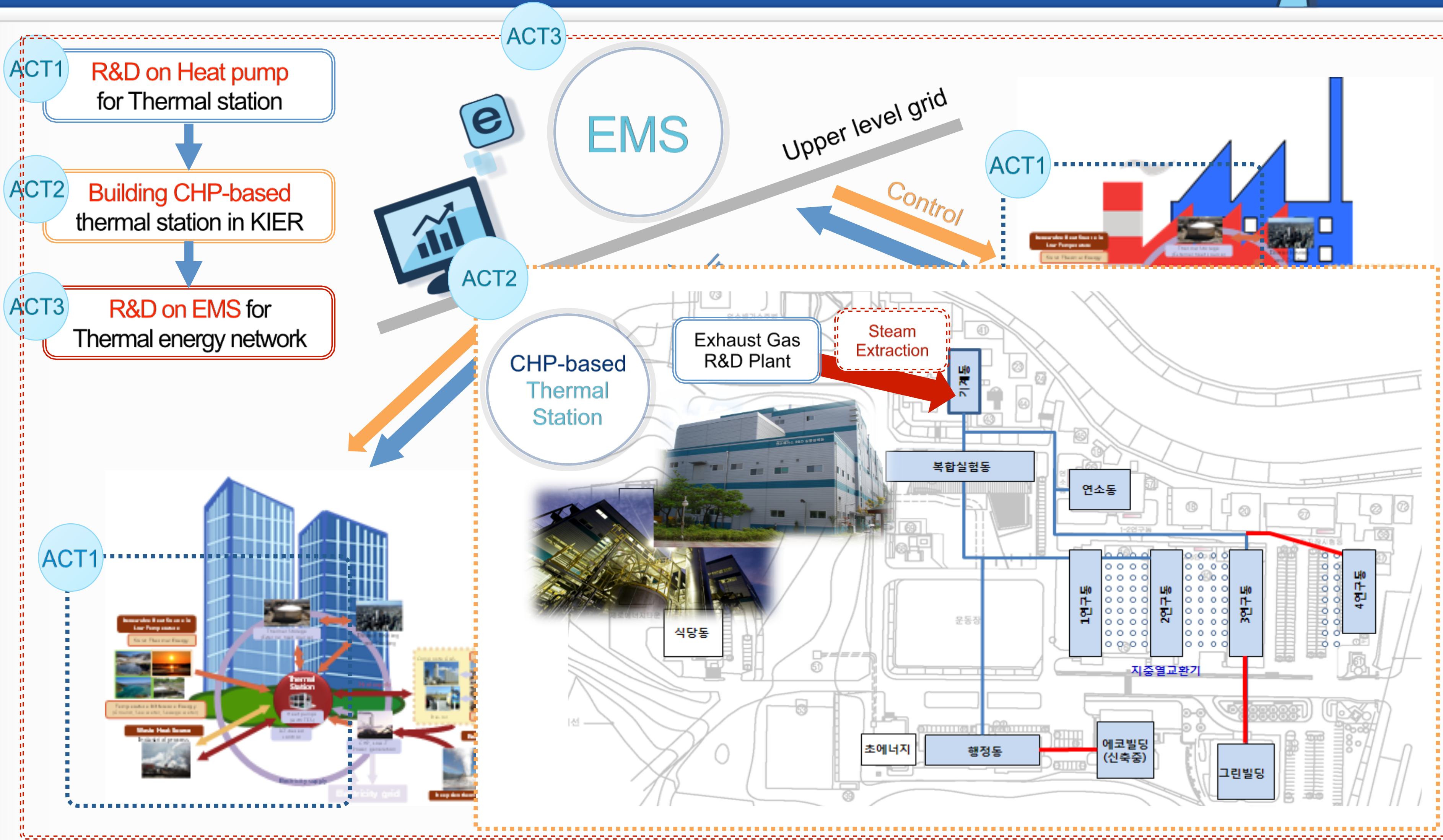
Heat source samples for industrial thermal station
- Heat sources of residential/ commercial thermal station
- Industrial waste heat
- Wastes/biomass fuels
- Sewage treatment center

Graphical representation of KIER's concept for a thermal station

- Objective : Minimizing energy use in thermal energy production by utilizing available resources near demand



Thermal energy network



Brief history of KIER R&D on Thermal Energy Network

- **Vision : Implementation of zero-waste energy network**
- Budget : $1M/yr for 2015-9
- Target for 2025 : 20% of energy saving in cooling and heating at KIER campus

Concept building (~2011)

- Heat pump-based thermal station
- Thermal station-based TEN

Core technologies for thermal station (2011~)

- KIER 3025 project planning
- Sea water source heat pump
- Industrial heat pumps

Lab-scale demonstrative R&D (2013~)

- KIER Energy Center
- Local EMS for uni-directional thermal energy supply system with a local source
- EMS for bi-directional thermal energy network
- Smart meter

μGrid-scale demonstrative R&D (2017~)

- Renewable-hybrid
- KIER 3025 project completion
- μGrid-scale demonstrative R&D planning

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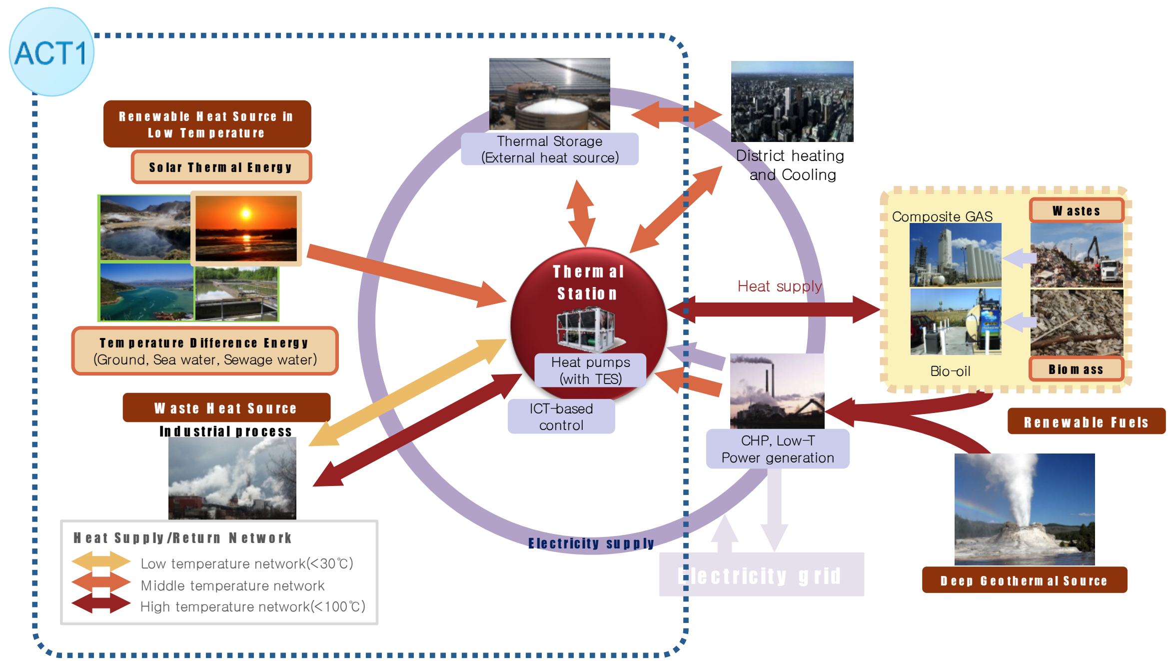
Chapter 03

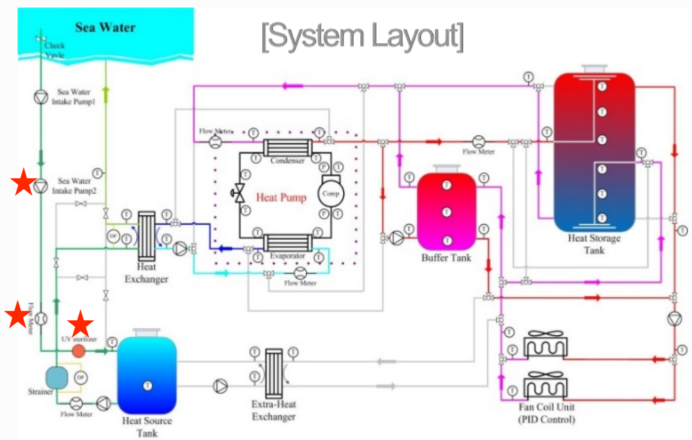
KIER's Activities I

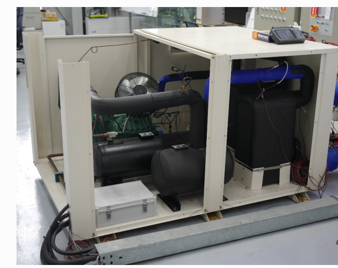
- R&D on heat pumps for TEN
  - Sea water source heat pump for a low-temperature TEN
  - Medium- and high-temperature heat pump for an industrial TEN

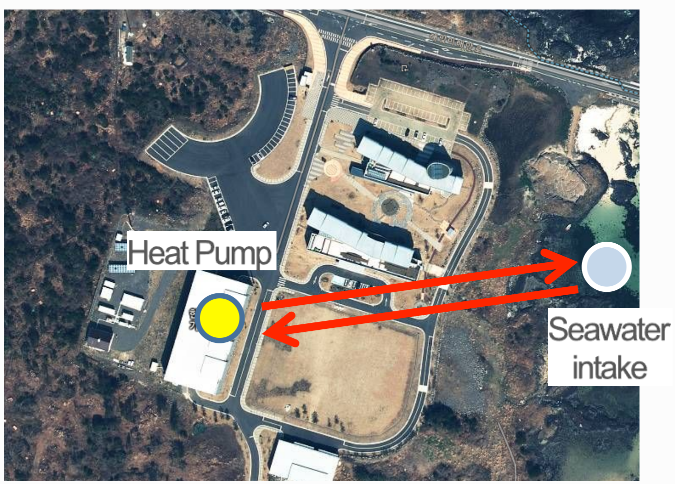


Sea water source heat pump for a low-temperature thermal energy network

- Objective of project : Development of CFC/HCFC-free 20 RT SWSHP
- Target performance
  Cooling COP in summer season : 4.5, cooling supply : 7℃ at sea water of 25℃
  Heating COP in winter season : 3.3, heating supply : 50~60℃ at sea water of 10℃
- Expected payback period : 5.9 year (with a subsidy from gvmt)

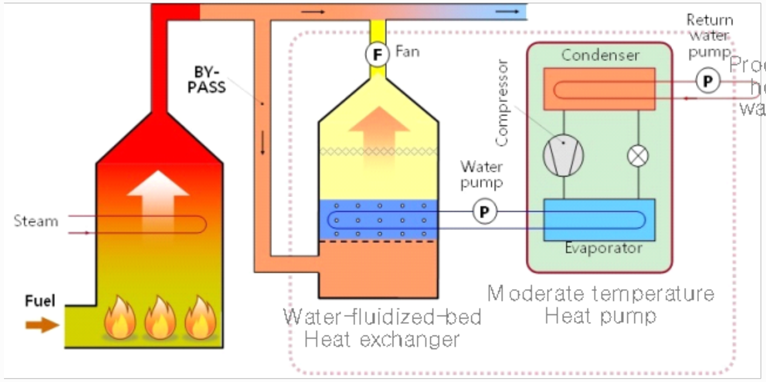


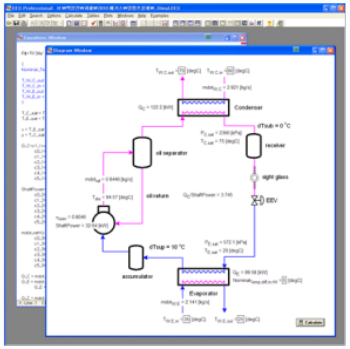




Demonstrative R&D on medium-temperature heat pump for an industrial TEN

- Objective of project : Development of waste heat recovery Heat Pump for industrial purpose
- 100kW of heating capacity with a heating COP of 3.5 at 65-70℃ of hot process water
- Increase in boiler efficiency : 8%
  (Fuel consumption reduction: 12 kg/h, cost reduction: $44,000/year)
- Expected payback period : 3.5 year



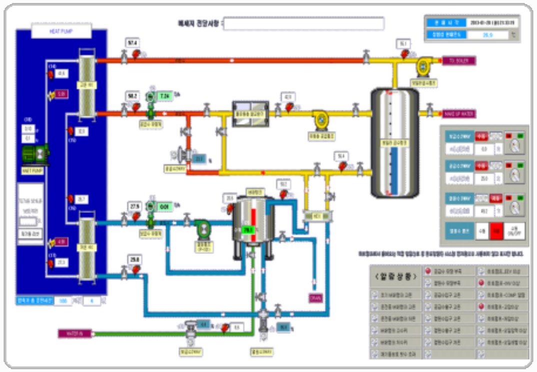


HP cycle analysis

Demonstration plant (Lotte food Co. Ltd.)

