Energy Audit Procedure & Practices

17 JAN 2018

KOREA ENERGY AGENCY
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I Introduction of Energy Audit Act

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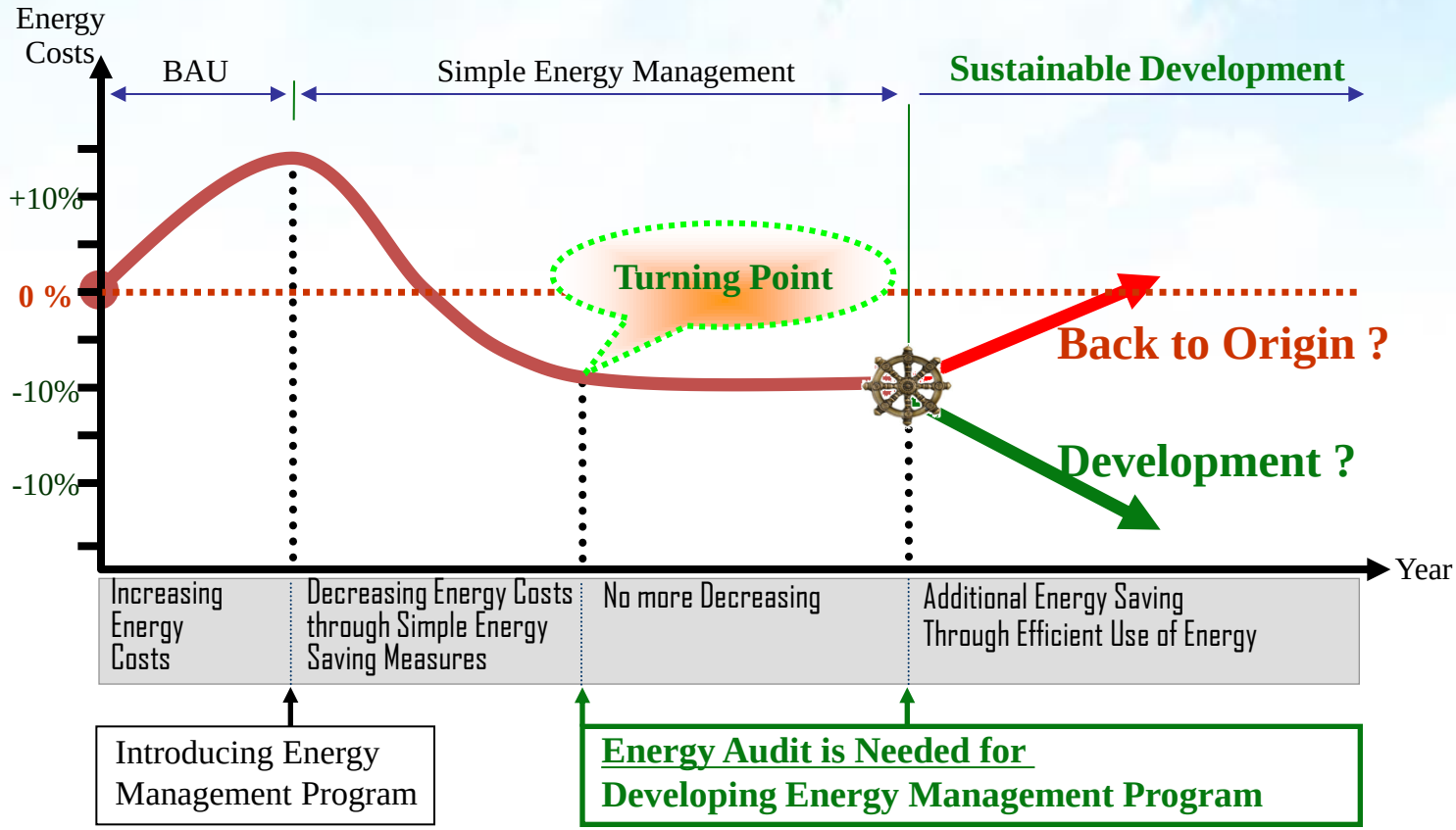
Why Energy Audit ?
Energy Audit will guide you to sustainable development



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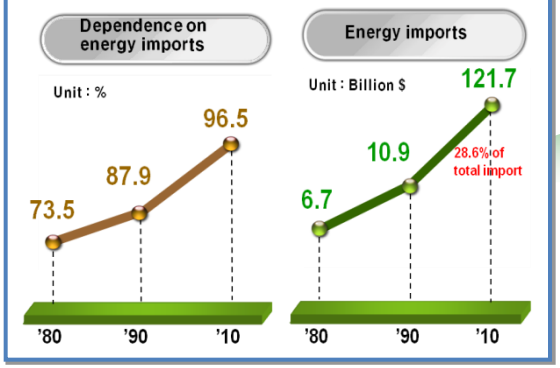
Korea adopted Mandatory Energy Audit Scheme to Respond UNFCCC and Continuous Rising of Oil Prices in 2007

Continuous Rising Energy Consumption & Oil Prices

Energy Audit is the Best Solution

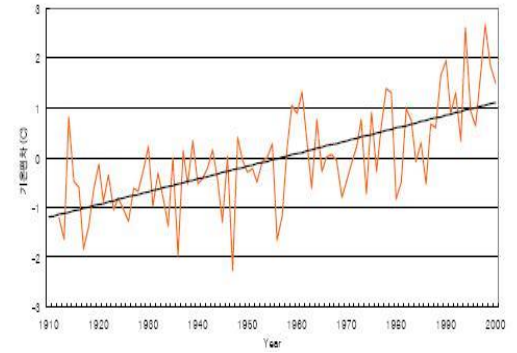
UNFCCC* Implementation Reduction GHG Needed

Energy Environment



New Effective Scheme Needed

Korea Climate Change



* UNFCCC : United Nation Framework Convention on Climate Change

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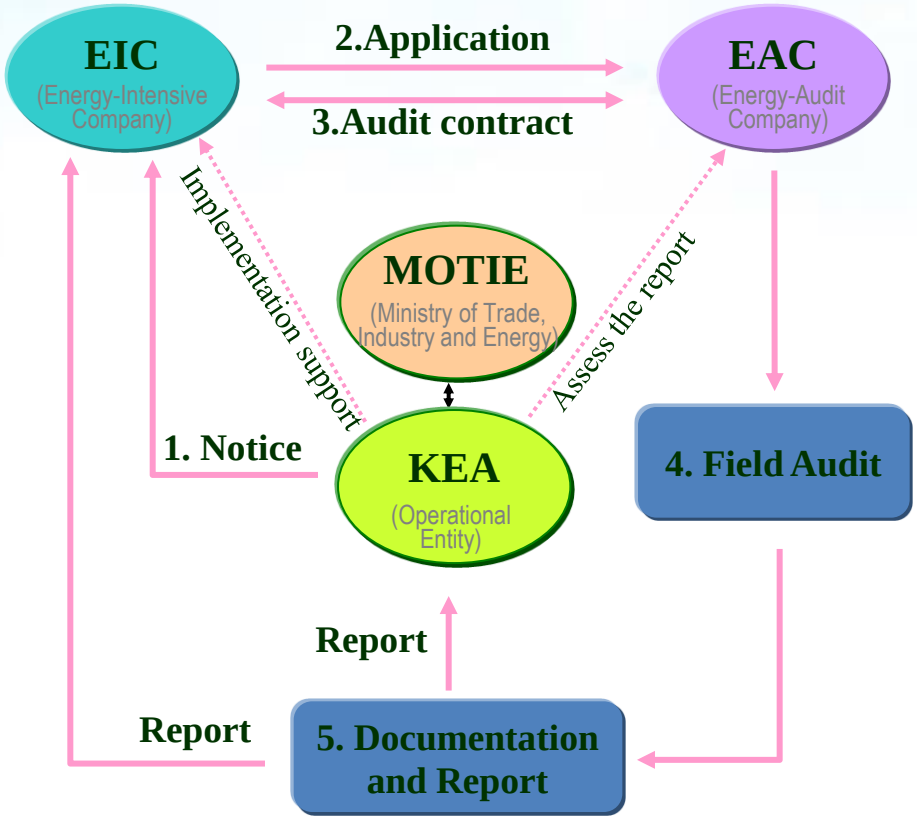
KEA is the Operational Entity of Energy Audit Scheme

Workflow of the Energy Audit Scheme



1. Notice
KEA notifies energy-intensive companies that are subjected to energy audit

2. Application
A company subject to an energy audit must apply to an energy audit company, 3 months before the end of its audit period

3. Energy Audit contract
Contracting between EIC and EAC

4. Conducting Field Energy Audit
EAC conduct on-site audit according to the contract

5. Documentation and Report
EAC submits a report for the results of energy audit to EIC and KEMCO

※ Post Audit Activities
- Assess the Report, Implementation of support

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Summary of Energy Audit Scheme

1. Stakeholders of Energy Audit Scheme :

- MOTIE(Ministry of Trade, Industry and Energy) : General Management Agency of Energy Audit Scheme
- KEA(Korea Energy Agency) : Operational Entity of Energy Audit Scheme
- EIC(Energy Intensive Company) : Target to be audited of energy
- EAC(Energy Audit Company) : There are 2 types of energy audit company, and 93 companies are designated from MOTIE by 2013(Type1 : conduct all kind of workplace, Type2 : conduct workplace that use less than 420TJ of energy consumption per year

2. Target : Energy intensive companies whose annual energy consumption is over 84TJ

3. Energy Audit Cycle : Energy audit target company has to take energy audit every 5 years

6. Energy Audit Days and Personnel : It depends on the amount of annual energy consumption, usually put 3~4 people and 10~50 days into on-site energy audit (except report writing days)

7. Energy Audit Fee : Determined according to the number of audit days and personnel

- If energy consumptions are 4,200 TJ, then costs are about 115,000USD, but costs can be adjusted by contract

8. Energy Audit Postponing : If company meets a natural disaster, bankruptcy and shut-down, plan to move etc, company can postpone up to 12 months

9. Energy audit Exemption and Extension : If it receives Presidential award or Prime Minister's award, energy audit can be exempted one cycle, and If it receives Ministerial award, energy audit cycle can be extended three years

10. Subsidies for Small and Medium sized Enterprises (SMEs) : Support energy audit fee up to 70%

11. Fines : If not take energy audit within the deadline, fines are imposed by every violation

- One time : 10 Million Won, Two times or more : 20 Million Won per violation

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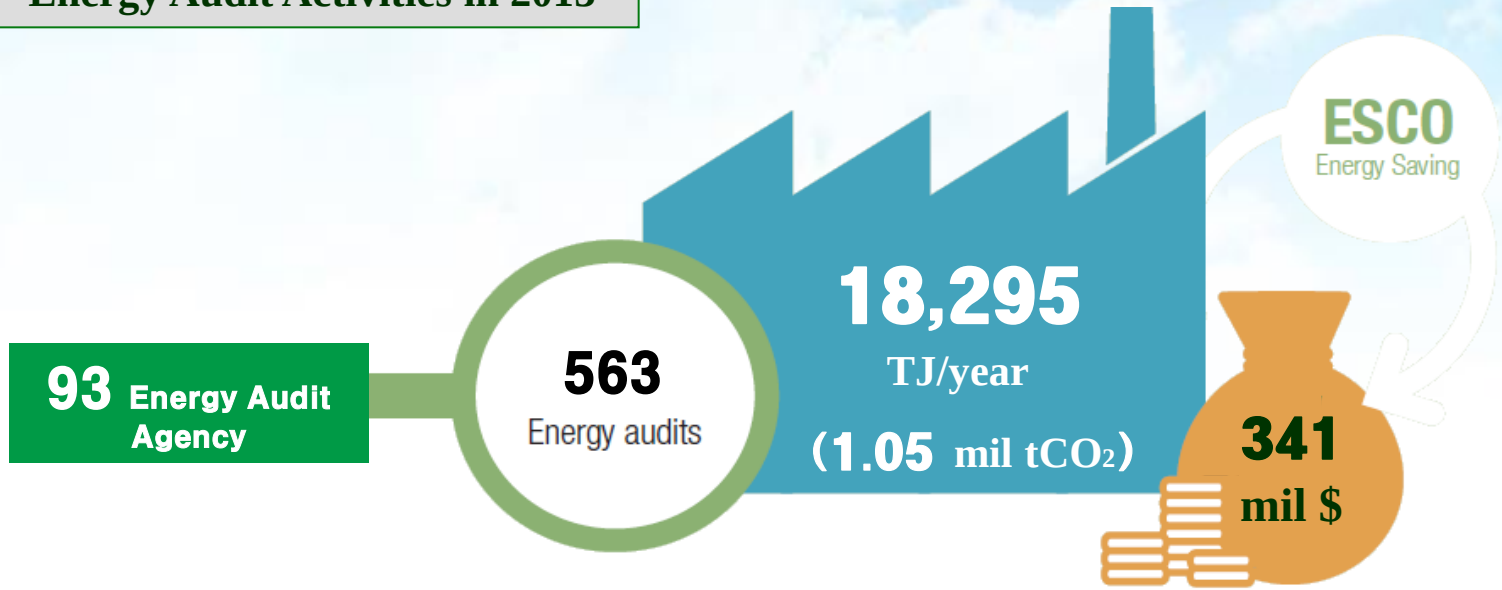
Korea Secured 18,295 TJ of Energy Saving Potential in 2013