Water-fluidized-bed Heat exchanger

Heat pump

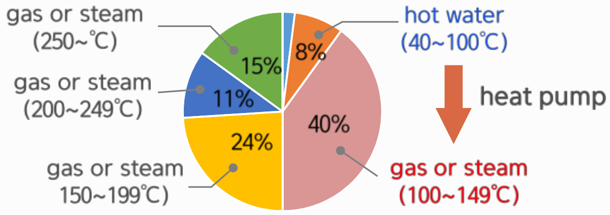


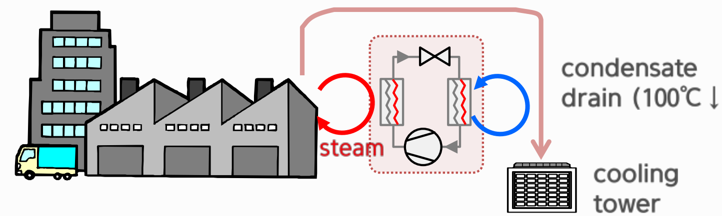
Control/ monitoring system

On-going project on high-temperature steam generation heat pump for an industrial TEN

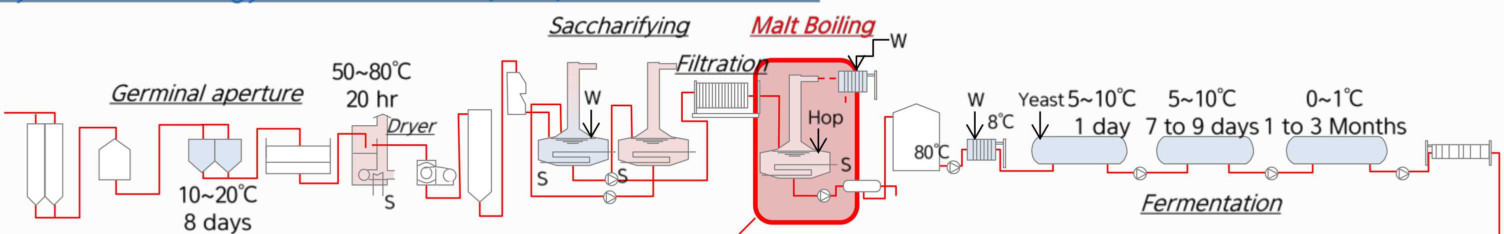
- Objective of project : Development of steam generation Heat Pump for industrial purpose
- Target performance : 300kW of heating capacity with a heating COP of 3.2 at 120℃ of steam temperature

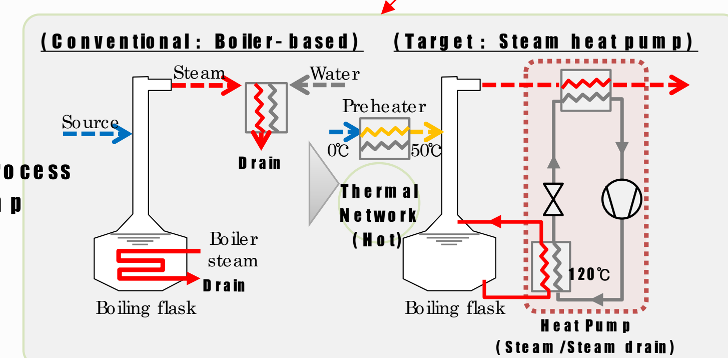
[Heats in industrial sector (Japan)]

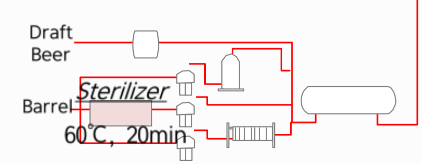




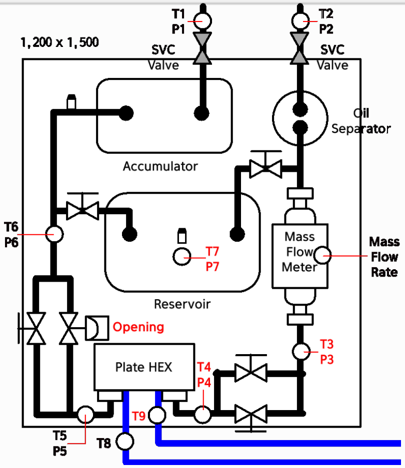
Case Study : Thermal energy network in Food (Beer) Production Process



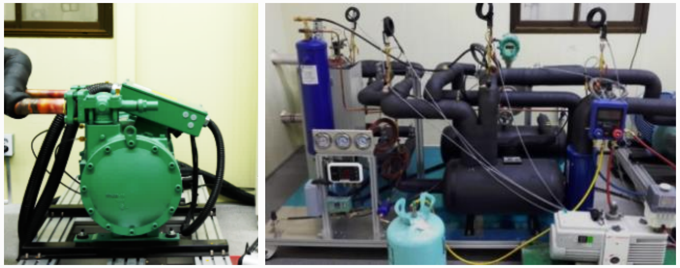




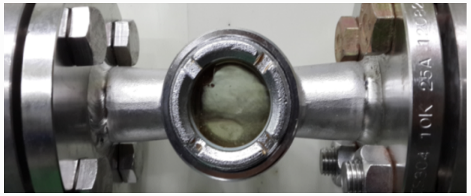
Building a TEN in malt boiling process by introducing a steam heat pump



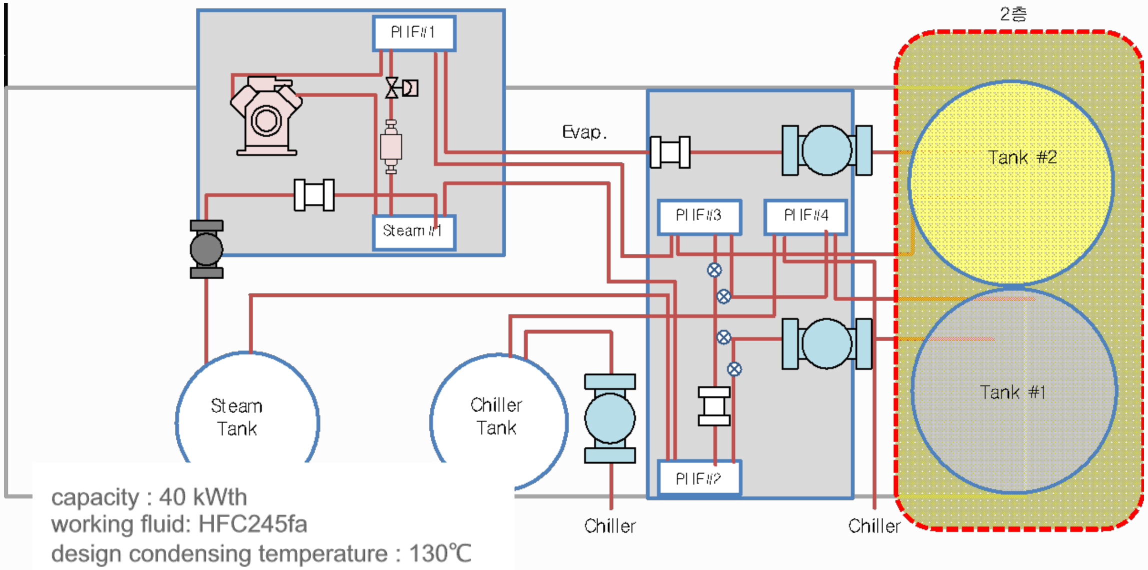
Prototype steam generation heat pump (40 kW) test loop



Compressor reliability test loop



100℃ of steam generated (quality = 0.1)



capacity : 40 kWth
working fluid: HFC245fa
design condensing temperature : 130℃

Steam generation heat pump system layout

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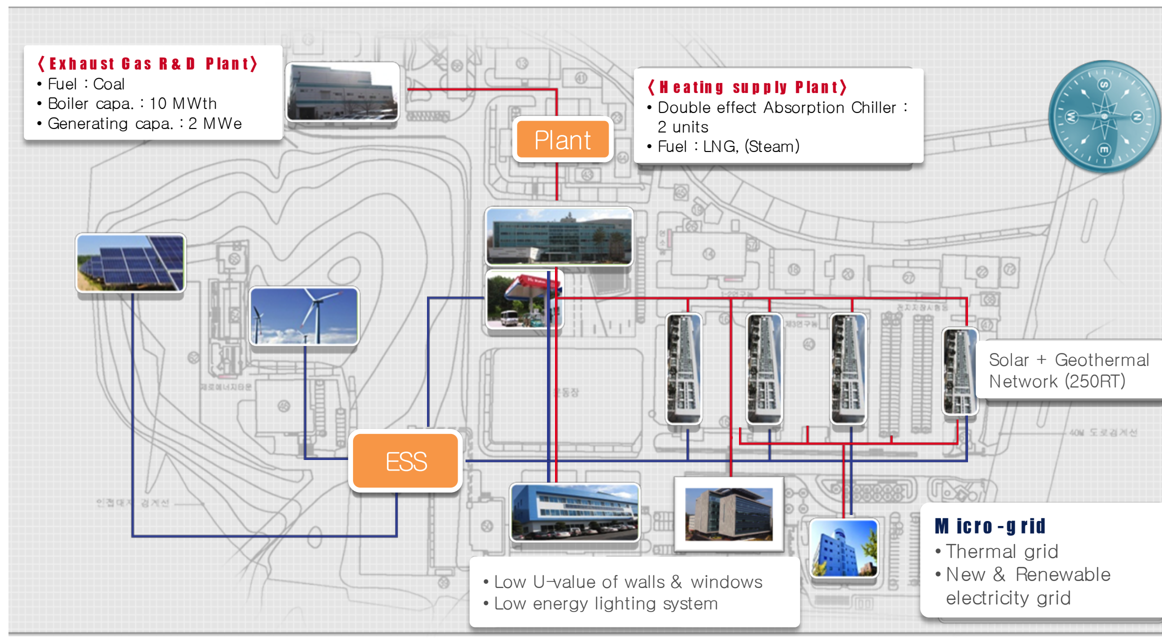
Chapter 04

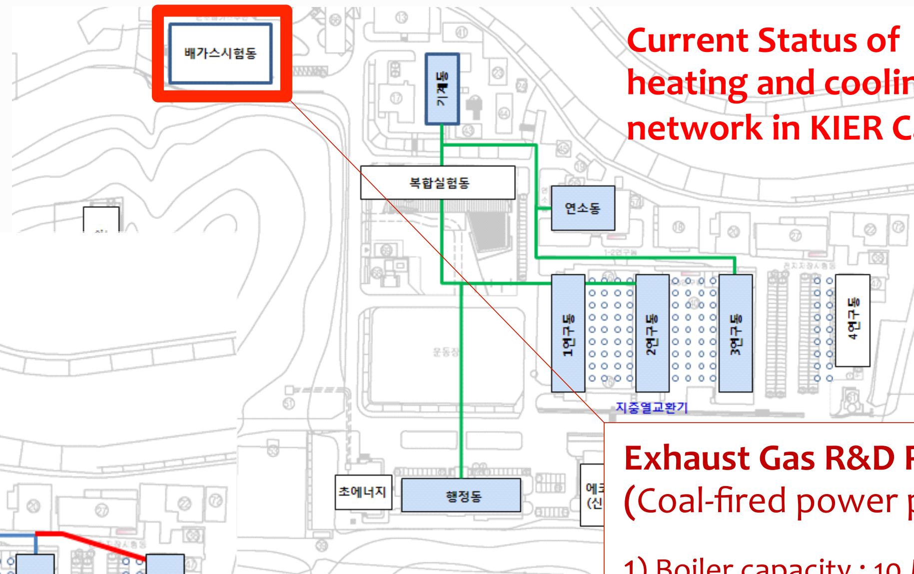
KIER's Activities II

- **KIER 3025 Project**
  - Overview of 3025 Project (Demonstrative Research on TEN in KIER campus)
  - KIER Energy Center

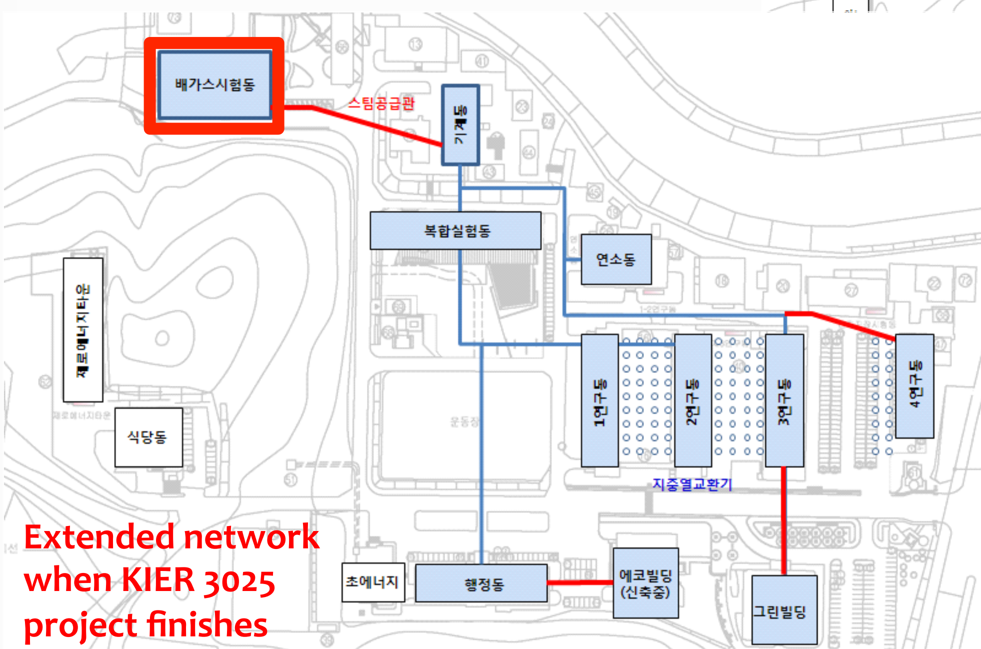


KIER 3025 Project (Demonstrative Research on TEN in KIER campus)

- Targeting KIER Daejeon headquarters to reduce 30% of energy consumption
- Remodeling 'Exhaust Gas R&D plant' into thermal station having combined heat and power plant