☞ Energy Audit Activities in 2013



- ▸ 5.0 %
  Savings rate of total energy consumption
- ▸ 2.0 year
  Payback period of energy audits
- ▸ 27.3 times
  Cost-effectiveness of energy audits (Energy savings potential/Audit Fee)

※ ESCO : Energy Service Company, Instead of energy users, ESCOs invest in energy saving facilities for energy conservation and reducing green house gas

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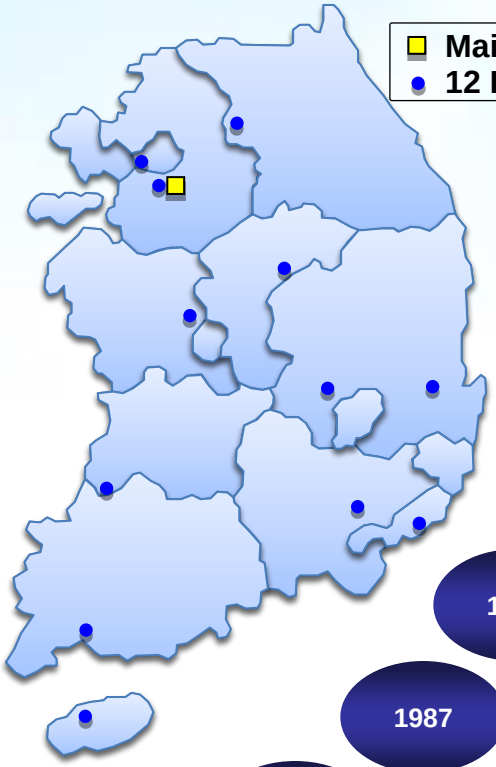
ENERGY AUDIT EVOLUTION WITH KEA



2011 ~ — **Development to Premium Energy Audit with Process simulation**
- Pinch Analysis, Column Targeting , etc.

2009 — **CDM/EnMS linked Customized Energy Audit**
- Energy Audit specialized in Petroleum Refinery, Steel Industry

2007 — **Establish Mandatory Energy Audit Act**
- for energy intensive companies 10,000 toe above

Expanding the use of Process Simulation Software (AspenOne, Exchanger, etc)

1998 ~ 2006 — **Introduced of Software Customized in Power Plant (Thermoflex)**
- Conduct Energy Audit in lots of power plants

1997 — **Development of software energy audit (Hypotech HYSYS)**
- Energy Audit Demand in Chemical Engineering and Metal Industry Increased

1994 — **Conducted Electricity Demand Side Management Survey, built Heat Balancing Standard (KS) of a boiler and program**
- Built Textile (Tenter), Food (Concentrator) related Heat Balance Excel Program

1989 — **Site Survey in each Industry (100 companies except in-depth management companies)**
- Measured Facility based operating efficiency and developed methods to reduce energy intensity

1987 — **In-dept Energy Audit in energy intensive companies (Cement, Steel Furnaces), and ships**

1985 — **General Energy Audit in Industries (Bus Audit, Thermal Image TVS Audit), Energy Audit in fired equipment** - Composed Computer based TVS report, Introduced Heat Balance Excel Program

1980 ~ 1984 — **In-Depth Energy Audit in Industry, Building (Heat, Electricity), Established Field-based Specialized Energy Audit Tear**
- Focused on Energy Audit in Combustion Facility, Utility System (Boiler flue gas Heat Recovery, Adjust Air fuel ratio, etc.)

1974 — Appointed to Heat Management and Audit Institution As Korea Energy Management Engineering Association has established, Developed Energy Audit Methods (Benchmarking Developed Countries)

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KEA's Energy Audit Purpose is to upgrade customer's energy conditions.

Enhancing Competitive Positions and Contribute to Climate Change mitigation

Energy Audit

Maximize Profits

- ✓ Reduce Operation Costs
- ✓ Improve Productivity

Minimize Energy & GHG

- ✓ Reduce Energy & CHG
- ✓ Achieve additional value

Build Capacity

- ✓ Upgrade M&V ability
- ✓ Find creative EMOs
- ✓ Set up GHG Inventory

KEA will fully support our customer's efficient energy management.

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II Energy Audit Procedure

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To Improve Energy Efficiency, Decrease Energy Costs and Reduce GHG, We conduct Audit by 10 procedures

☞ Energy Audit Procedure

To Improve Efficiency, Decrease Costs and Reduce GHG

10. Reporting
9. Writing Detailed EMOs
8. Results Presentation
7. Assess the Benefits
6. Identify EMOs*
5. Comparative Analysis
4. Energy & Mass Balancing
3. Measuring & Verifying
2. Energy Flow Analysis
1. Condition Survey

To determine Where, When, Why And How Energy is Being Used

☞ Main Deliverables

- Efficiency & Intensity of Energy System
- Description of EMOs and Implementation Methods
- Estimation of Energy Savings & GHG reduction potential
- Economic Analysis (NPV, IRR, etc)
- M & V Methods for post-implementation assessment

* EMOs : Energy Management Opportunities

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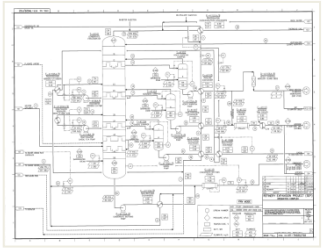
ENERGY AUDIT PROCEDURES

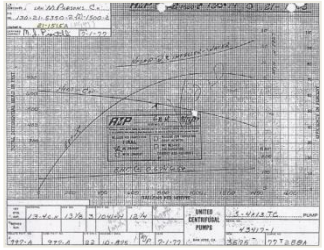
- GENERAL PROCEDURES OF ENERGY AUDIT (AT A GLANCE)

Start meeting

- Kick-Off with officials

Data collections



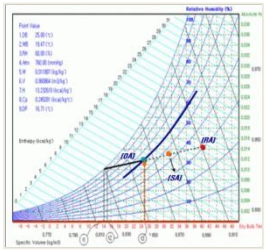


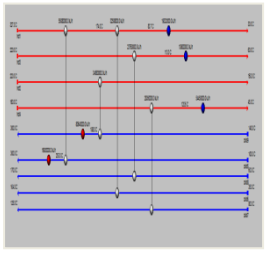
- Taking PFD, P&ID, Equipment list, Performance curves and so on for energy analysis

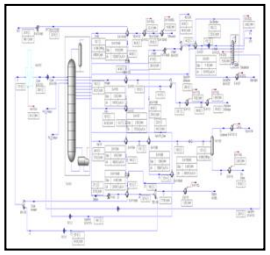
Measurements

- Operating condition check if necessary data is not enough

Analysis of Base and Improvement case

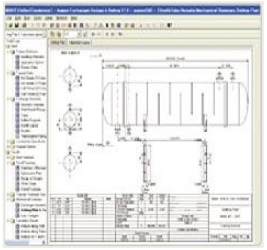


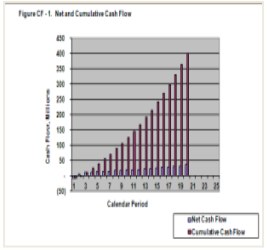




- Energy performance analysis using collected and measured data
- Energy loss check through pinch analysis
- Base simulation model construction using Aspen tools and so on
- Creating Energy Improvement opportunities
- Project simulation model construction using Aspen tools and so on

Design and Economics





- Design of new equipments to be installed
- Investment cost estimation
- Economic analysis by cash flow

Presentation

- The final review meeting for energy audit results

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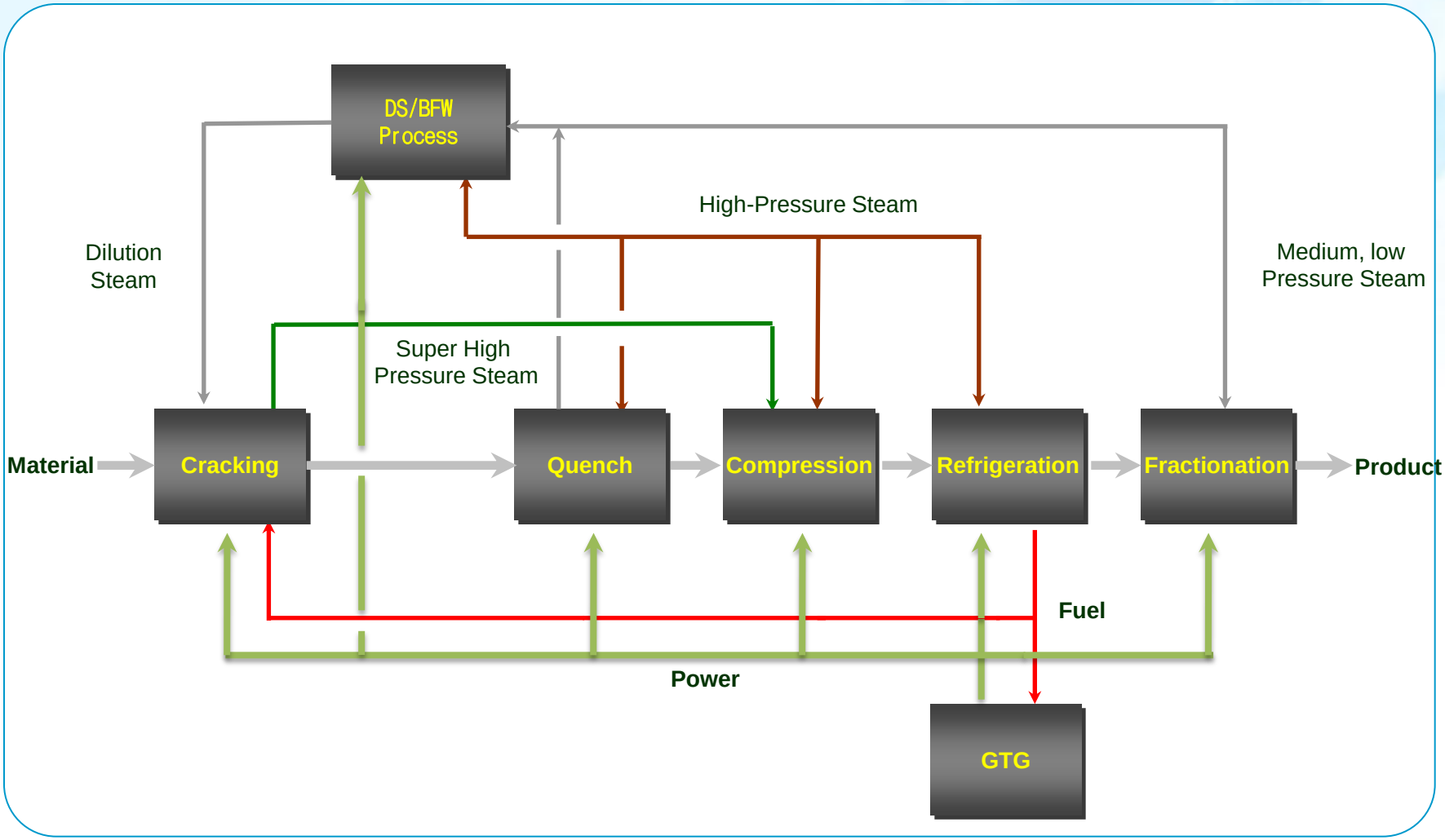
ENERGY AUDIT PROCEDURES

Understanding Procedures (Using PFD, P&ID)