Current Status of heating and cooling supply network in KIER Campus



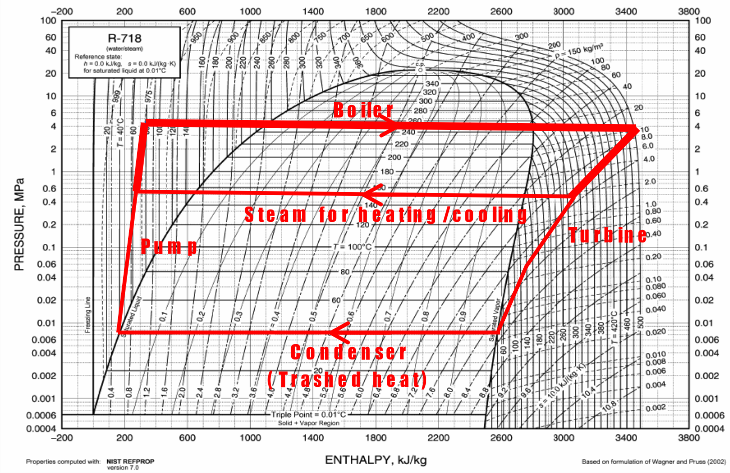
Extended network when KIER 3025 project finishes

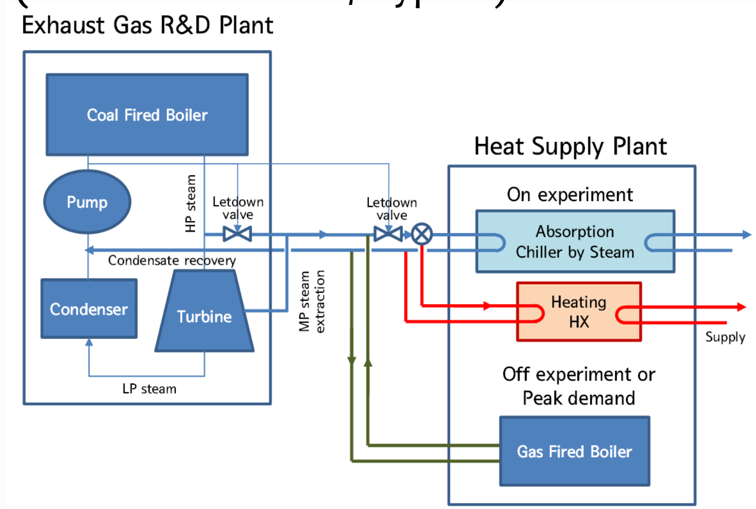
Exhaust Gas R&D Plant
(Coal-fired power plant)

1) Boiler capacity : 10 MWth
2) Electric capacity : 2 MWe
3) Operating schedule : 50%
4) Steam condition
   - Temperature : 450℃
   - Pressure : 46 kg/㎠.g
   - Enthalpy : 800 kcal/kg
   - Mass rate : 12,000 kg/h
5) Steam Rankine cycle

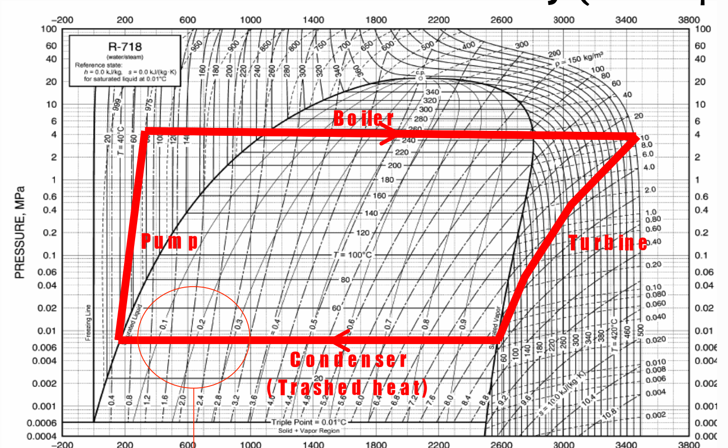
Scenario-based analysis on TEN in KIER campus

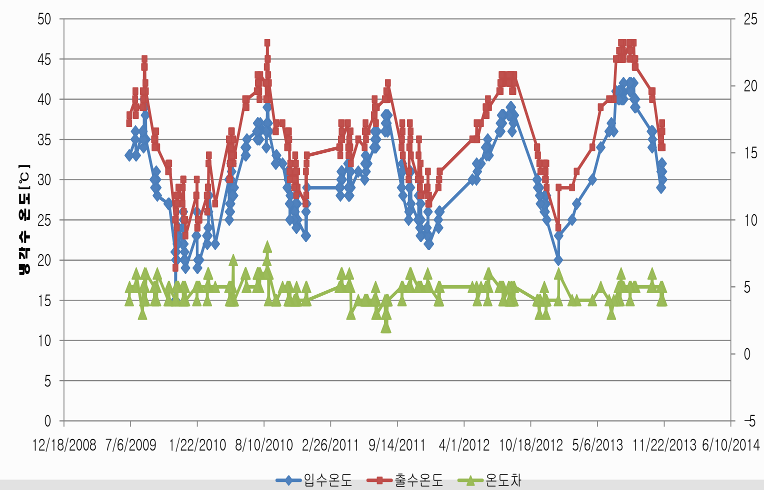
- **Case 1 : Combined Heat and Power Application** (Steam extraction / bypass)





- **Case 2 : Condenser Heat Recovery** (Absorption heat pump of type I)

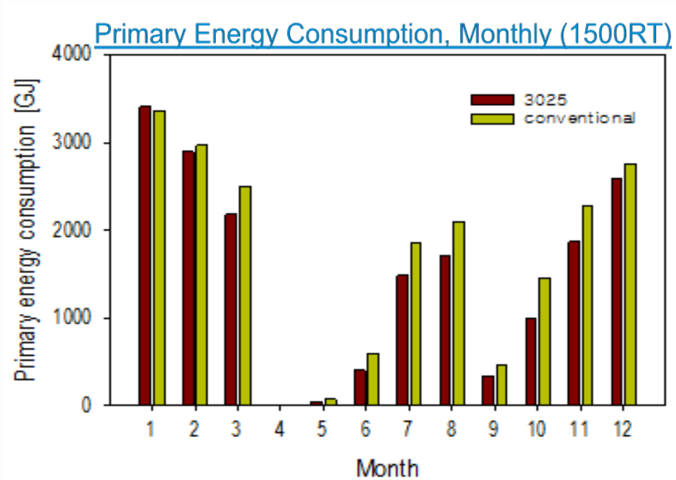


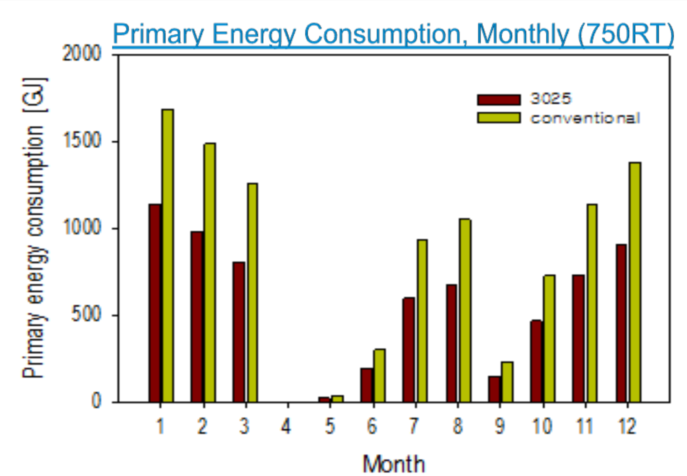


- Direct utilization of condenser waste heat

Cost estimation and economic analysis

- 35% of energy saving (equiv. $140 thousands of annual cost saving)

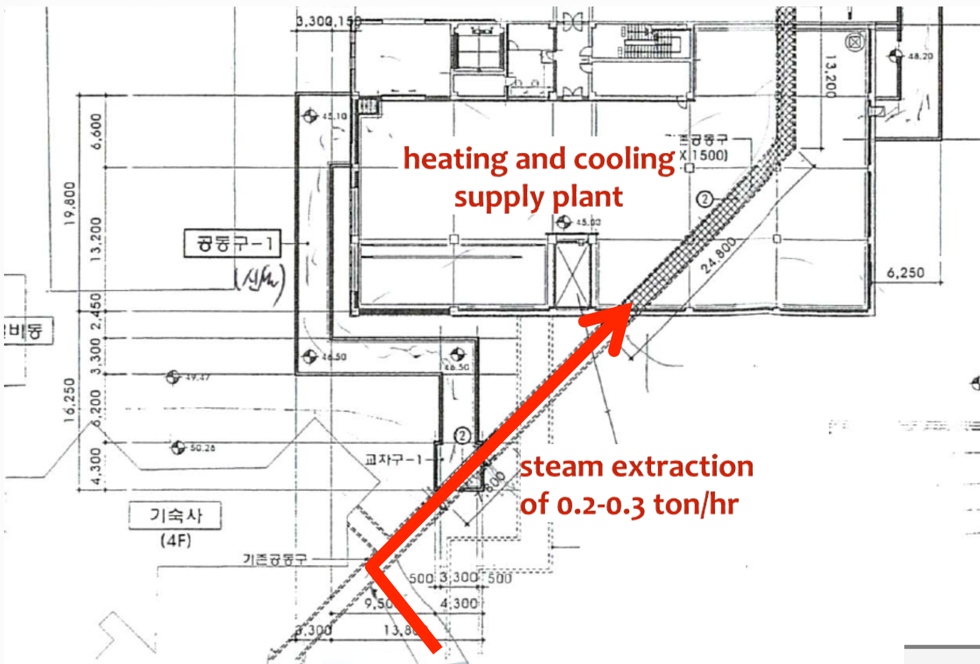




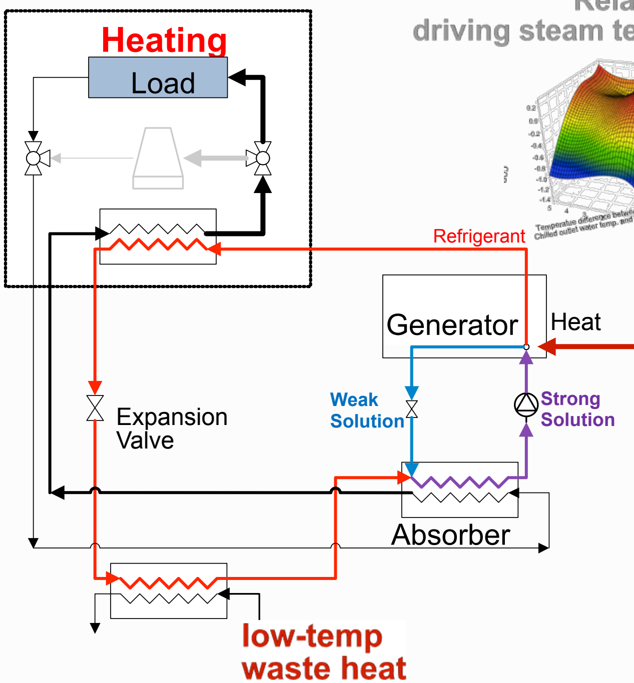
	1500RT	750RT
Layout	Extraction ≒ By-pass (Applied to total thermal network of KIER)	Extraction ≫ By-pass (excluding Green Bld., Eco Bld., Complex Tech. Bld.)
Energy saving (based on LHV)	About 12.4% per year - Heating energy saving: 10% - Cooling energy saving: 22%	**About 34.7% per year** - Heating energy saving: 34% - Cooling energy saving: 36%
Cost saving (Energy cost)	About $270 thousand per year Heating: $230 k/ Cooing $40 k	**$140 thousand per year**
remarks	Effect of electricity reduction in EHP equipped Bld. wa s not considered in cost saving analysis	Net investment budget to building thermal energy net work is $400 thousand and estimated pay back period is about 3 years.

Piping /facilities planning for a demonstrative thermal station

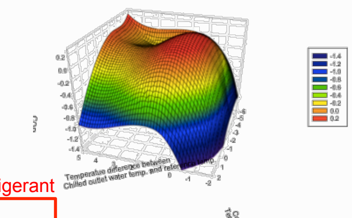
Steam extraction + Absorption HP (350 kWth-class)



Exhaust Gas R&D Plant
(Coal-fired power plant)



Relation between driving steam temp and COP

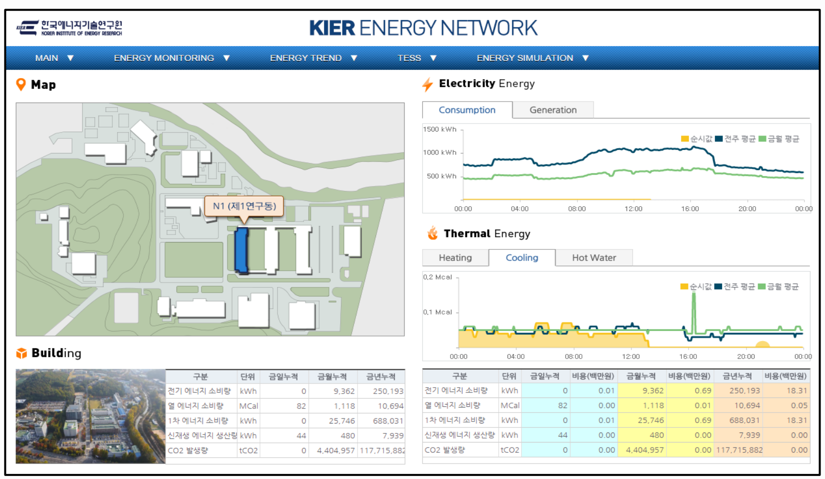


	Conventional gas-fired AHP	Extracted steam driven AHP
heating capacity	350 kWth	
thermal energy input	350 kWth	206 kWth
primary energy consumption	412 kWth **(100%)**	242 kWth **(59%)**