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ENERGY AUDIT PROCEDURES

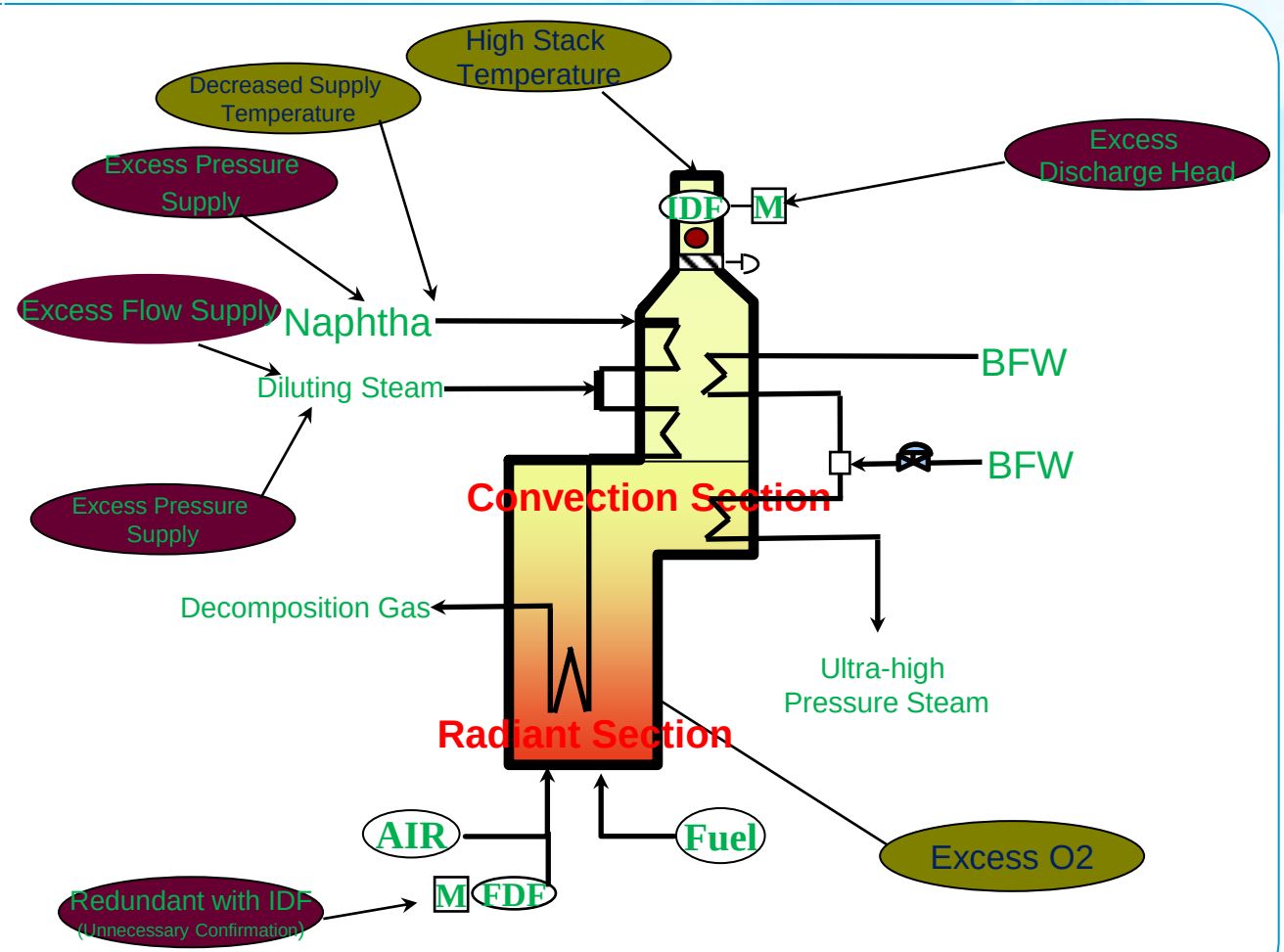
Excavating Themes by Function Analysis

Theme Excavation

Facility Equipment Energy Insertion Operation Management

Excess, Replaceable Connection or applying in fusion, or Rearrange Overlapped Adoption, oppose Unnecessary Function

Improvement IDEA



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ENERGY AUDIT PROCEDURES

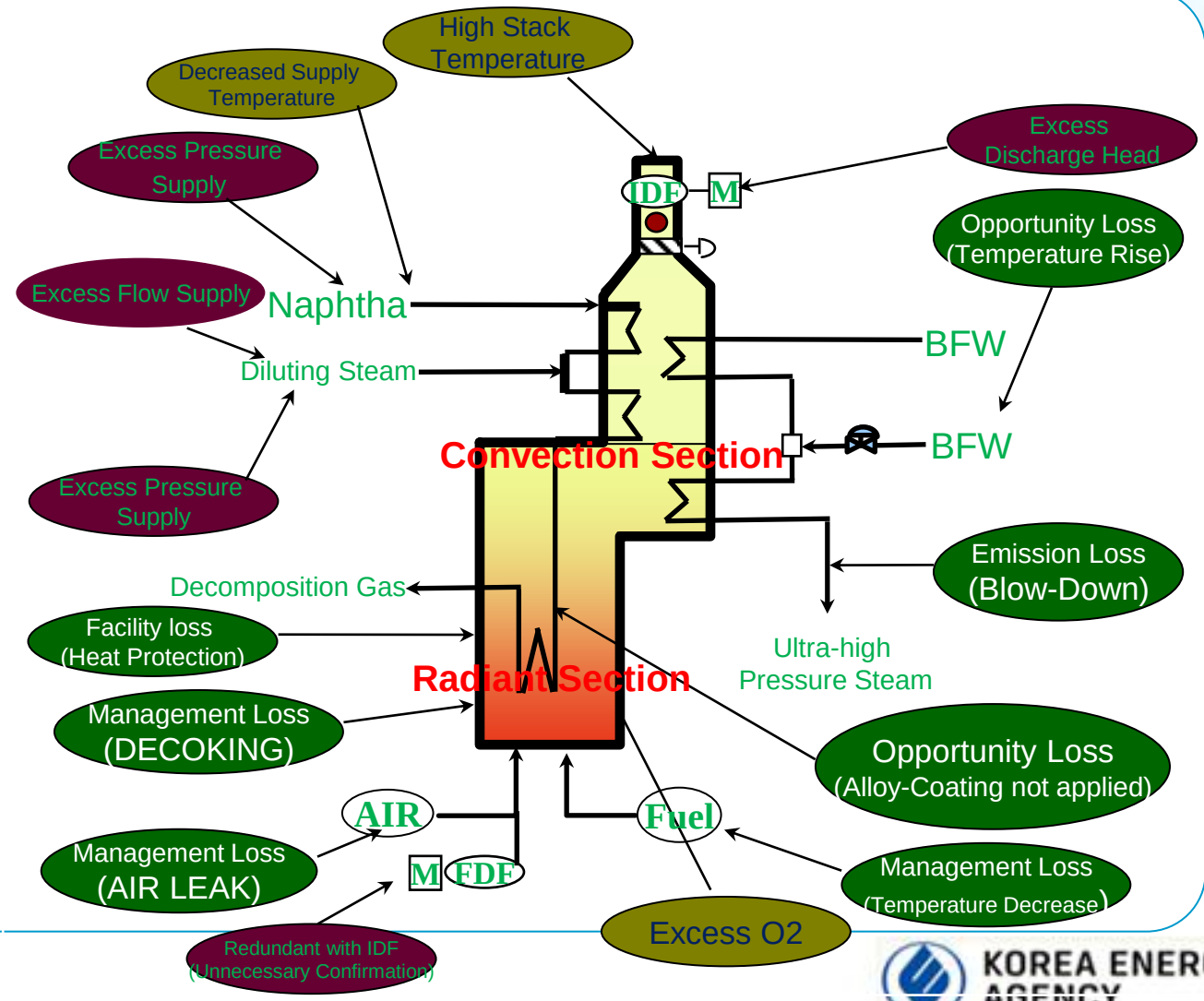
Theme Excavation by Loss Structure Analysis

Theme Excavation

Defining new Loss Theory
Minimum energy to satisfy essential performance of the process

Analyzing Gap Between Theory and Practice

Improvement IDEA



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ENERGY AUDIT PROCEDURES

Find Improvement Idea for Excavation Theme

Find Possible Improvement Idea

Bring Up Ideas

Gathering Information

Theme 100

Expert Advise

Simulation

Possible to Execute 60

Impossible to Execute 40

-Technical Problem
- Improvement Effect and Invest Payability Problem

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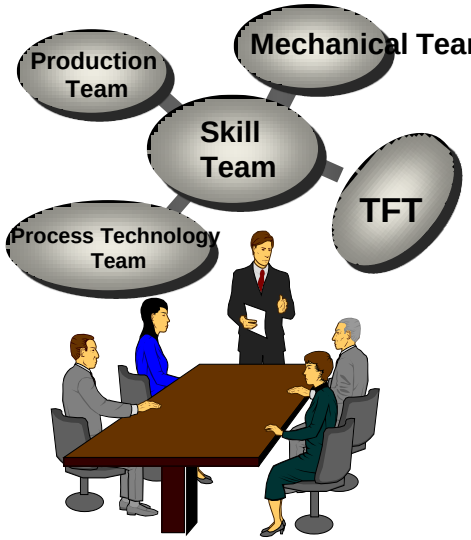
ENERGY AUDIT PROCEDURES

Find out Possible Solution through mutual discussion

Review Possibility for Ideas

Mutual Discussion



Risk Analysis and backup measures for Most suitable Solution

Possible Solutions

- Possible Solution(1)
- Possible Solution(2)
- Possible Solution(3)

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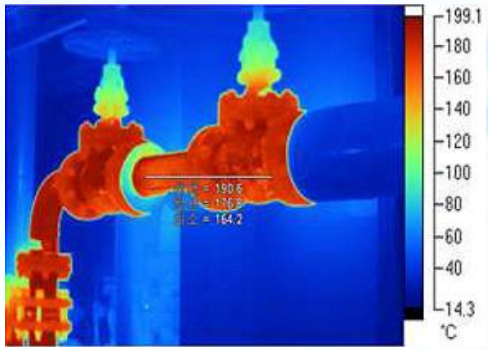
EQUIPMENTS FOR ENERGY AUDIT

- Infrared Camera



- A device checking the heat loss such as insulation performance and exothermic of electric

- Flue Gas Analyzer

- A device checking the combustion performance and temperature of flue gas

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EQUIPMENTS FOR ENERGY AUDIT

- Multi Temperature Humidity Meter

- A device measuring temperature or humidity

- Ultrasonic Flow Meter

- A device measuring flow rate in pipe

- Power Measurement Device

- A device measuring power consumption

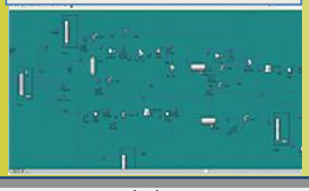
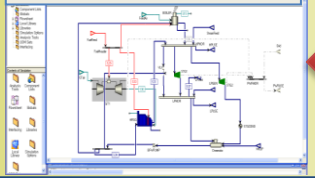
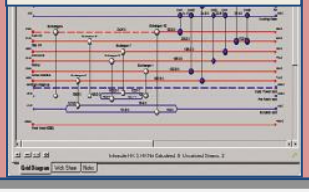
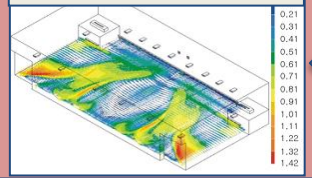
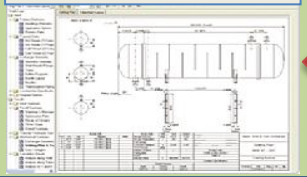
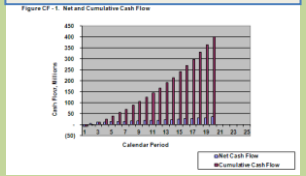
- Continuous Power Meter

- A device measuring power consumption

Energy Audit using Computer Software

- **KEA's Audit with World Class Software and High Tech Devices**

Integrated Solution with Rigorous Software and High-tech Devices

Current Situation Analysis	HYSYS/PLUS/THX 	Utility Planner 	M&V 
	Base model construction	Utility optimization	Measurement & verification
Energy Loss Factor Analysis	PINCH software 	CFD analysis 	M&V 
	Cross pinch analysis	3D Fluid dynamics	Measurement & verification
Find out Solution and Verify	HYSYS/PLUS/THX 	Equipment Design 	Economic analysis 
	Project model construction	Equipment sizing and costing	Feasibility estimation

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III Energy Audit Practices

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Energy Audit Visualizes Current Situation

Why is Data Analysis So Important?

- **You can see the present and the future condition through Instrument Panel in the Pilot seat**

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Why is Data Analysis So Important?

- CEO should be able to see company's present and future condition in Management Cockpit

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Why is Data Analysis So Important?

What is Data?
Phenomenon of Objects expressed with numbers (Digits)

What is the hidden meaning of Data?
According to Prof. Sung Hyun Park of Seoul National University,

- **All data is information, meaning it is just as dead if it is not refined and analyzed.**
- **Data is NOT an Inference.**
- **What People look for is an Inference, not Data.**
- **Even after analyzed, only few Data can obtain lives.**
- **There is no Bad Data, only data with Bad Intentions exist.**

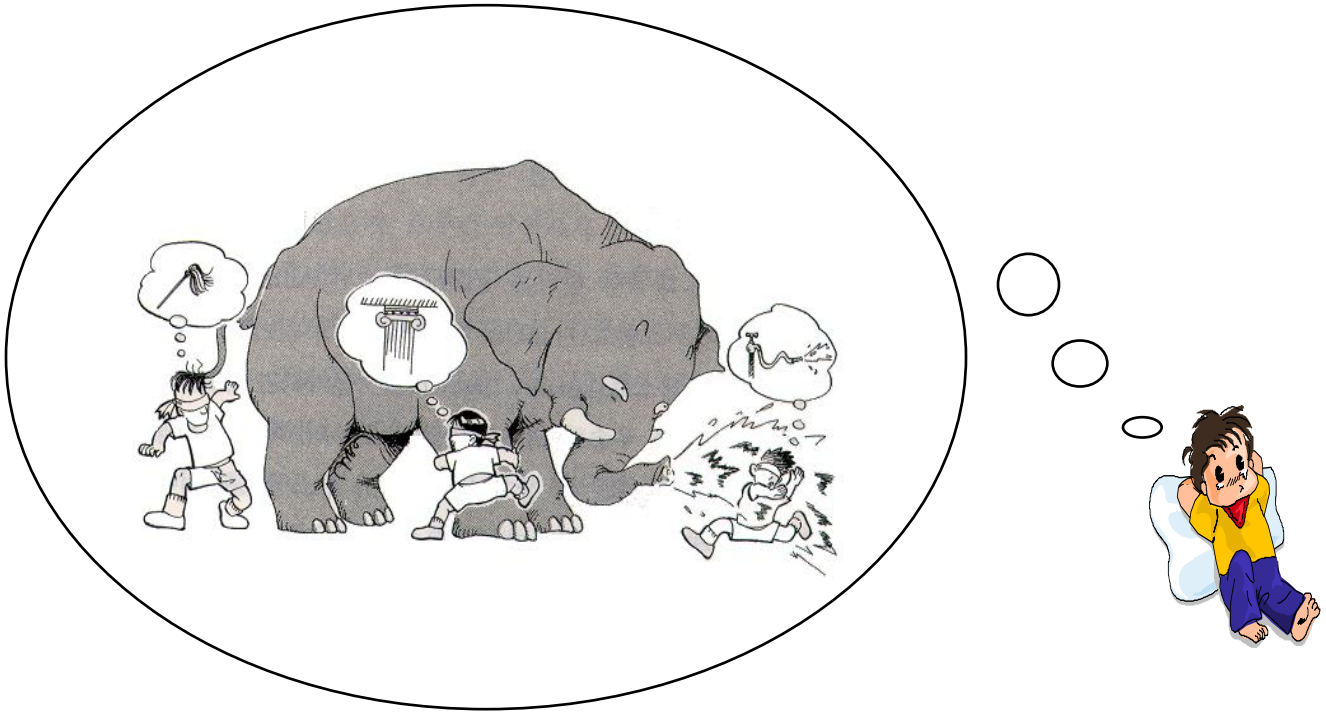
Why is Data Analysis So Important?

◈ Let's Think about it… Importance of Measurement

- ◆ We do not know the fact that we do not know.
- ◆ If we cannot express what we know through accurate measurement, then we do not know enough.
- ◆ If we do not know enough about them, we cannot manage them.
- ◆ If we cannot manage them, the result depends on luck.
- ◆ If we do not know about them, we cannot take measures against them.
- ◆ If we can take measures against them, the risk can be managed.
- ◆ But, if we know about them and not take measures, we deserve the damage inflicted by them

Why is Data Analysis So Important?

Can a single sample represent the whole group?



If a sample not representing whole group is extracted and made judgment from it, You will make judgment error just like blind men touching elephant.

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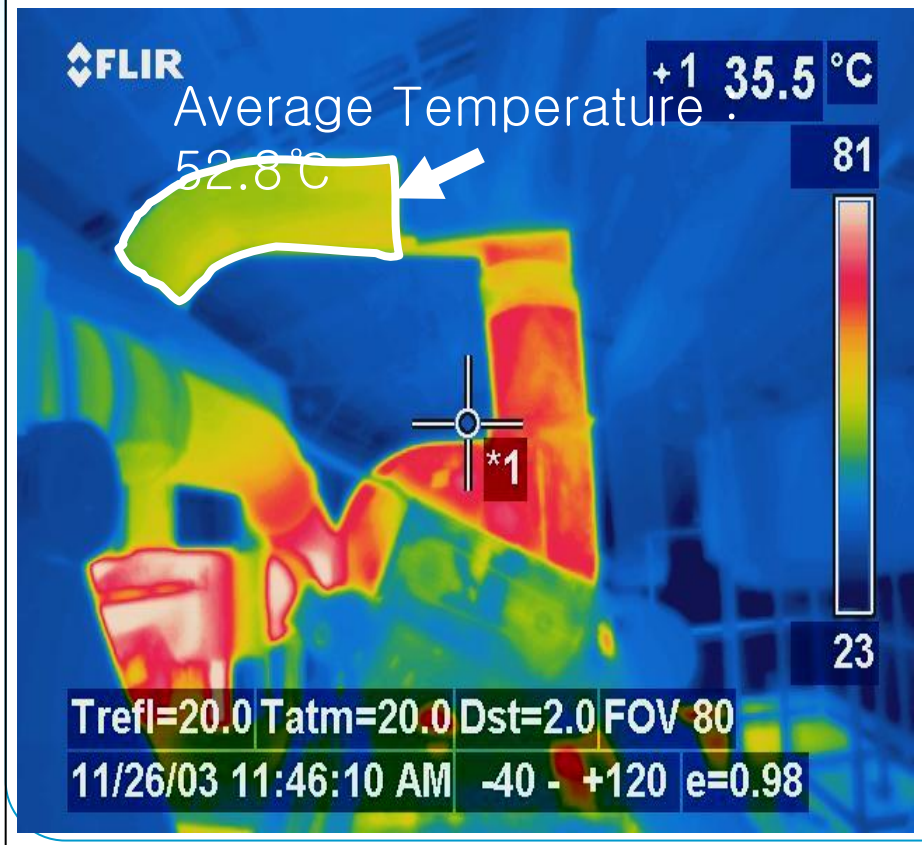
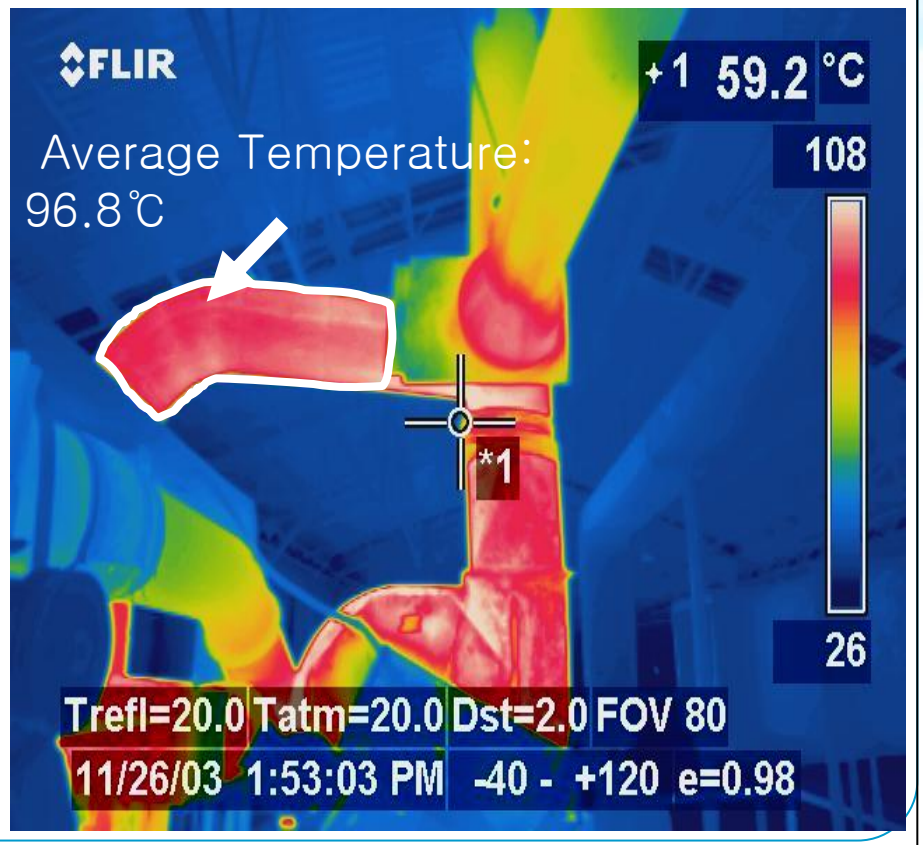
Measurement Cases: Duct Automatic Damper breakdown (Malfunction)

◆ Lack of Hot-air due to Damper breakdown



◆ Normal supply of Hot air after Damper Improvement



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Measurement Case: Equal and Efficient Heating System Management

- **Problems**
  - Heating Inequality occurs when Residence with sufficient heating opens window, and insufficient residence has complains for not provided enough heat.
  - Complains for taxed with same amount even if heating inequality occurs.

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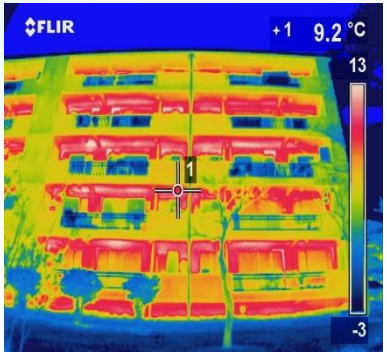
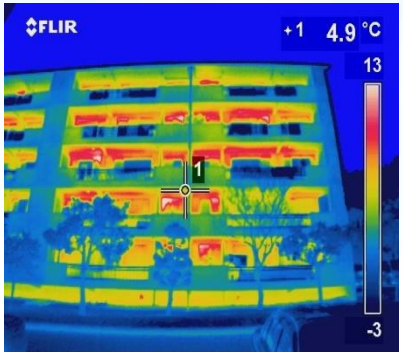
Measurement Case: Equal and Efficient Heating System Management

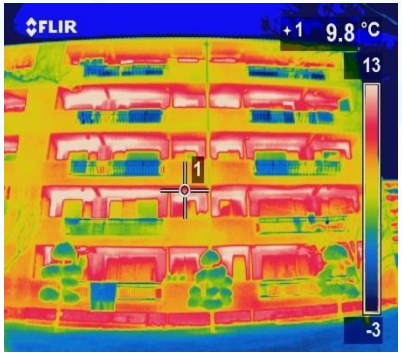
Infrared Thermal Imaging Photo



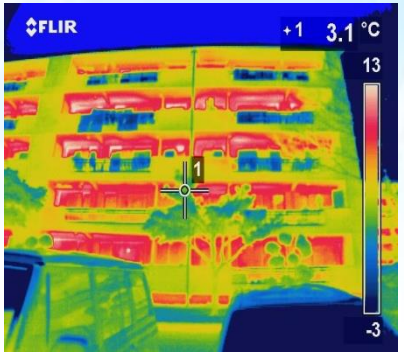
Residence 1



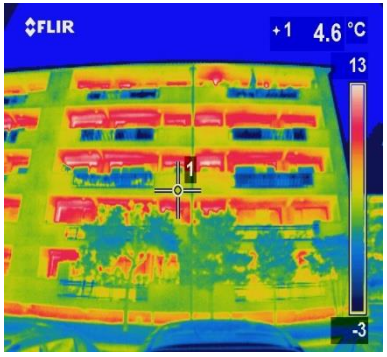
Residence 2



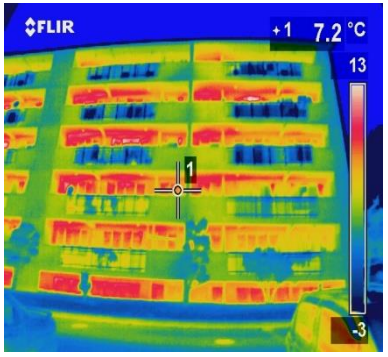
Residence 3



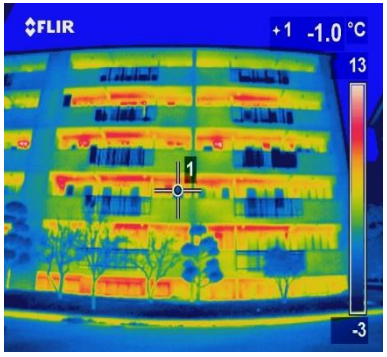
Residence 4



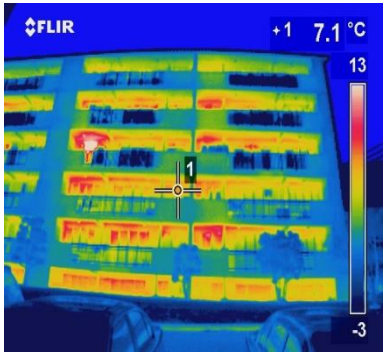
Residence 5



Residence 6



Residence 10



Residence 11

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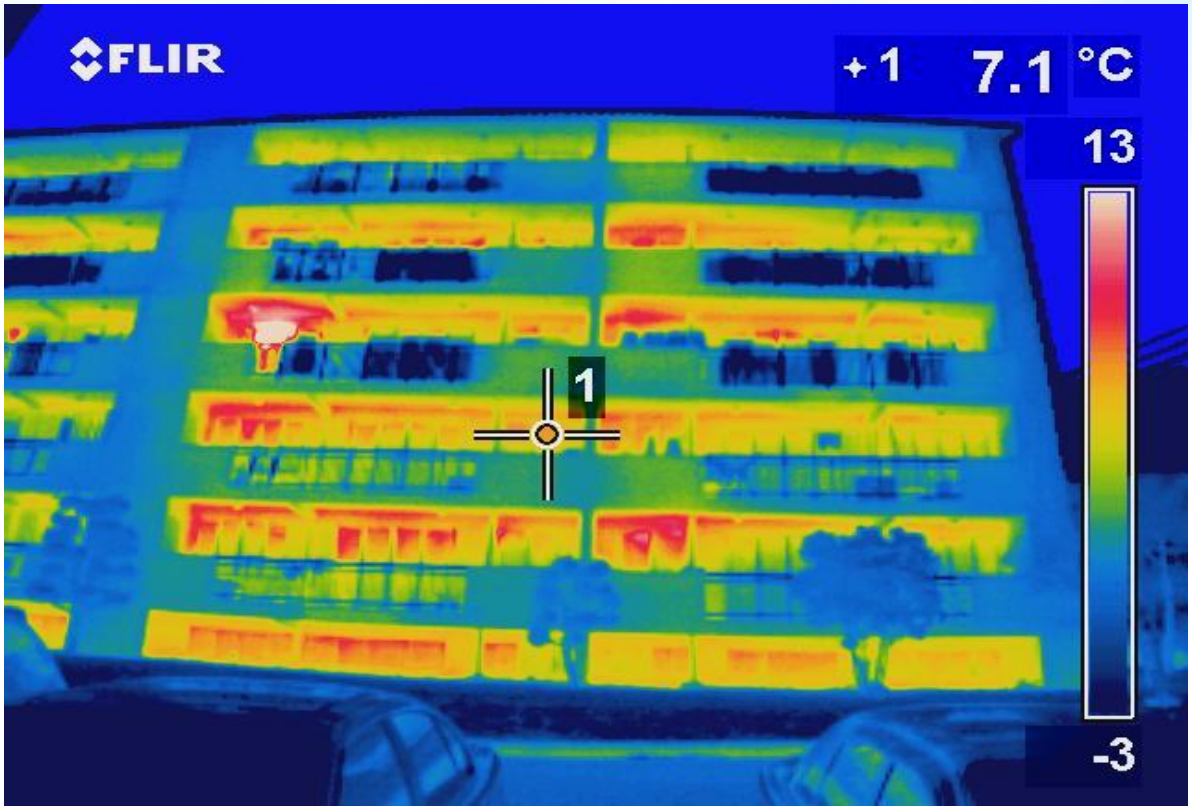
Equal and Efficient Heating System Management