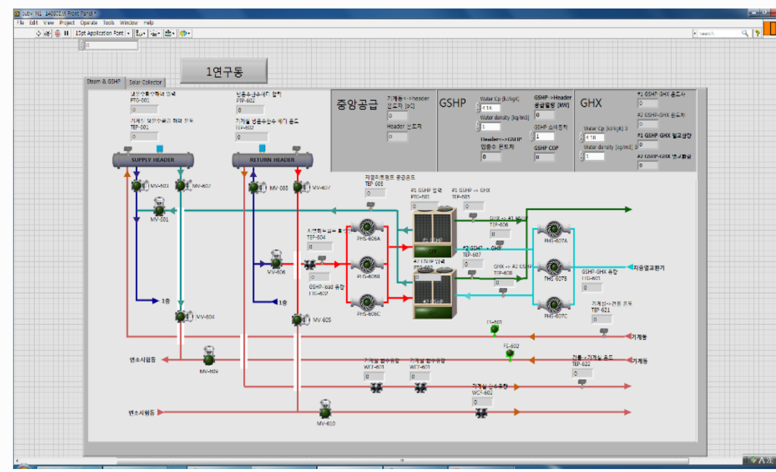
Real-time Energy Monitoring System (KIER Energy Center)

- Goal : Optimizing energy use in KIER campus
- Features
  - Real-time monitoring
  - Tag list of total 9,648 points
  - Web-based access/ Ethernet protocol
  - RTDB access through web browser
  - Web-based simulation

KIER Energy Center

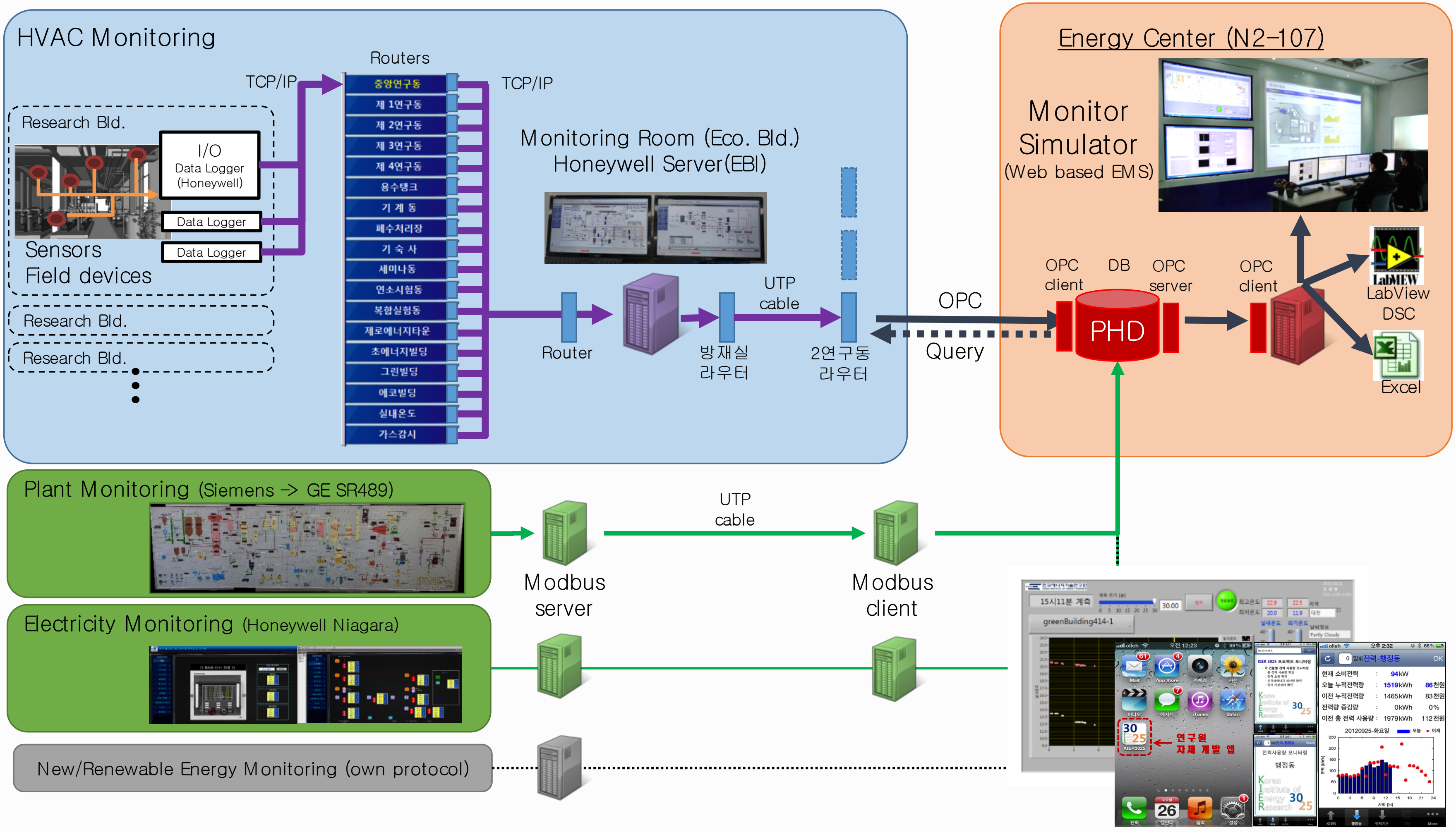


KIER Energy Center Homepage

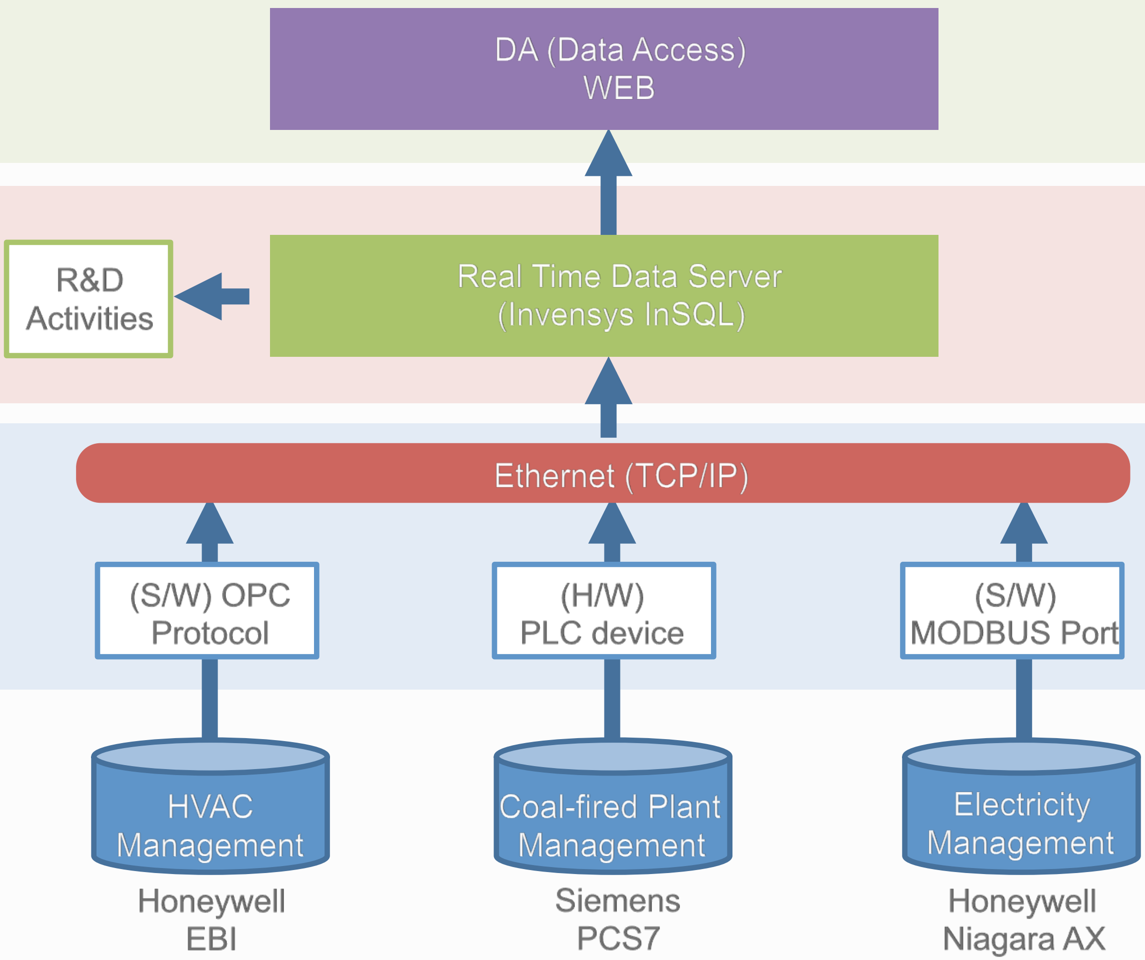


Laboratory building facilities Status

Schematic diagram of data flow



Hierarchial structure of data



Web-based EMS System
- Access RTDB through web browser
- Web-based simulation

Energy Network DB Server
- Tag list of total 9,648 points
  .. Direct access: 9,066
  .. Post-processed : 582

Infra: Ethernet Access
- Network infra (H/W or S/W) to enable access through Ethernet protocol

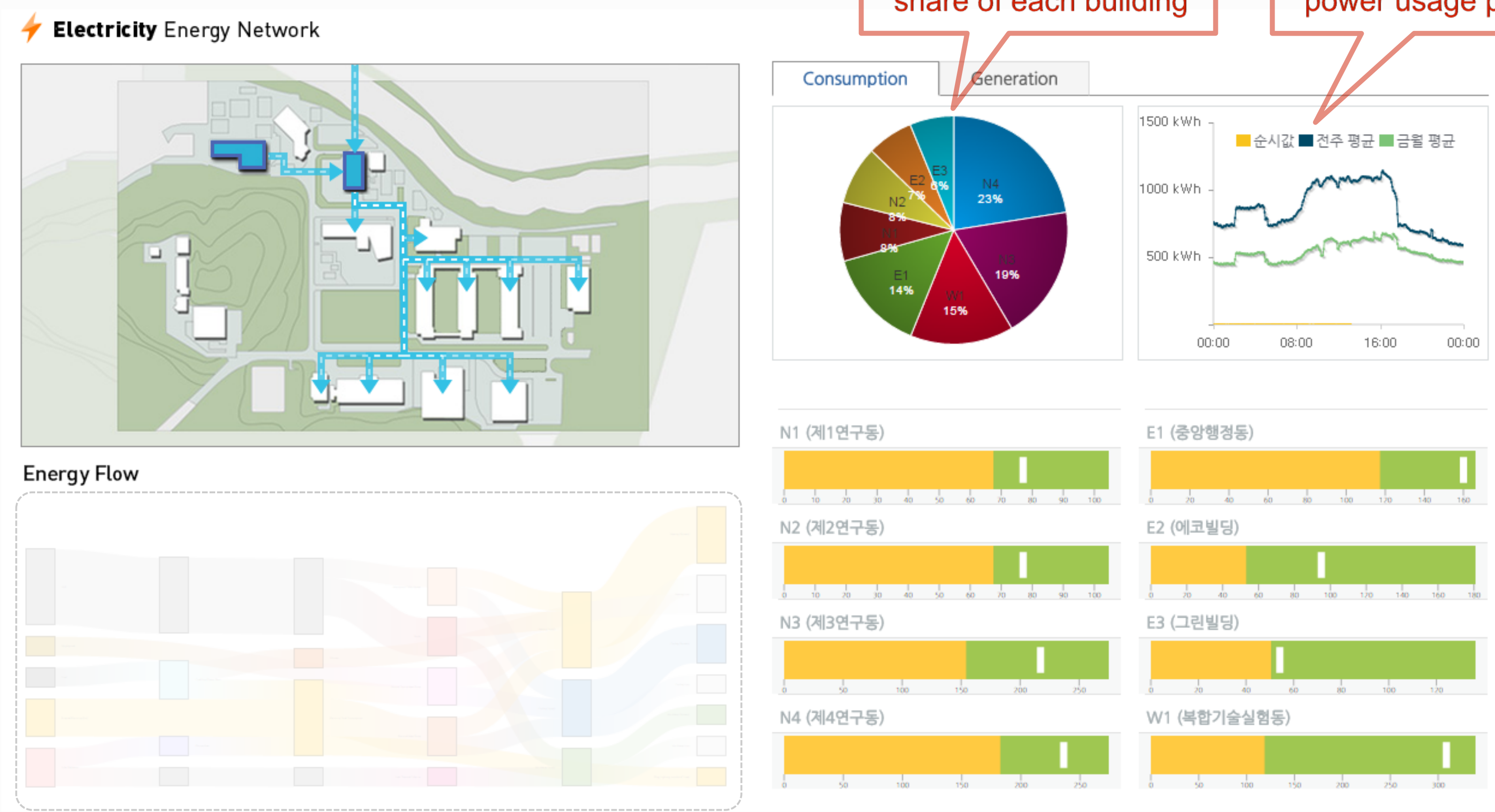
Individual monitoring systems are distributed in buildings respectively

Some features of KIER Energy Center

Real-time Electricity Network status

share of each building

power usage pattern



Real-time office building room temperature

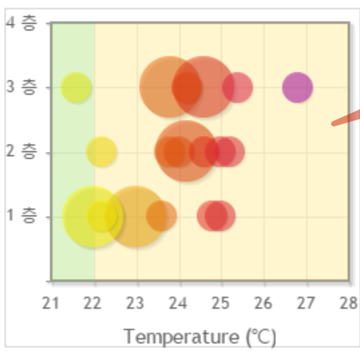
N1 (제1연구동)

실내온도 | 설비

facilities status tab

건물전경

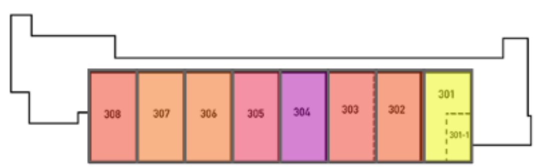
실내온도 분포



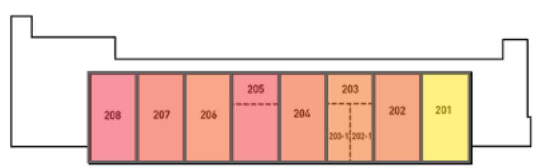
실내온도 모니터링

room temperature distribution

3층

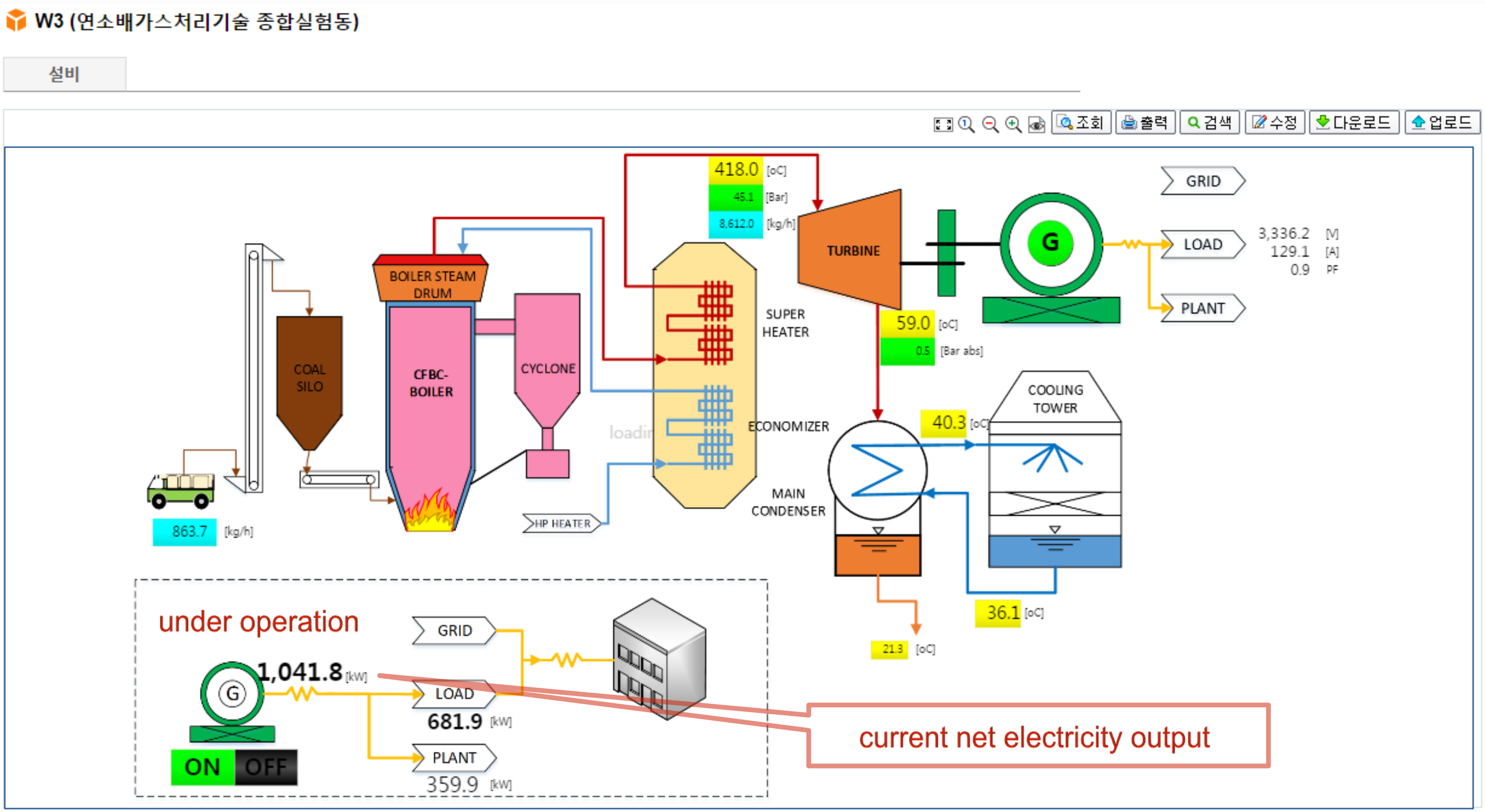


2층



실 명	실내온도	설정온도
101호	22.2	26.5
102호	22.1	26.5
103호	22.2	26.5
104호	23.0	26.5
105호	23.8	26.5
106호	24.9	26.5
107호	25.1	26.5
108호	23.2	26.5
201호	22.4	26.5
202호	24.2	26.5
203호	24.0	26.5
204호	24.4	26.5
205호	25.1	26.5
206호	24.3	26.5
207호	24.7	26.5
208호	25.2	26.5
301호	21.7	26.5
302호	24.3	26.5
303호	24.8	26.5
304호	26.9	26.5
305호	25.5	26.5

Real-time coal power plant operating status

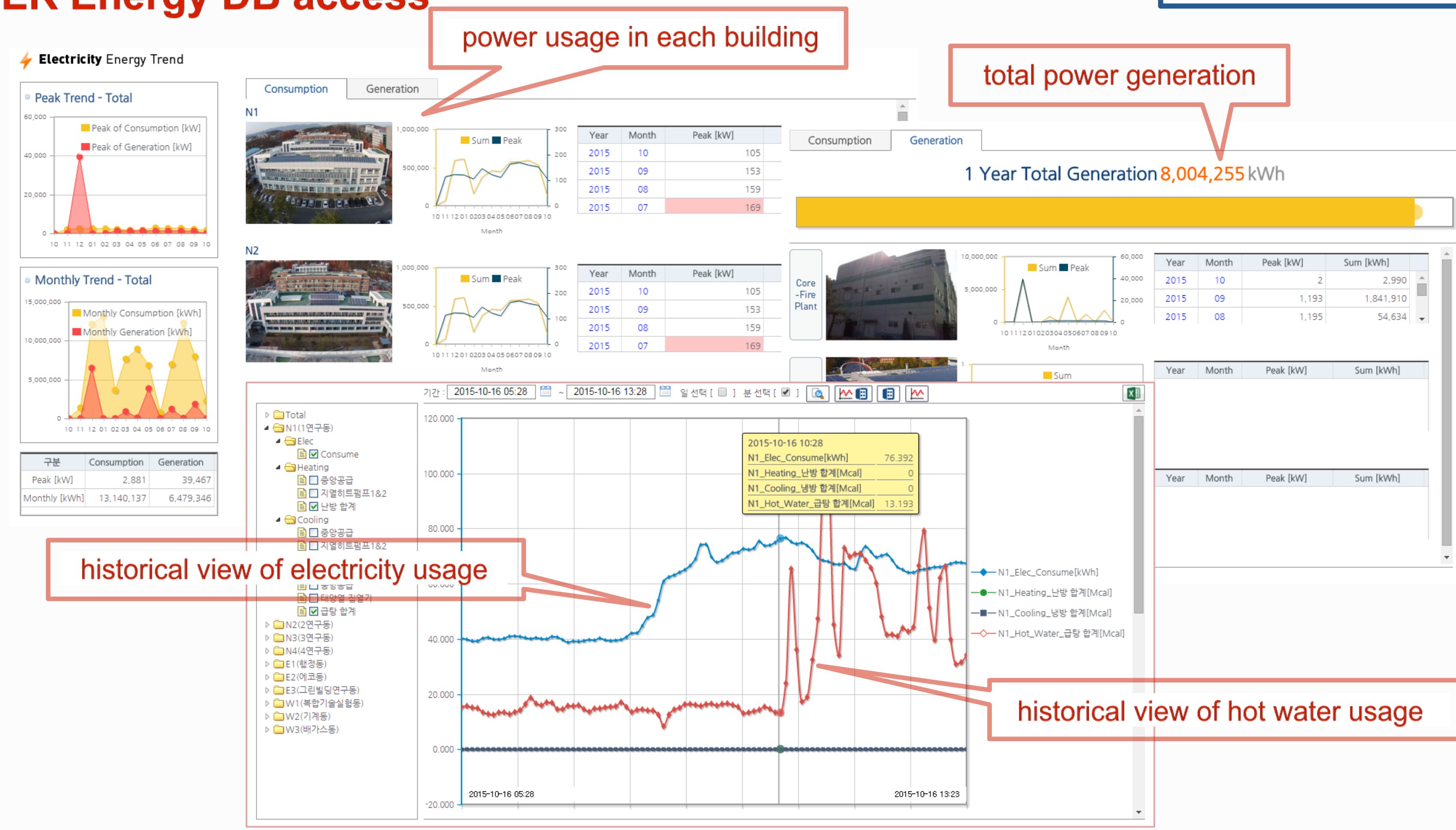


GLOBAL KIER TECHNOLOGIES

KIER

KIER ENERGY CENTER

KIER Energy DB access



GLOBAL KIER TECHNOLOGIES

Goal of KIER 3025 Project

<Exhaust Gas R&D Plant>
- Fuel : Coal
- Boiler capa. : 10 MWth
- Generating capa. : 2 MWe

Plant

<Heating supply Plant>
- Double effect Absorption Chiller : 2 units
- Fuel : LNG, (Steam)

Solar + Geothermal Network (250RT)

ESS

- Low U-value of walls & windows
- Low energy lighting system

Micro-grid
- Thermal grid
- New & Renewable electricity grid

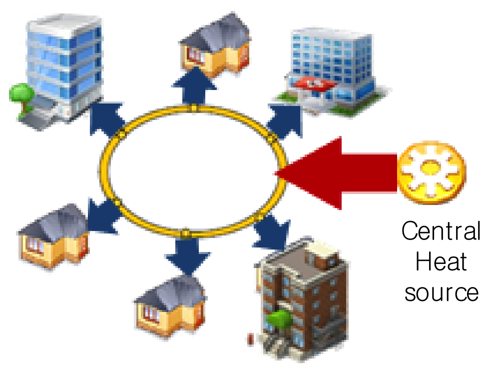
KIER

Chapter 05

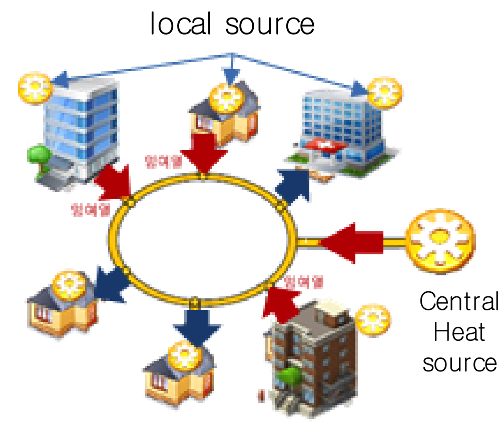
KIER's Activities III

R&D on EMS for TEN

- Local EMS for uni-directional thermal energy supply system with a local source
- EMS for bi-directional thermal energy network



uni-directional supply

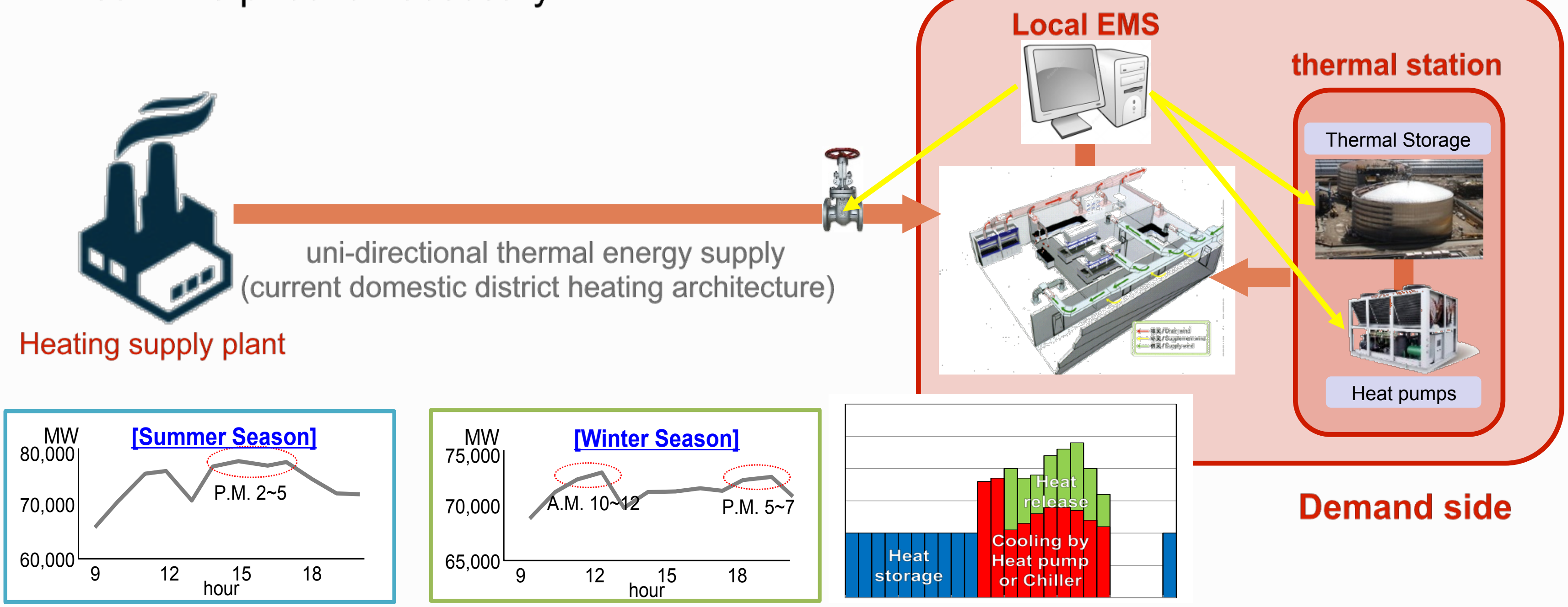


bi-directional supply

Local EMS for uni-directional thermal energy supply system with a local source

Overview

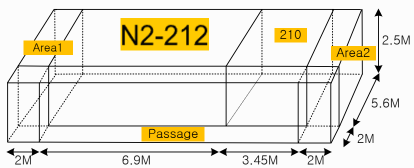
- When a demand has a thermal station, and uni-directional thermal energy supply is also available, we can have a chance of cost or energy saving by using the local EMS.
- Optimal operation strategy of the local EMS considering demand, capacity, and real-time price is necessary.