Operating status (Residence 11)



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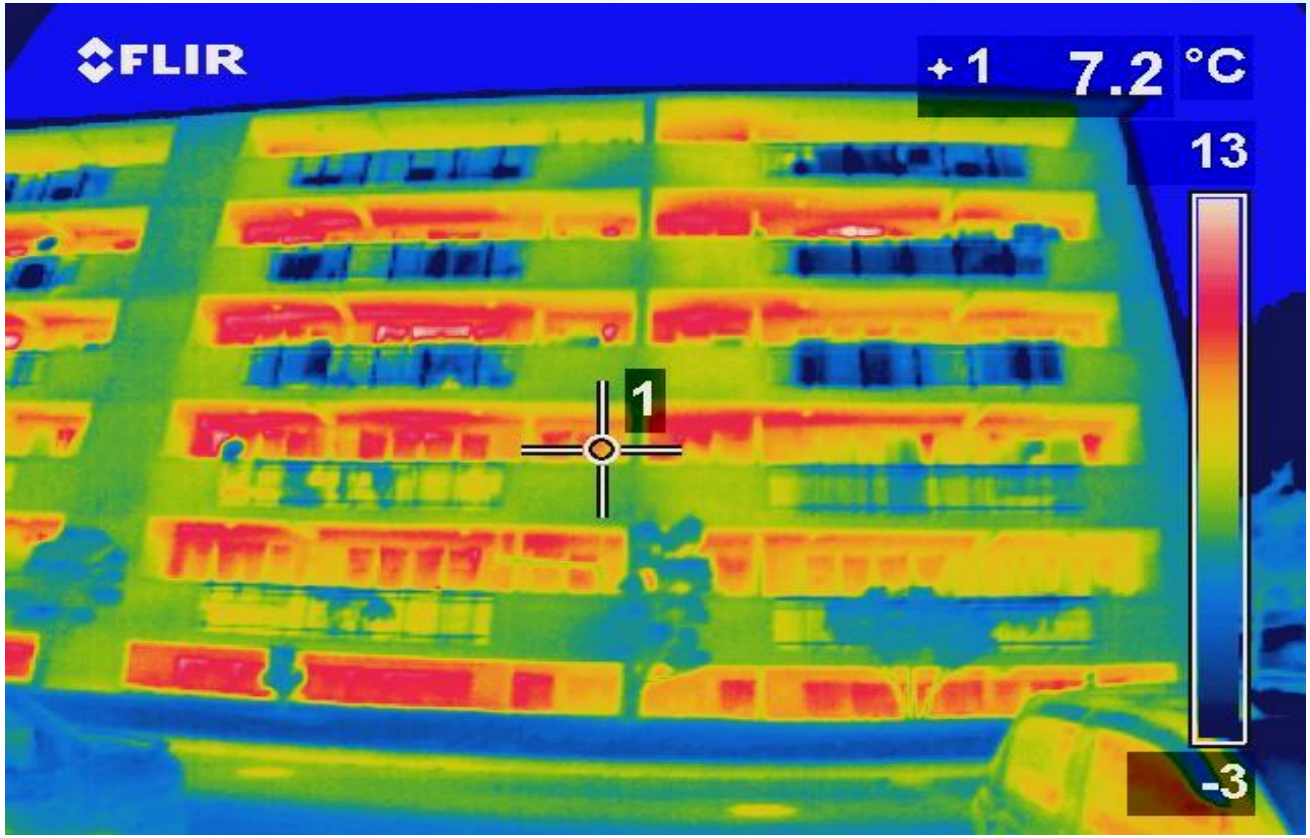
Equal and Efficient Heating System Management

Operating Status (Residence 6)



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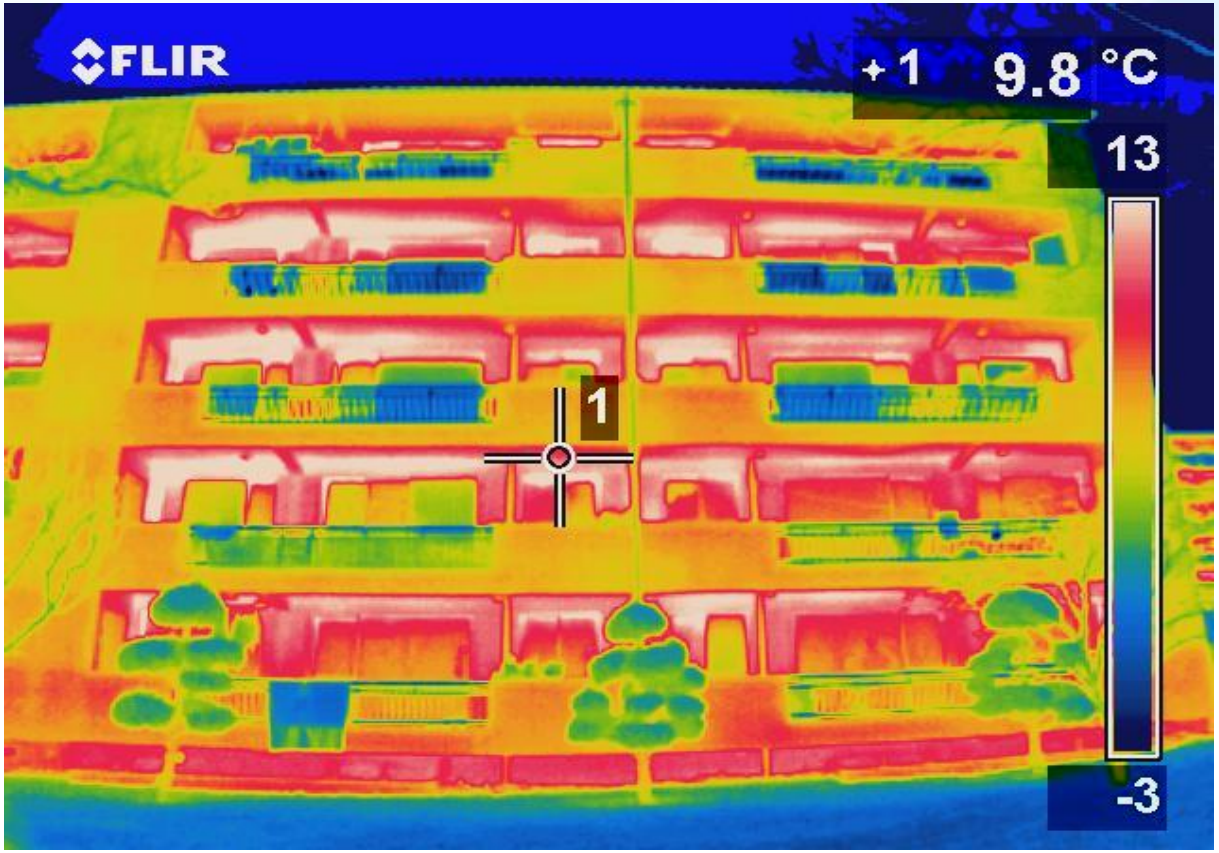
Equal and Efficient Heating System Management

Operating Status (Residence 3)



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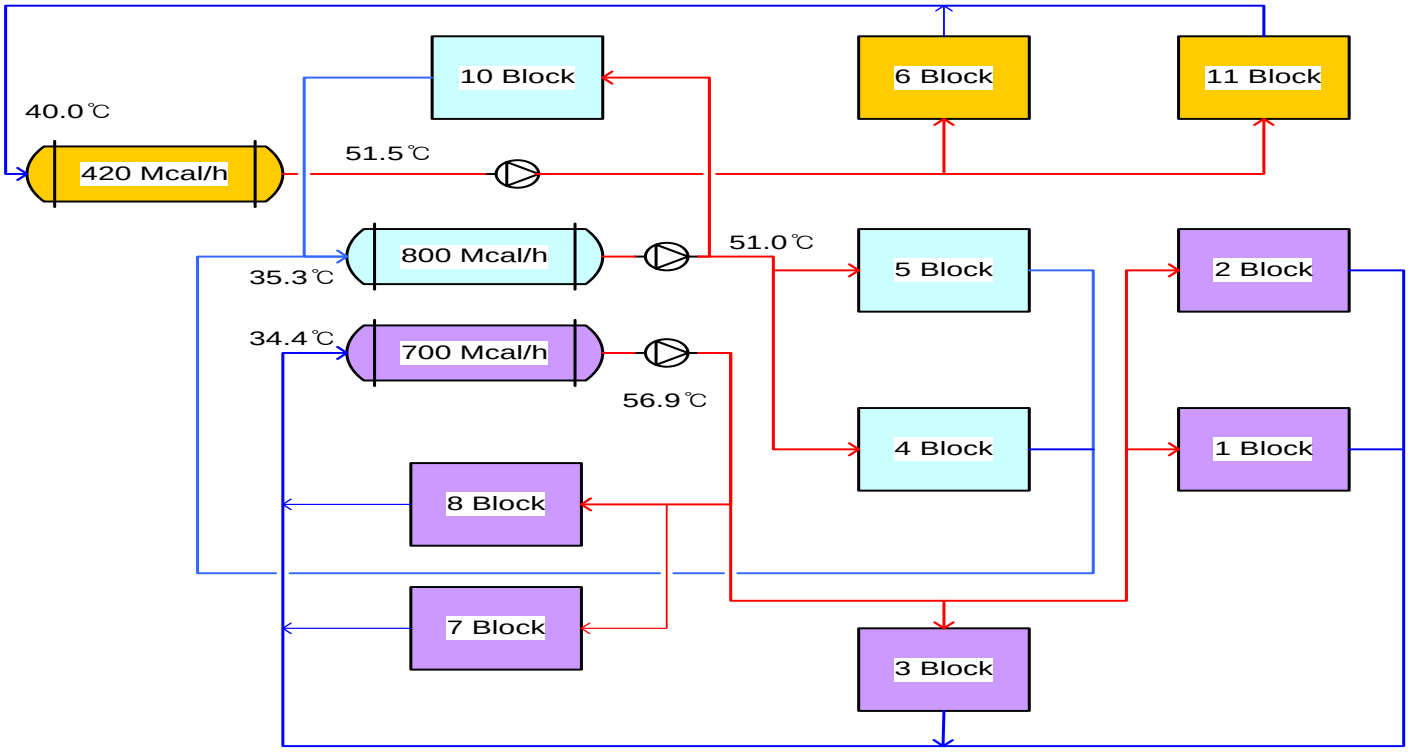
Equal and Efficient Heating System Management