Simulation approach

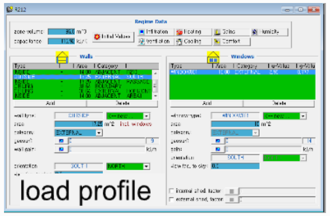
Heating and cooling demand analysis

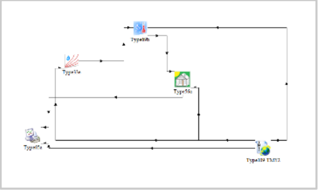
Office model



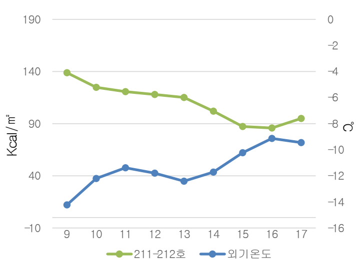
Plan for demonstrative system at the office of N2-212

TRNSYS Simulation

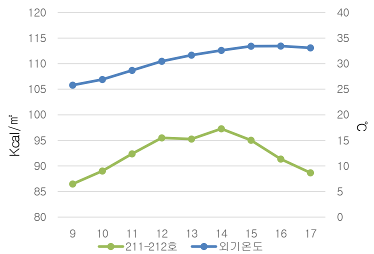




Max. daily heating demand 980kcal/m^2

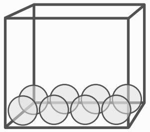


Max. daily cooling demand 830kcal/m^2



Experimental approach

Thermal storage-heat pump-based thermal station



Max. capacity (cooling) 32,000 kcal (x load%)

- Ice: 400 kg(ice)+Brine
- Water: 3,200 kg (ΔT=10℃)
- **PCM: 530 kg(PCM)+Brine**

	phase change temp(℃)	hatent heat (kJ/kg)	density (kg/l)	specific heat (kJ/kgK)
J11	3~5	252.30	0.825	2.07 (s)
W14	5~7	257.29	0.83	-

Thermal energy storage

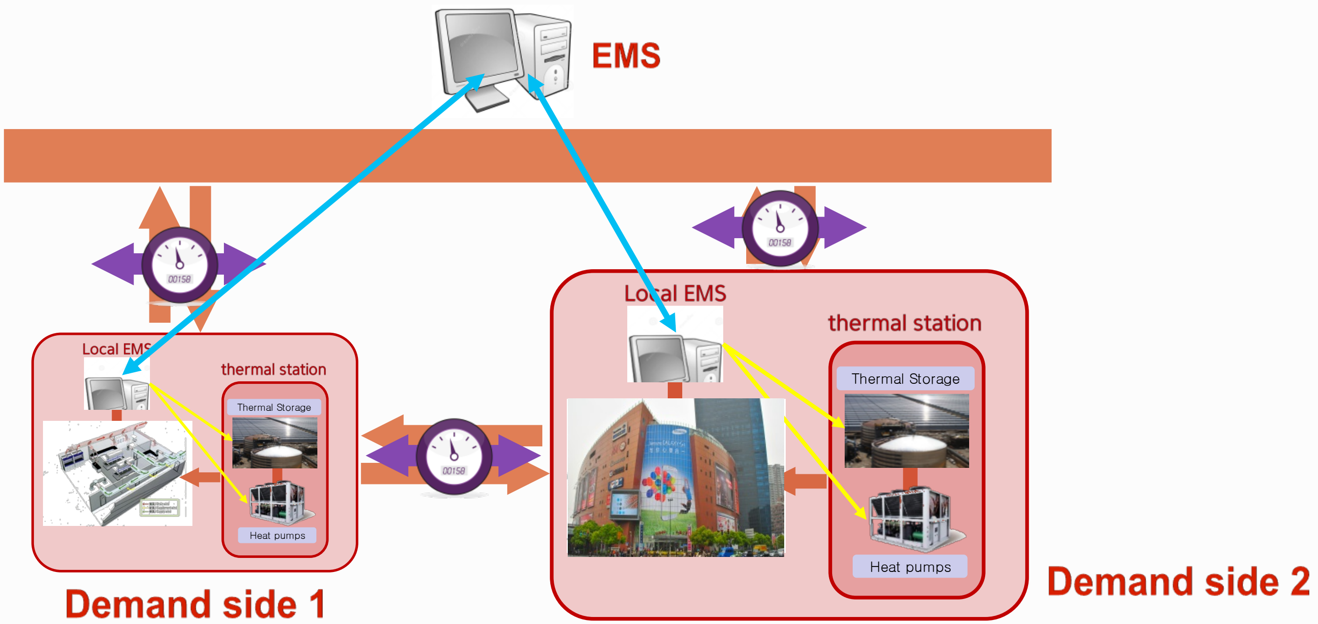
indoor fan coil unit

heat pump

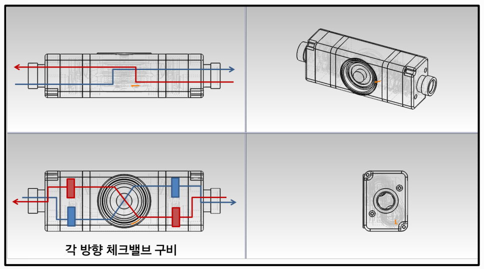
EMS for a bi-directional thermal energy network

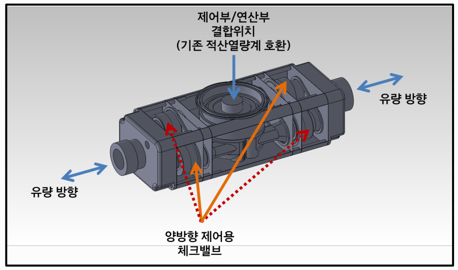
Overview

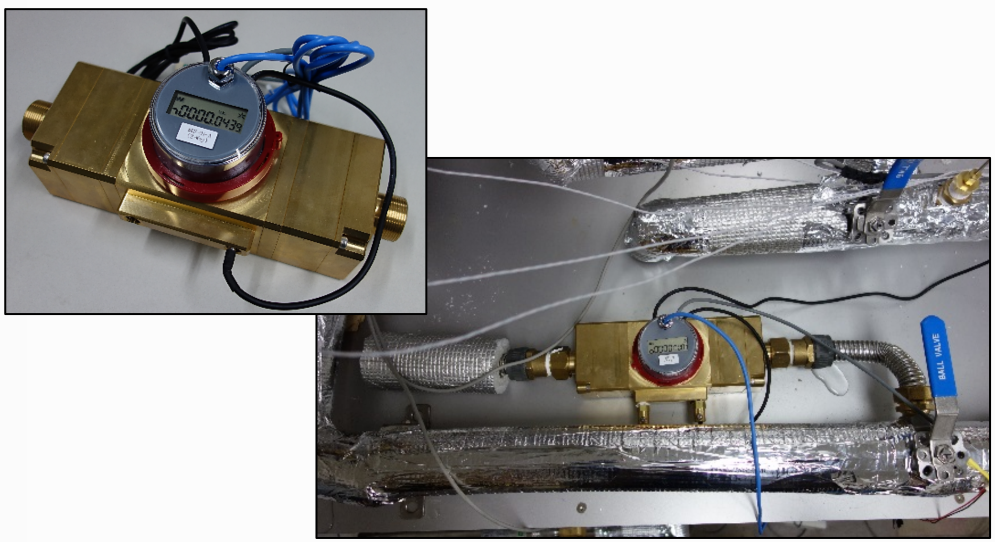
- When multiple demands have different load pattern, we can have a chance of cost or energy saving by transmitting overs and shorts to neighbors.
- Another EMS, which transmits information on neighbors' status to each other, is necessary.
- Bi-directional heat meters are also necessary for a payment.



Bi-directional heat meter





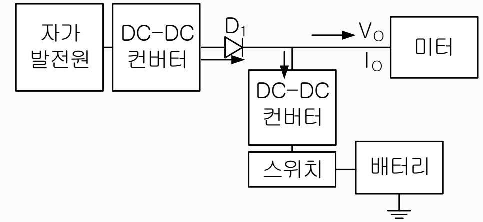


Bi-directional heat meters designed by KIER

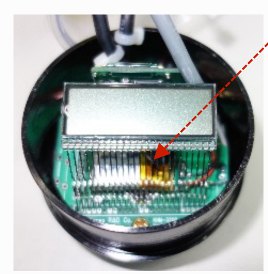
MODBUS RTL bi-directional data transfer protocol

STX	ACQ	LEN	ID	정방향열량	유량당열량	온도	연산유량	역방향열량	Status	CS	ETX
1Byte	1Byte	1Byte	1Byte	5Byte	3Byte	4Byte	1Byte	5Byte	1Byte	1Byte	1Byte

Bit8(MSB)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1(LSB)
⑧	⑦Sensor Error	⑥	⑤	④Reverse flow	③	②	①Battery Low



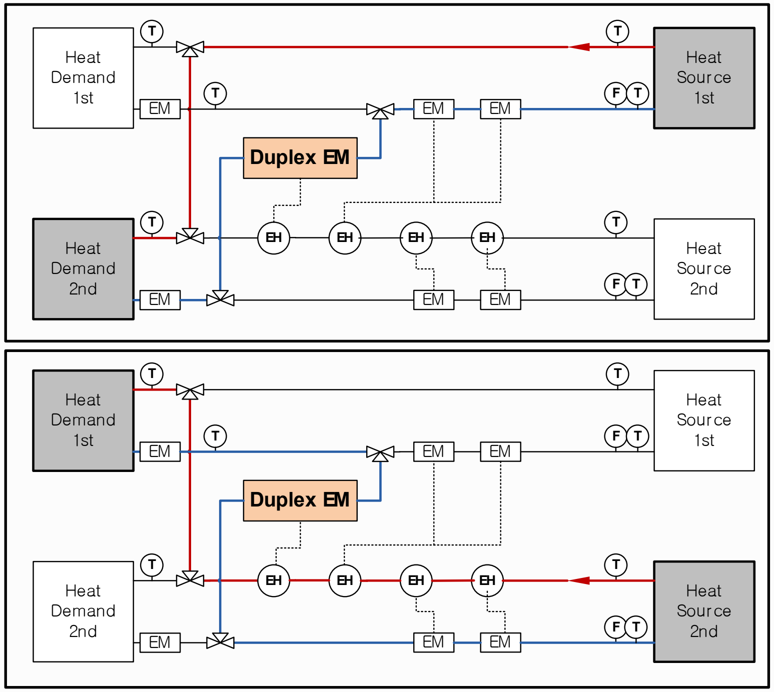
Self-rechargeable battery
(with a thermo-electric energy harvester)



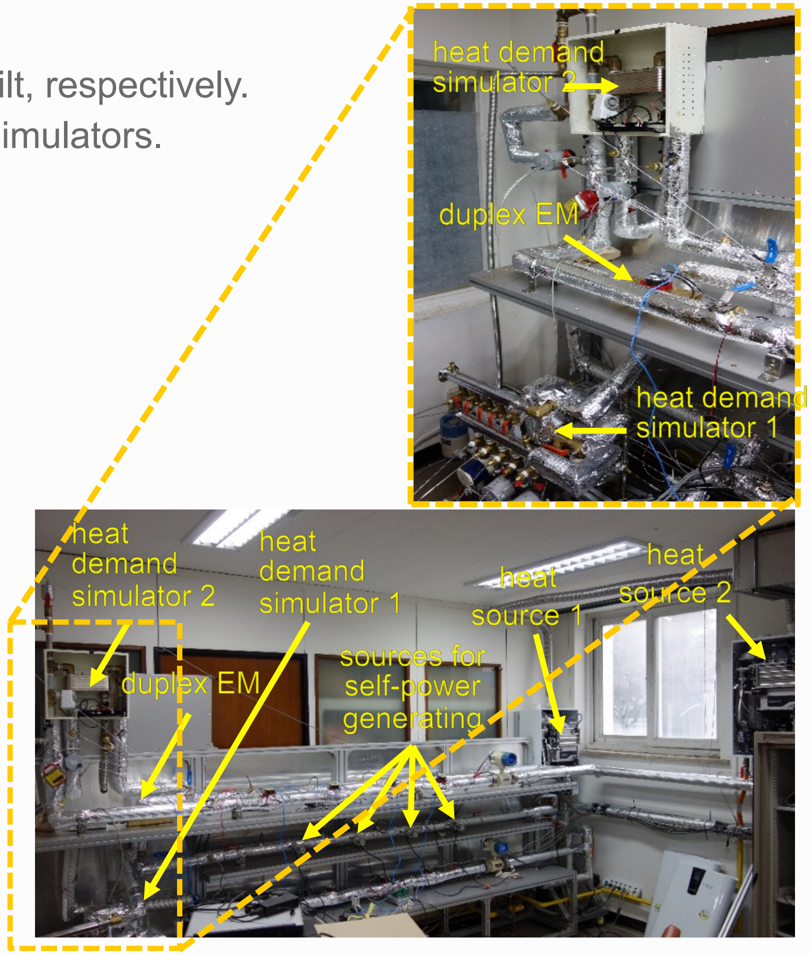
Electric circuit and protocol

Performance and reliability test

- Two heat demand simulators were designed and built, respectively.
- Two heat sources were linked to two heat demand simulators.

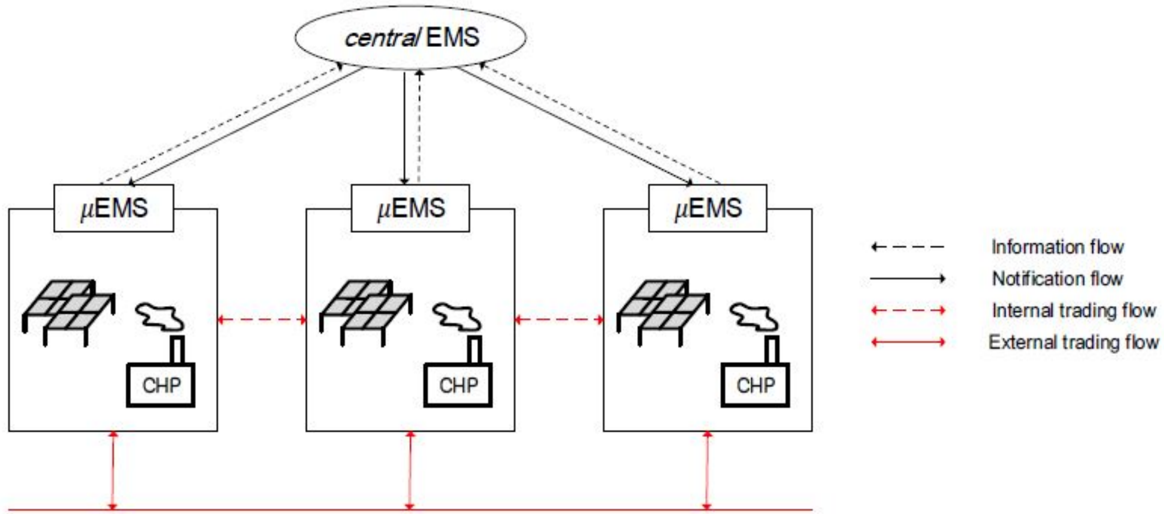


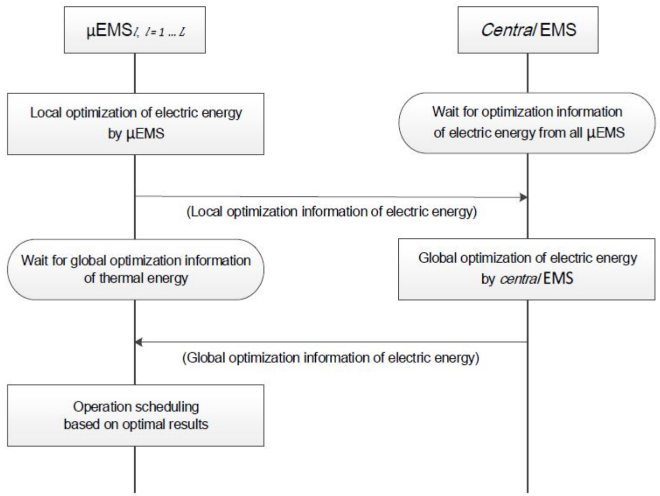
Bi-directional heat meter test loop with multiple sources and demands



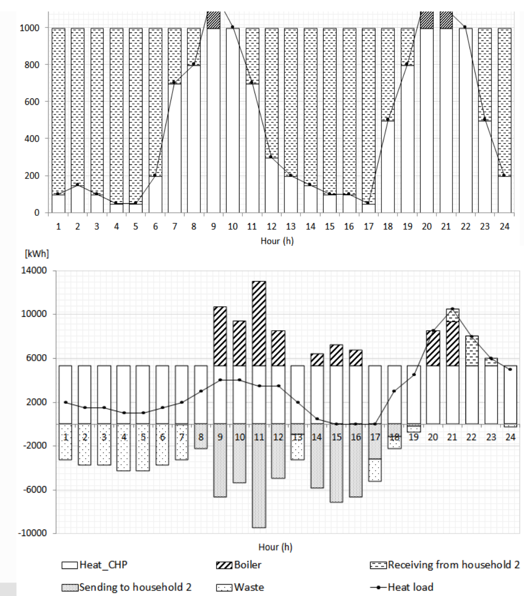
HILS approach to design a cost-optimized operating schedule of EMS on a bi-directional TEN

(Hardware-in-the-Loop Simulation)





CHP-based bi-directional heat trade EMS Simulator for optimal operation



GLOBAL KIER TECHNOLOGIES

Mathematical model of the EMS on a CHP-based bi-directional thermal energy network

Modeling for the optimal design of EMS for a bi-directional TEN

Step 1 : BEMS

Objective function $C_l^e\left(M_{CHP_1}^e(t) \;\dots\; M_{CHP_L}^e(t)\right)$

$$= \sum_{l=1}^{L}\left\{(C_{CHP_l}^e \cdot M_{CHP_l}^e(t)) + \left(C_{BUY_l}^e(t)\cdot M_l^{e-}(t)\right) - \left(C_{SELL_l}^e(t)\cdot M_l^{e+}(t)\right)\right\}$$

- 각 빌딩 단독으로 내부 수요량 충족
- μEMS로 잉여/부족 전기 에너지량 전달

Step 2 : μEMS

Objective function of electric part

$$C^{Elec}\left(M_{TRADE_1}^e(t) \dots M_{TRADE_L}^e(t), M_{BUY_1}^e(t) \;\dots\dots, M_{BUY_L}^e, M_{SELL_1}^e(t) \;\dots\dots, M_{SELL_L}^e\right)$$

$$= \sum_{l=1}^{L}\{(S_l^e(t)\cdot max\,[C_{CHP_l}^e(t), C_{SELL}^e(t)]\cdot M_{TRADE_l}^e(t)) + (C_{BUY}^e(t)\cdot M_{BUY_l}^e(t)) - (C_{SELL}^e(t)\cdot M_{SELL_l}^e)\}$$

Objective function of heat part

$$C^{Heat}\left(M_{CHP_1}^{e\to h}(t) \;\dots\; M_{CHP_L}^{e\to h}(t), M_{CHP_1}^h(t) \dots M_{CHP_L}^h(t), M_{HOB_{1,1}}^h(t) \dots M_{HOB_{L,J}}^h(t)\right)$$

$$= \sum_{l=1}^{L}\left\{(C_{CHP_l}^e\cdot M_{CHP_l}^{e\to h}(t)) + \left(C_{CHP_l}^h(t)\cdot M_{CHP_l}^h(t)\right) + \sum_{j=1}^{J}(C_{HOB_{l,j}}^h(t)\cdot M_{HOB_{l,j}}^h(t))\right\}$$

- BEMS에 의하여 제출된 잉여/부족 전기 에너지를 통한 μENet 내부 전력 거래량 결정
- μENet 내부 열 에너지 거래량 결정
- 각 빌딩(BEMS)으로 내부 에너지 거래량 통보

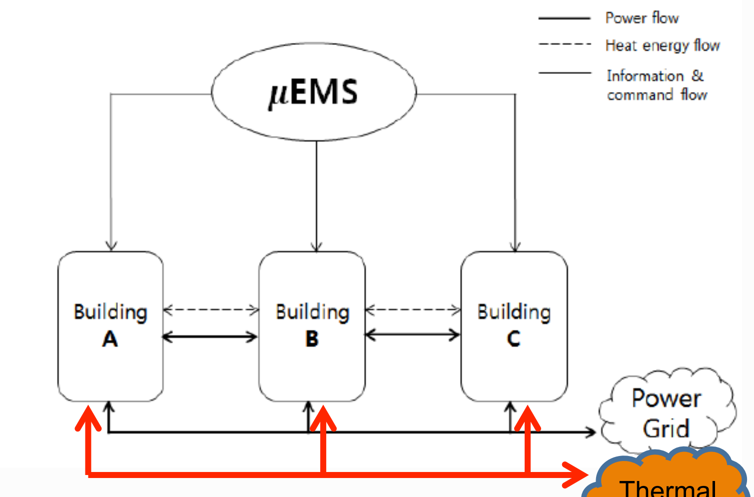
Step 3 : BEMS

Objective function

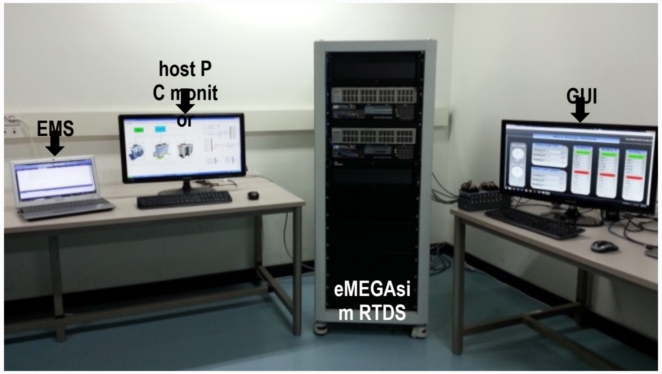
$$C_l^{Comb}(t) = \left(M_{CHP_1}^{e'}(t) \dots M_{CHP_L}^{e'}(t), M_{CHP_1}^h(t) \dots M_{CHP_L}^h(t), M_{HOB_{1,1}}^h(t) \dots M_{HOB_{L,J}}^h,\right.$$
$$\left. M_{BUY_1}^e(t) \;\dots\dots\; M_{BUY_L}^e, M_{SELL_1}^e(t) \;\dots\dots M_{SELL_L}^e\right)$$

$$= \sum_{l=1}^{L}\left\{(C_{CHP_l}^e\cdot M_{CHP_l}^{e'}(t)) + \left(C_{CHP_l}^h(t)\cdot M_{CHP_l}^h(t)\right) + \sum_{j=1}^{J}(C_{HOB_{l,j}}^h(t)\cdot M_{HOB_{l,j}}^h(t))\right.$$
$$\left. + \left(C_{BUY}^e(t)\cdot M_{BUY_l}^{e'}(t)\right) - \left(C_{SELL}^e(t)\cdot M_{SELL_l}^e\right)\right\}$$

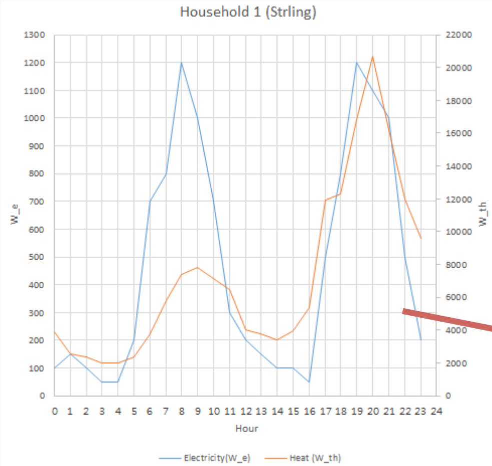
- 결정된 내부 에너지 거래량을 바탕으로 각 빌딩의 BEMS에 의한 전기/열원 설비 최적화 수행



① Optimization (BEMS)
② Informing surplus/short energy information
③ Optimization (EMS)
④ Informing results of optimization
⑤ Re-optimization (BEMS)

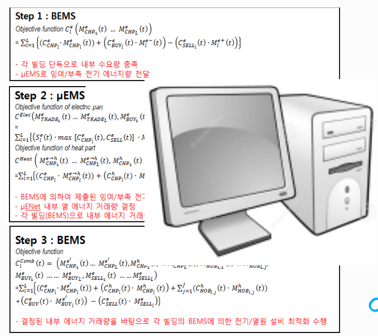


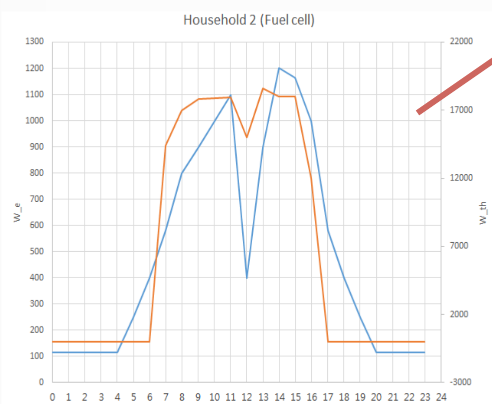
Role of an EMS



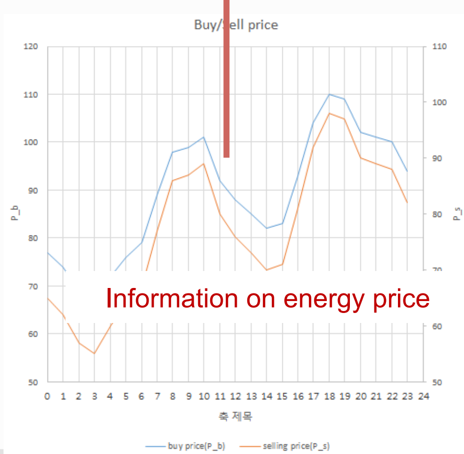
Electricity and thermal load profiles in demand 1 (house) with a Stirling engine-based CHP

EMS calculates cost-optimized operating schedule of each CHP system based on predicted load profiles and energy price.