- **Operating Status**

  - Residence Heating Water Supply System



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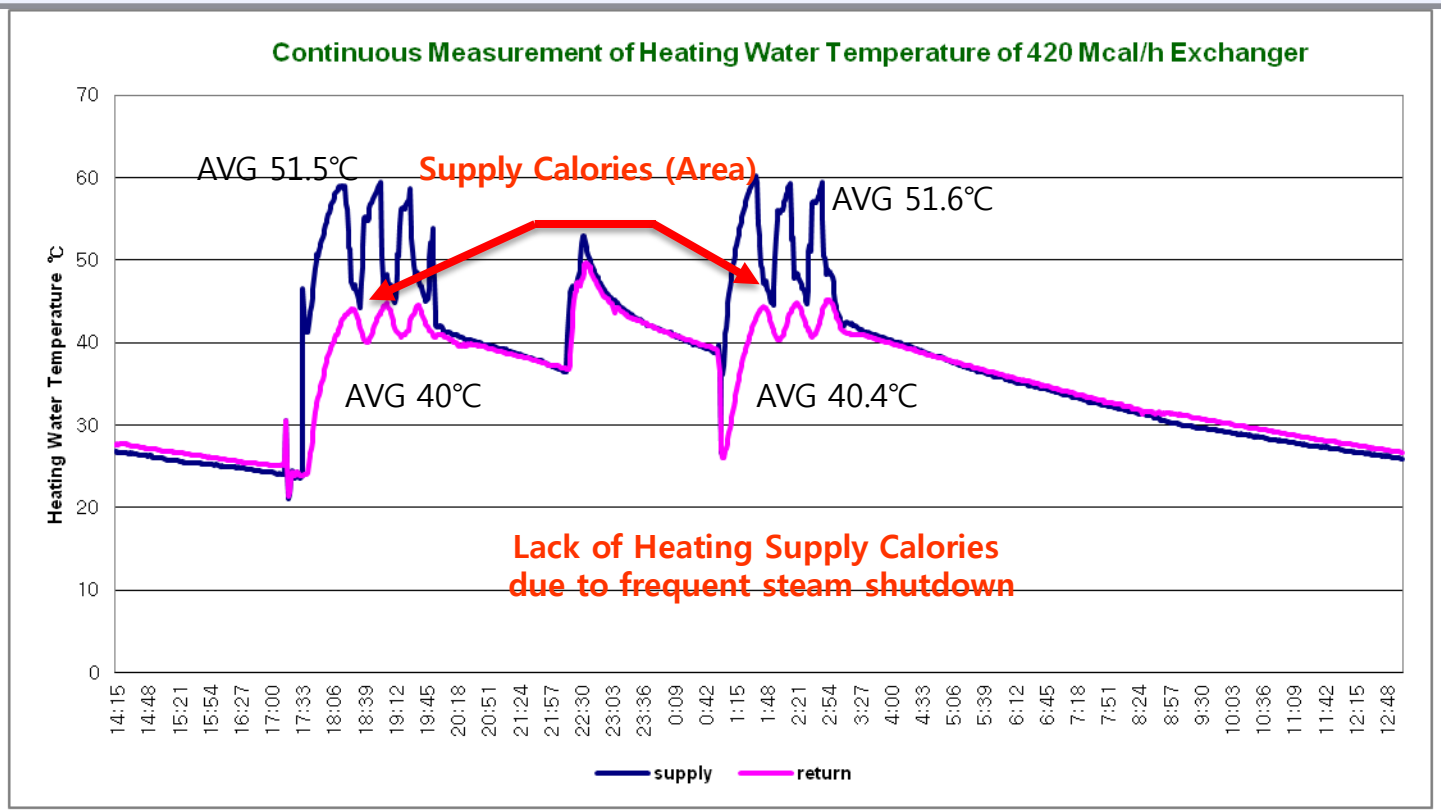
Equal and Efficient Heating System Management

- **Measurement and Analysis (420M heat exchanger (Residence 6, 11))**



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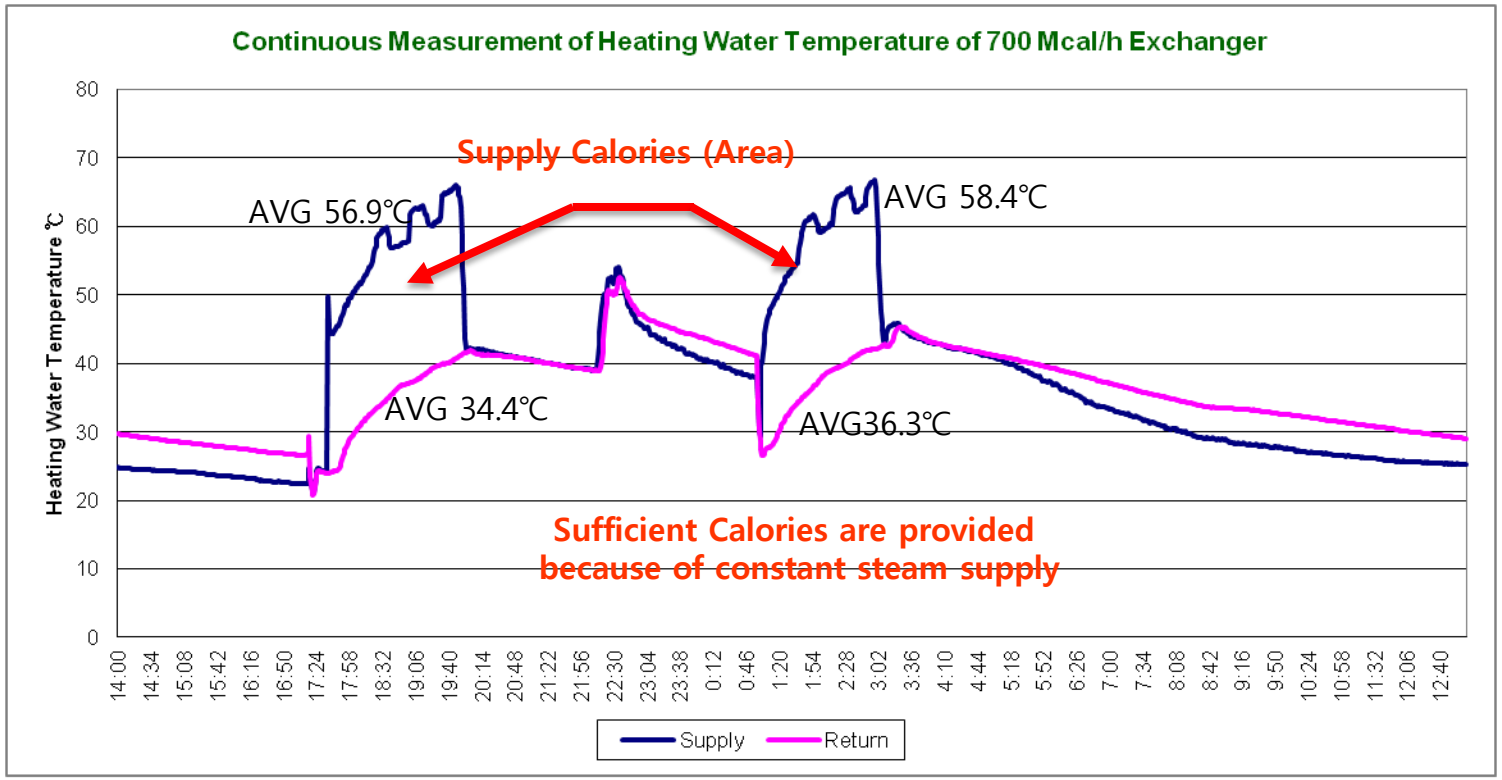
Equal and Efficient Heating System Management

- **Measurement and Analysis (700M heat exchanger (Residence 1, 2, 3, 7, 8))**



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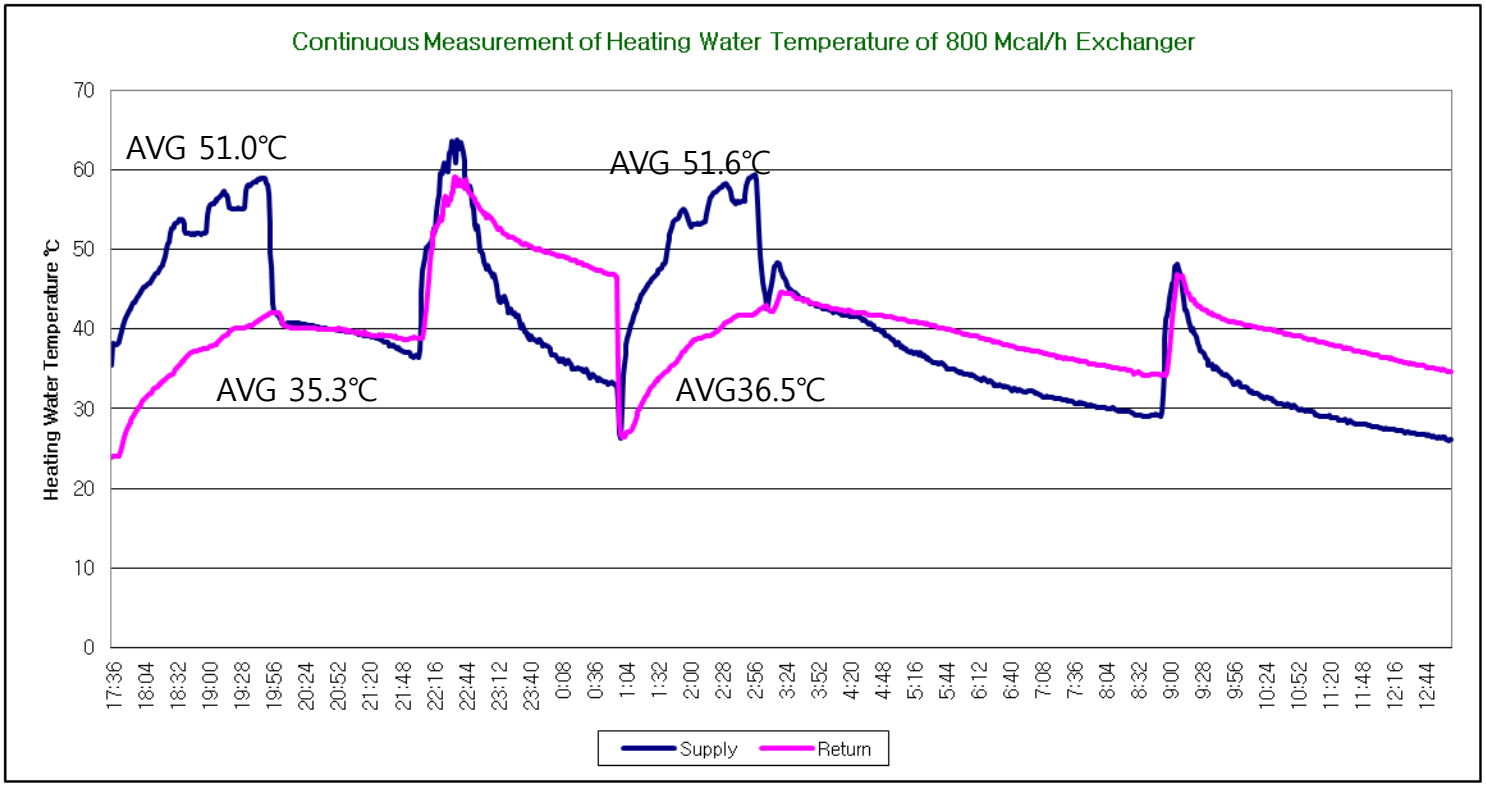
Equal and Efficient Heating System Management

- **Measurement and Analysis (800M heat exchanger (Residence 4, 5, 10))**



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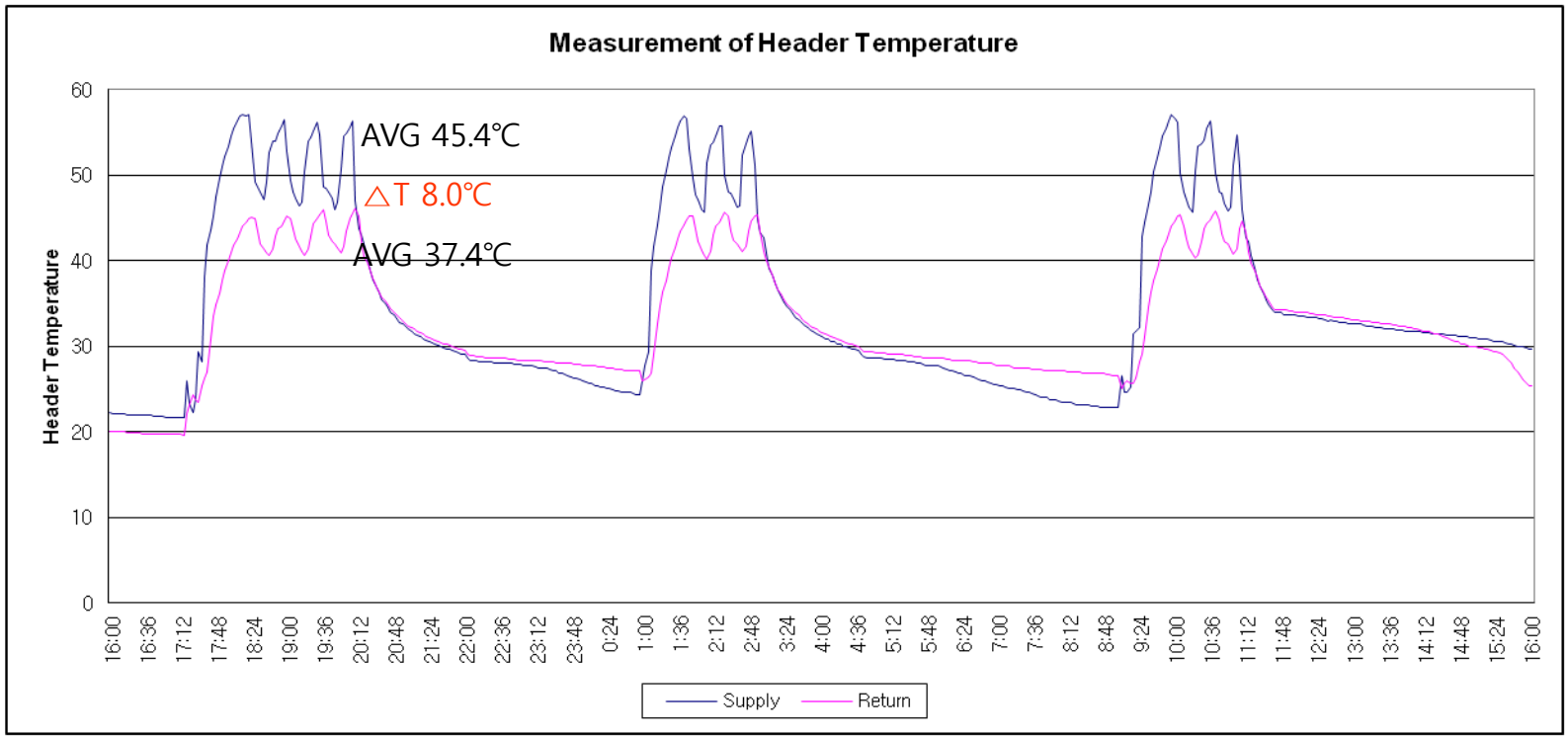
Equal and Efficient Heating System Management