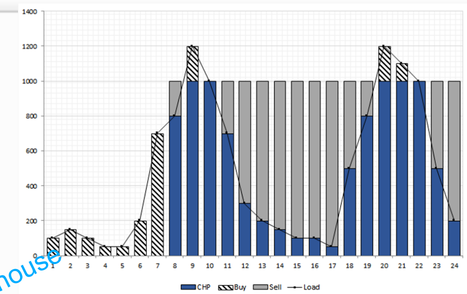
Electricity and thermal load profiles in demand 2 (office) with a PEMFC-based CHP



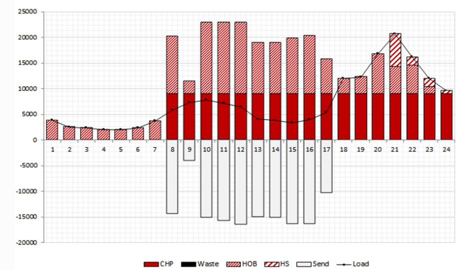
Information on energy price

Cost-optimized operating schedule of a Stirling engine-based CHP in house

〈Electric part〉

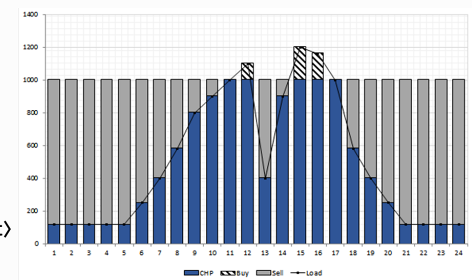


〈Heat part〉

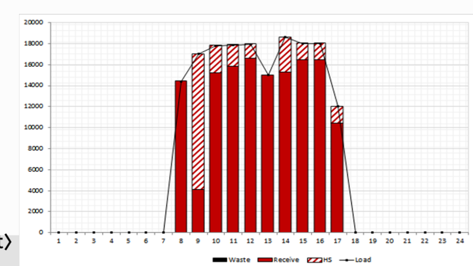


Cost-optimized operating schedule of a PEMFC-based CHP in office

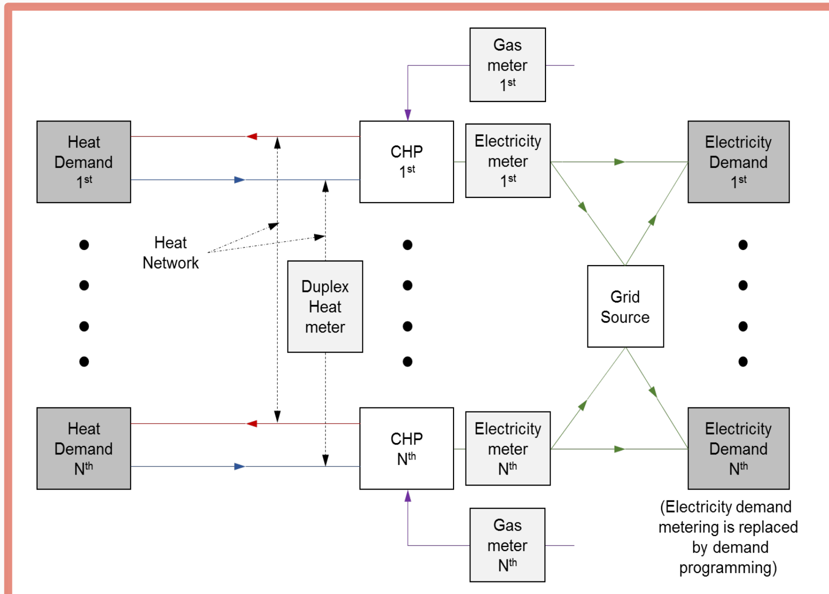
〈Electric part〉



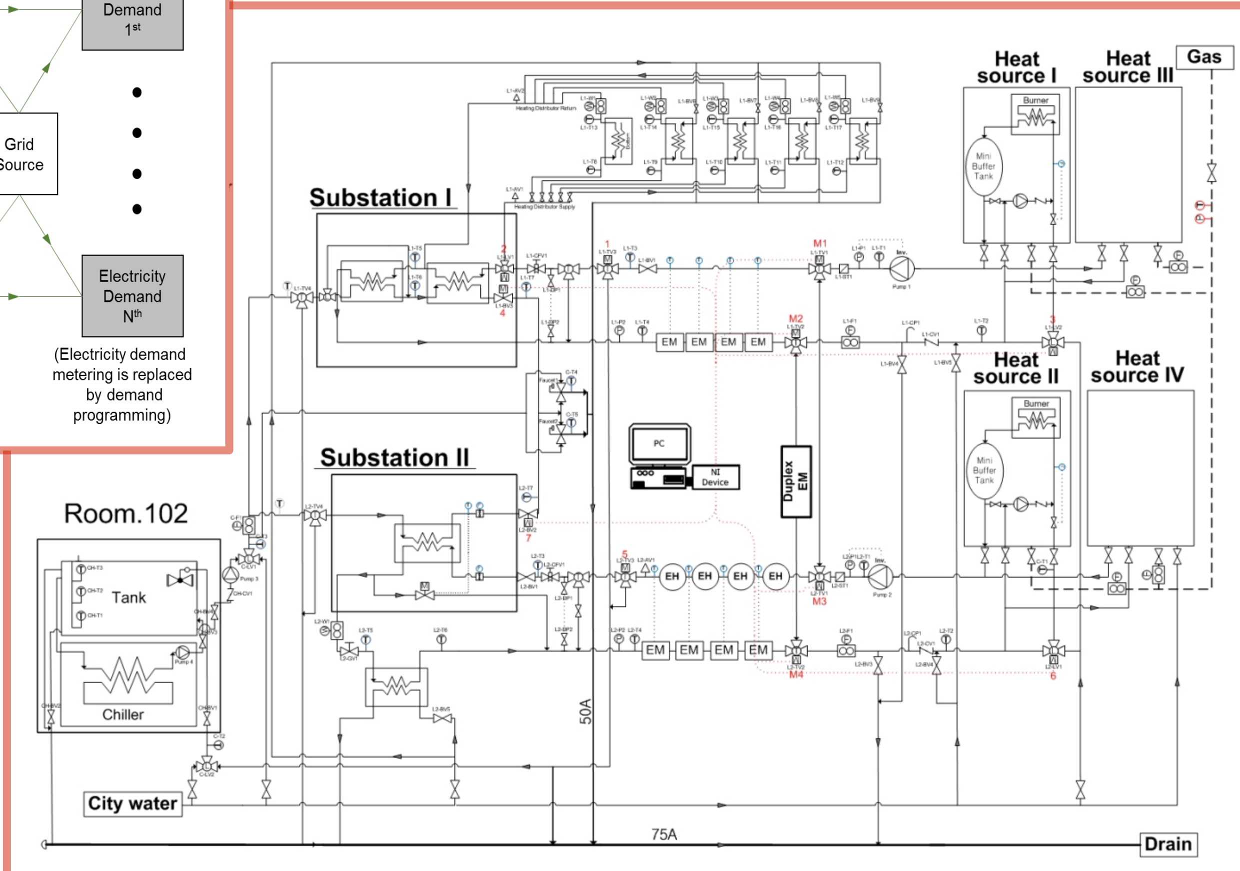
〈Heat part〉



Plan for experiments to validate the optimized EMS



← Schematic diagram of CHP-based bi-directional micro ene rgy network architecture

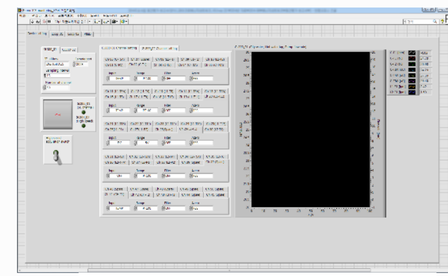


Schematic diagram of CHP-based bi-directional micro energy network test bed →

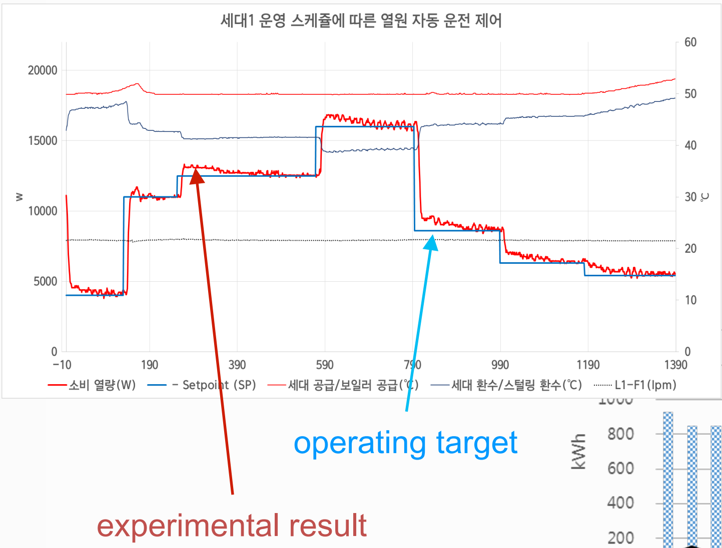
EMS test facility

Experimental test of the optimized EMS on a CHP-based bi-directional thermal energy network

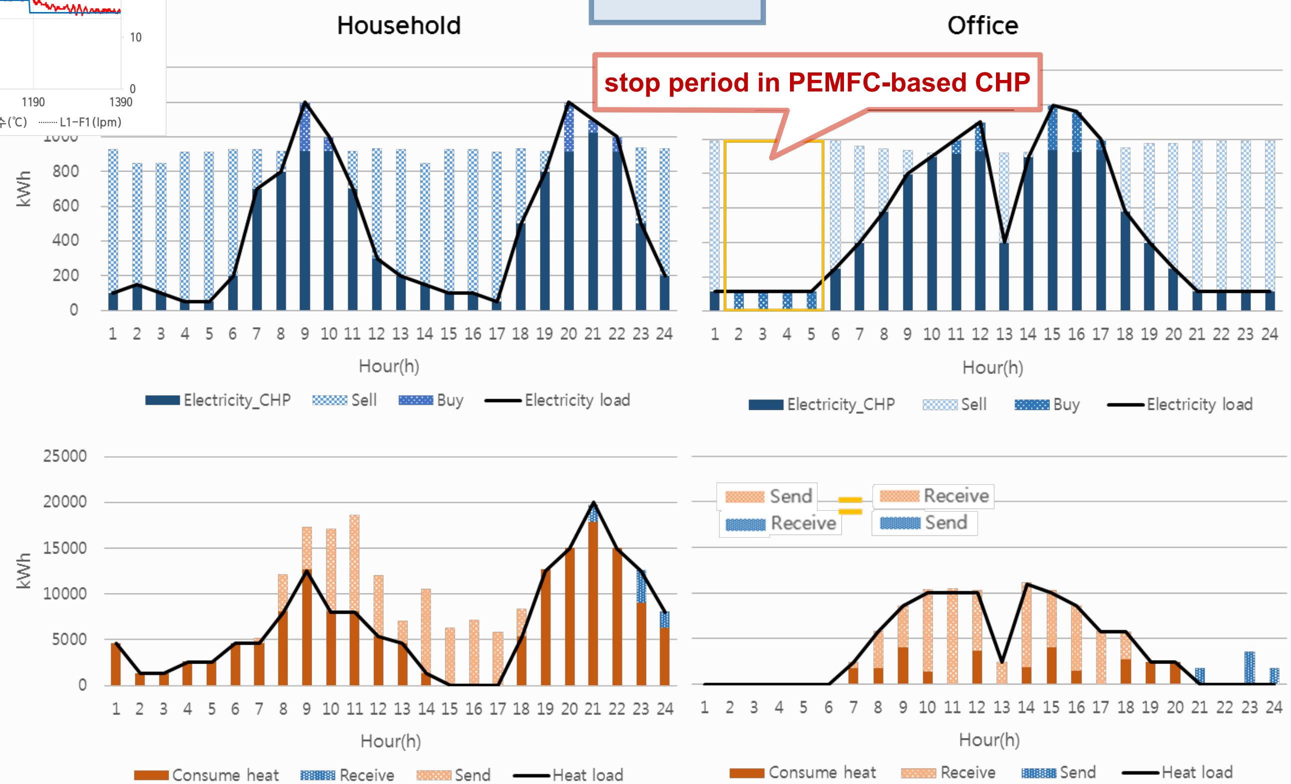
- Two CHP-based thermal stations were introduced.
- Two heat demand simulators were designed and built, respectively.
- Bi-directional heat meter was introduced for heat trading.
- Cost-optimized scheduled EMS was tested.



EMS test results



20.9% of energy saving by introducing a cost-optimized scheduled EMS on the bi-directional thermal energy network



GLOBAL KIER TECHNOLOGIES

KIER

Chapter 06

Summary

The KIER, a global energy innovator, does its best in pursuing its mission to invent world-class energy technologies based on open innovation, life-cycle research quality assurance, participatory and open communication. Therefore the KIER will become the best energy technology R&D institute in the world, contributing to the creation of wealth and improvement of quality of life for the people.

KIER

Summary

- **KIER was introduced.**
  - History, personnel and budget
  - R&D Strategies and organization
- **KIER's activities on thermal energy network were discussed.**
  - KIER's approach to thermal energy network
  - Brief history of KIER R&D on thermal energy network

  R&D on heat pumps for TEN
  - Sea water source heat pump for a low-temperature TEN
  - Medium- and high-temperature heat pumps for an industrial TEN

  3025 Project
  - Overview of 3025 Project (Demonstrative Research on TEN in KIER campus)
  - KIER Energy Center

  R&D on EMS for TEN
  - Local EMS for uni-directional thermal energy supply system with a local source
  - EMS for bi-directional thermal energy network
- KIER hopes our meeting today will be a new initiative to strengthen our future cooperation !

KIER

GLOBAL KIER
TECHNOLOGIES

Thank you !

The KIER, a global energy innovator, does its best in pursuing its mission to invent world-class energy technologies based on open innovation, life-cycle research quality assurance, participatory and open communication. Therefore the KIER will become the best energy technology R&D institute in the world, contributing to the creation of wealth and improvement of quality of life for the people.