- **Measurement and Analysis (Residence 11 Header Heating Water Input and Output Temperature)**



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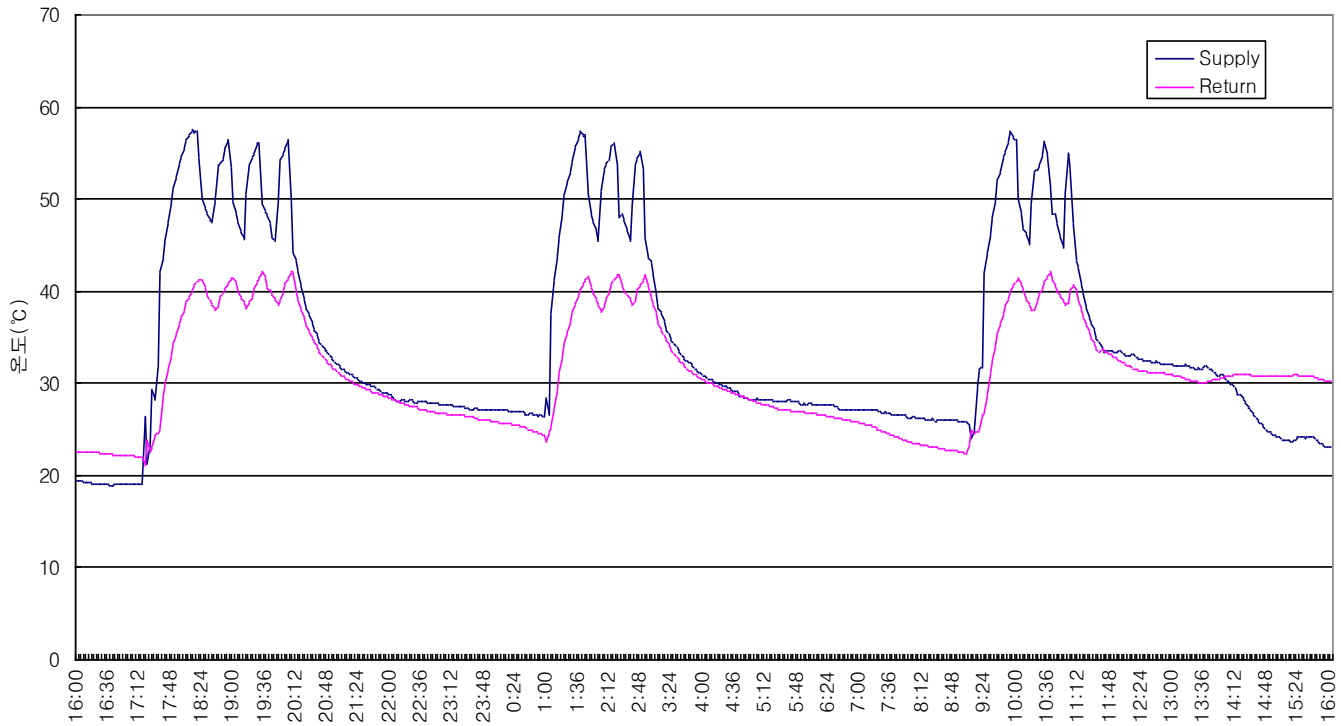
Equal and Efficient Heating System Management

- **Measurement and Analysis (Residence 6 Header Heating Water Input and Output Temperature)**



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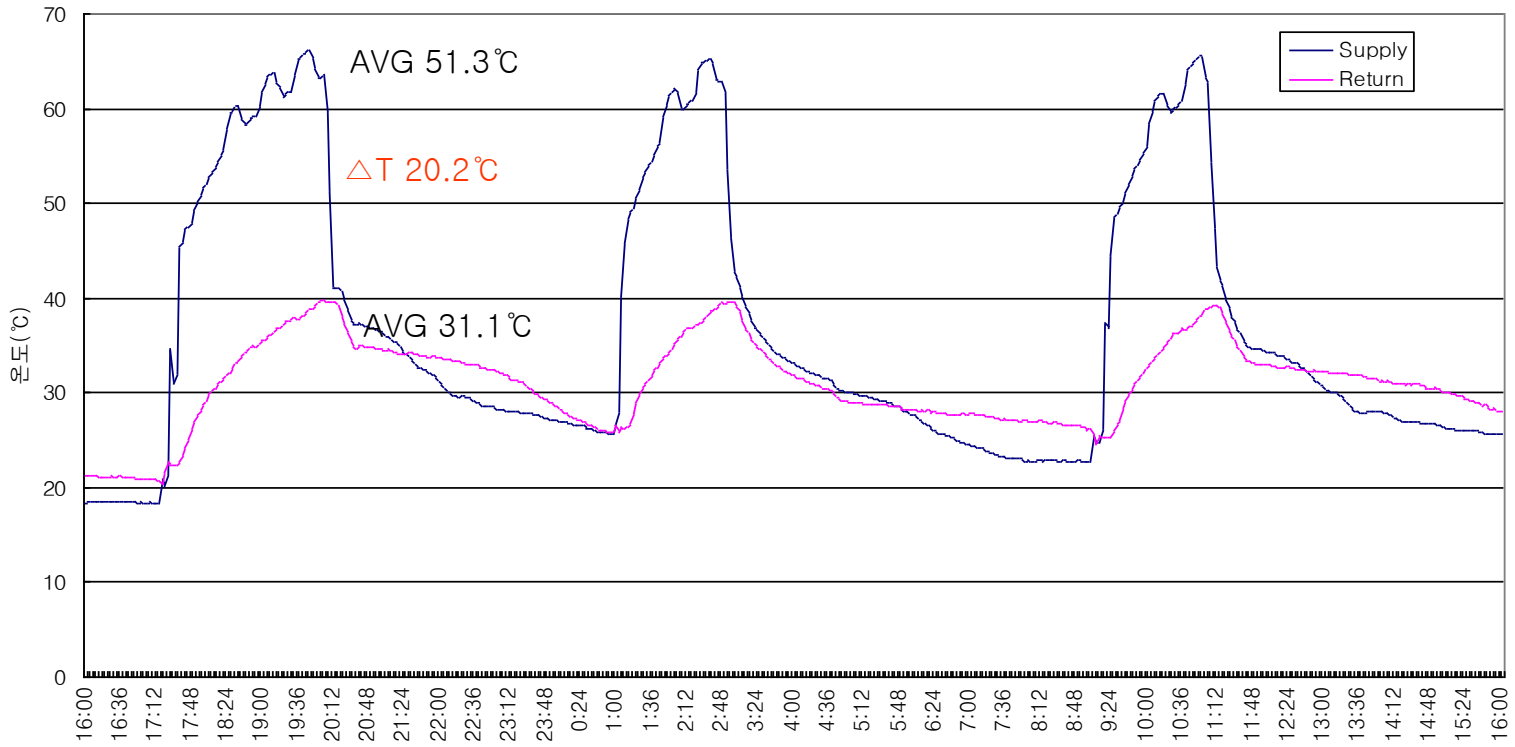
Equal and Efficient Heating System Management

- **Measurement and Analysis (Residence 3 Header Heating Water Input and Output Temperature)**



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Equal and Efficient Heating System Management

- Measurement and Analysis
  - Residence 6 and 11 have multiple complaints due to insufficient heating provided
  - Thermal Imaging Results can verify the complaints
  - Insufficient Calories provided in 420M heat exchanger, provides heat to residence 6 and 11

Heat exchanger Capacity (Mcal/h)		Residence 6, 11		Residence 1,2,3,7,8		Residence 4,5,10	
		420		700		800	
Heating Area (m^2)	Possible Supply Calories per Area (kcal/m^2)	4132	102	8151	86	7821	102
Heating Water Circulation (ℓ /h)		29,900		42,800		51,600	
Supply/Return Temperature (℃)		51.5	40.0	56.9	34.4	51.0	35.3
Heating water Supply Calories (Mcal/h)		343		961		814	
Actual Supplying Calories per Calories (kcal/m^2)		83		118		104	

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Equal and Efficient Heating System Management

- Operating Status
  - Residence 6 and 11 are set to shut down steam supply in return temperature above 37℃ through electric valve.
  - Because of low absorption rate of residence 6 and 11, 30~50 minutes after initiating return temperature of the heating water remains high (45℃).
  - Because return temperature remains high, steam supply is frequently shut down, leaving insufficient calories for heat exchanger.
  - Because steam supply pressure is 0.4~1.0㎏/㎠, lower than Design Value 2 ㎏/㎠, steam supply is not adequate.

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Equal and Efficient Heating System Management

- Operating Status – Current Steam supply pressure of 0.4 ~ 1.0 kg/cm^2 cannot provide enough steam in heat exchanger -> Insufficient supply Calories

	Required Steam amount in heat exchanger (kg/h)			Possible Steam amount in Supply Pipes (kg/h)		
	0.7kg/㎠g	1kg/㎠g	2kg/㎠g	0.7kg/㎠g	1kg/㎠g	2kg/㎠g
42 (Mcal/h)	799	794	813	716	730	1,215
70 (Mcal/h)	1,331	1,323	1,354	1,145	1,160	1,755
80 (Mcal/h)	1,521	1512	1,548	1,145	1,160	1,755

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Equal and Efficient Heating System Management

- Improvement Ideas
  - Continuous operation of pump until return water temperature of residence 6 and 11 is 35℃.
  - Regulator is set so that Intermediate machine room steam supply pressure remains 2㎏/㎠
  - If current steam supply pressure is left unchanged, enlarging heat exchanger capacity does not give effective heating water supply calories.

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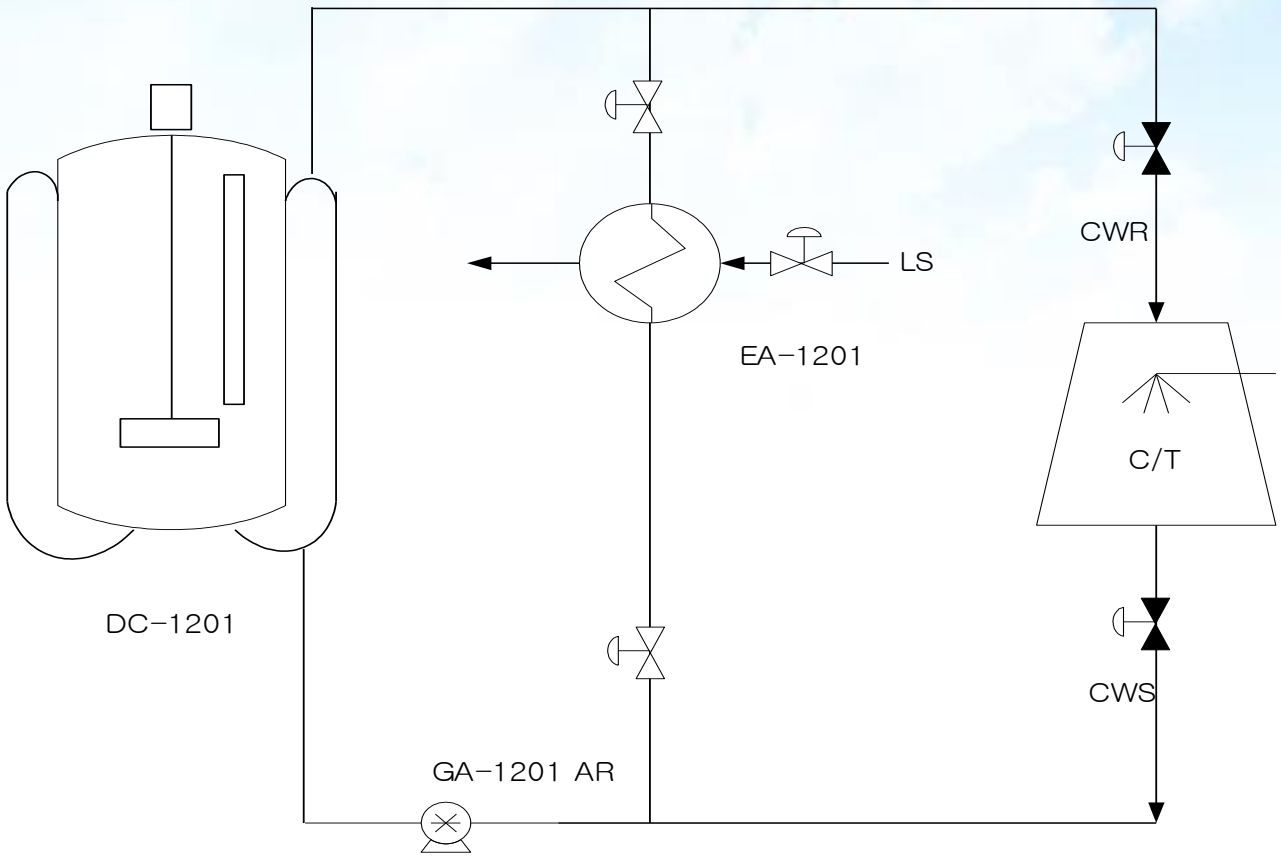
Rationalizing EPS Reactor Heating/Cooling System

◇ Operating Status



Picture explains heating process, and EA-1201 Front and Back valves are closed in cooling process

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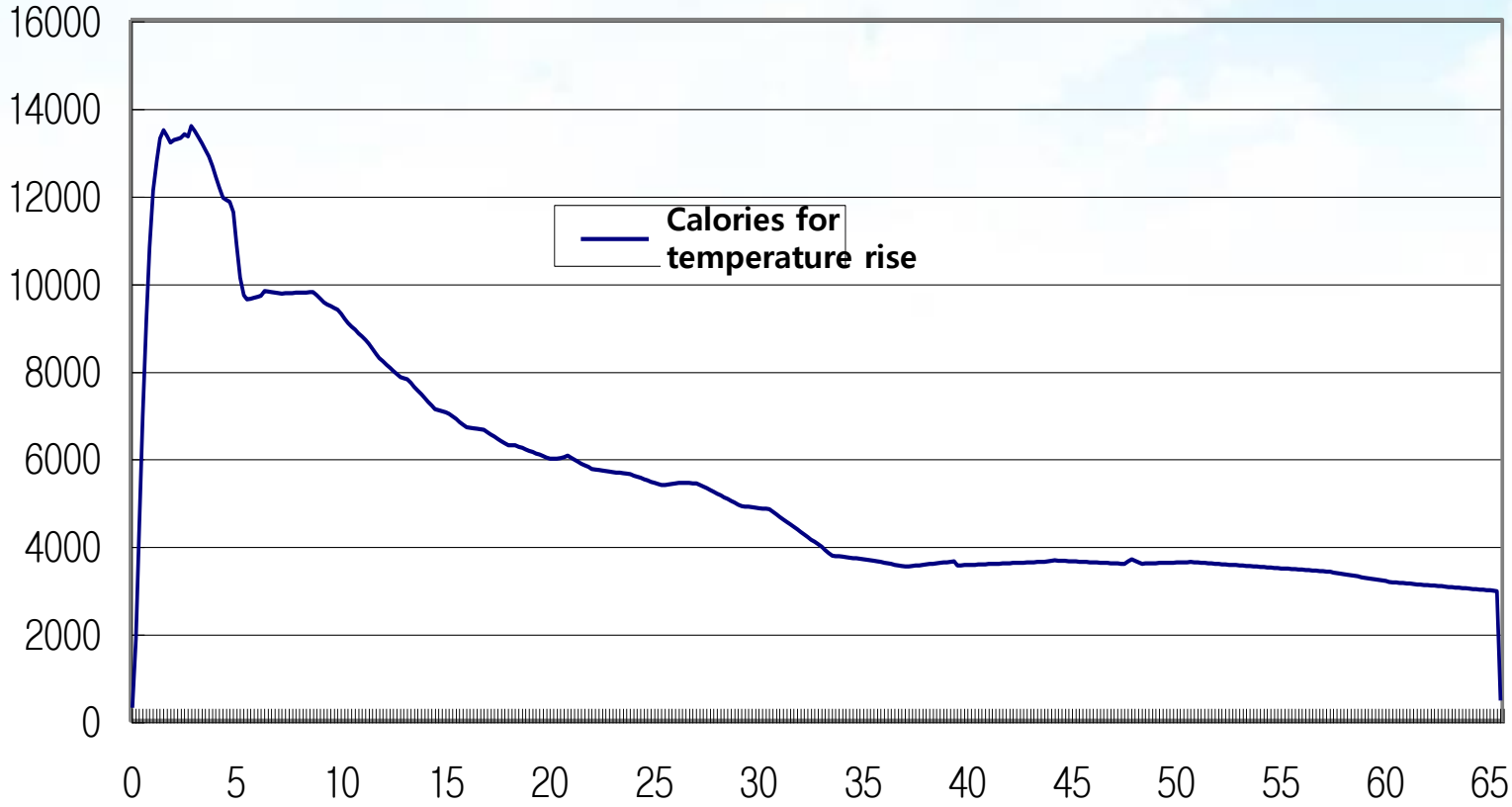
◇ Heating Load Profile in 1st temperature rise of reactor (0min~ 65.3min)



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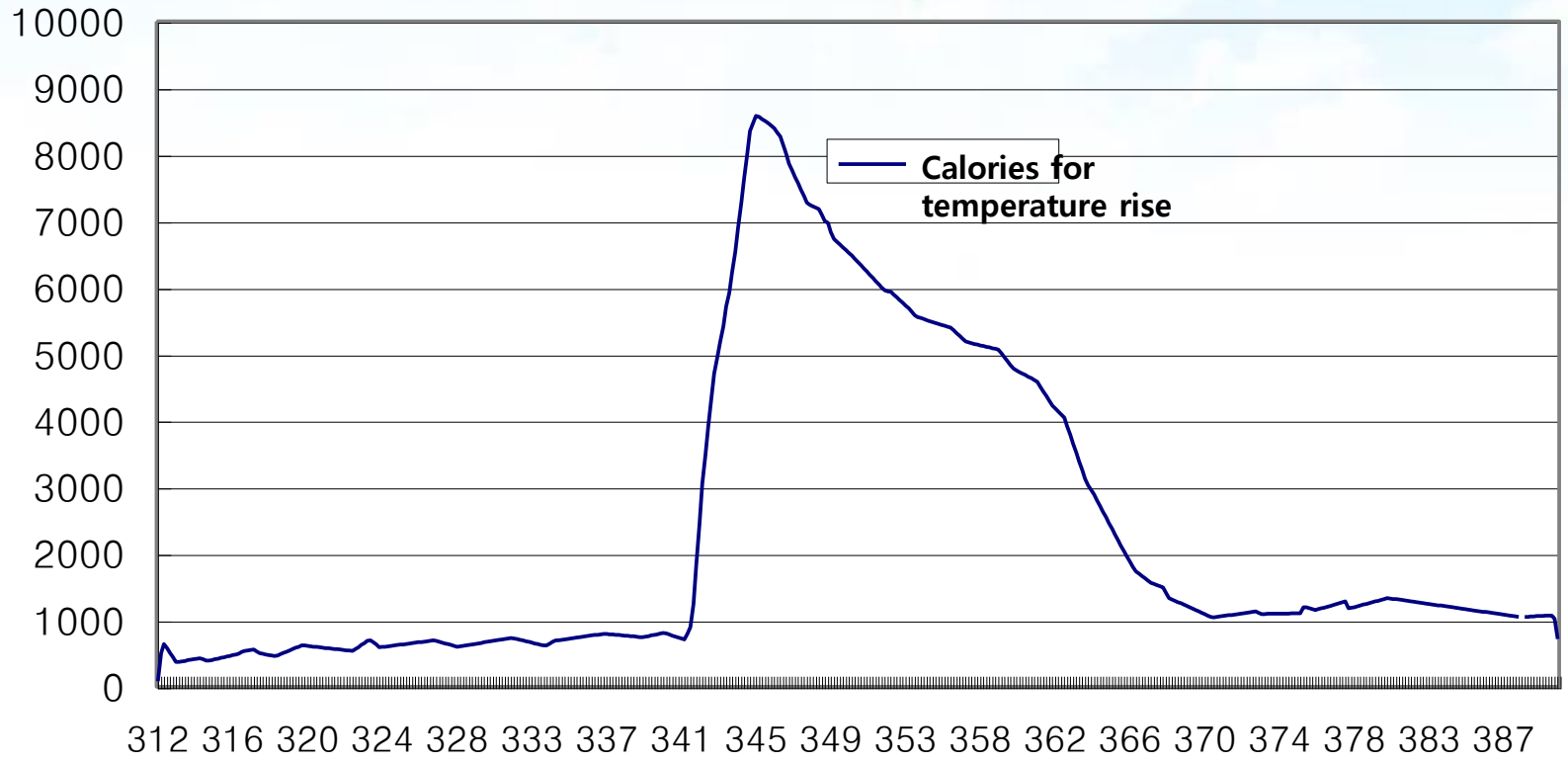
◇ Heating Load Profile in 2nd temperature rise of reactor (311.7 min~ 388min)



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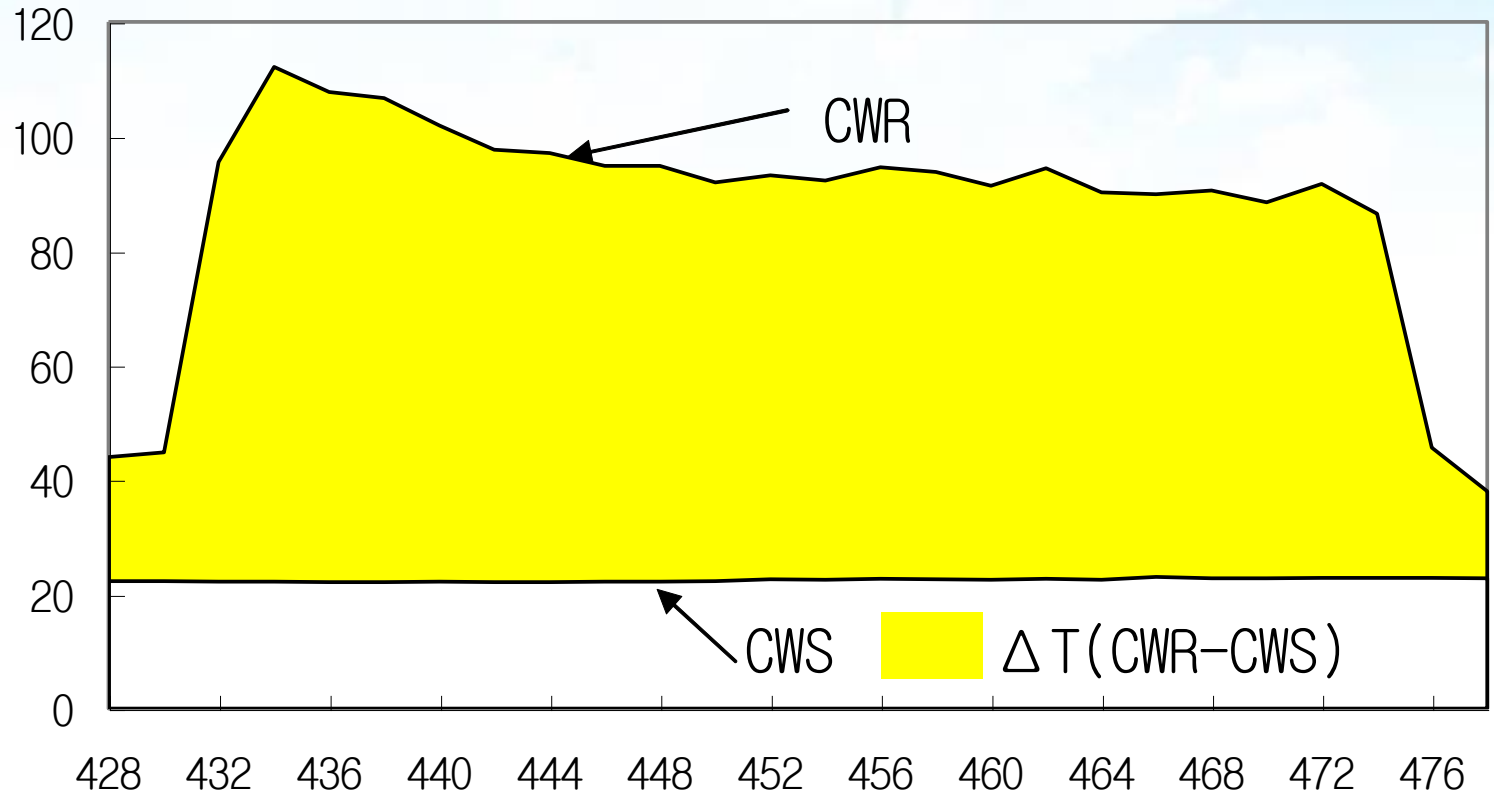
◇ CWS , CWR Temperature Profile When Reactor is Internally Cooling(428~478min)



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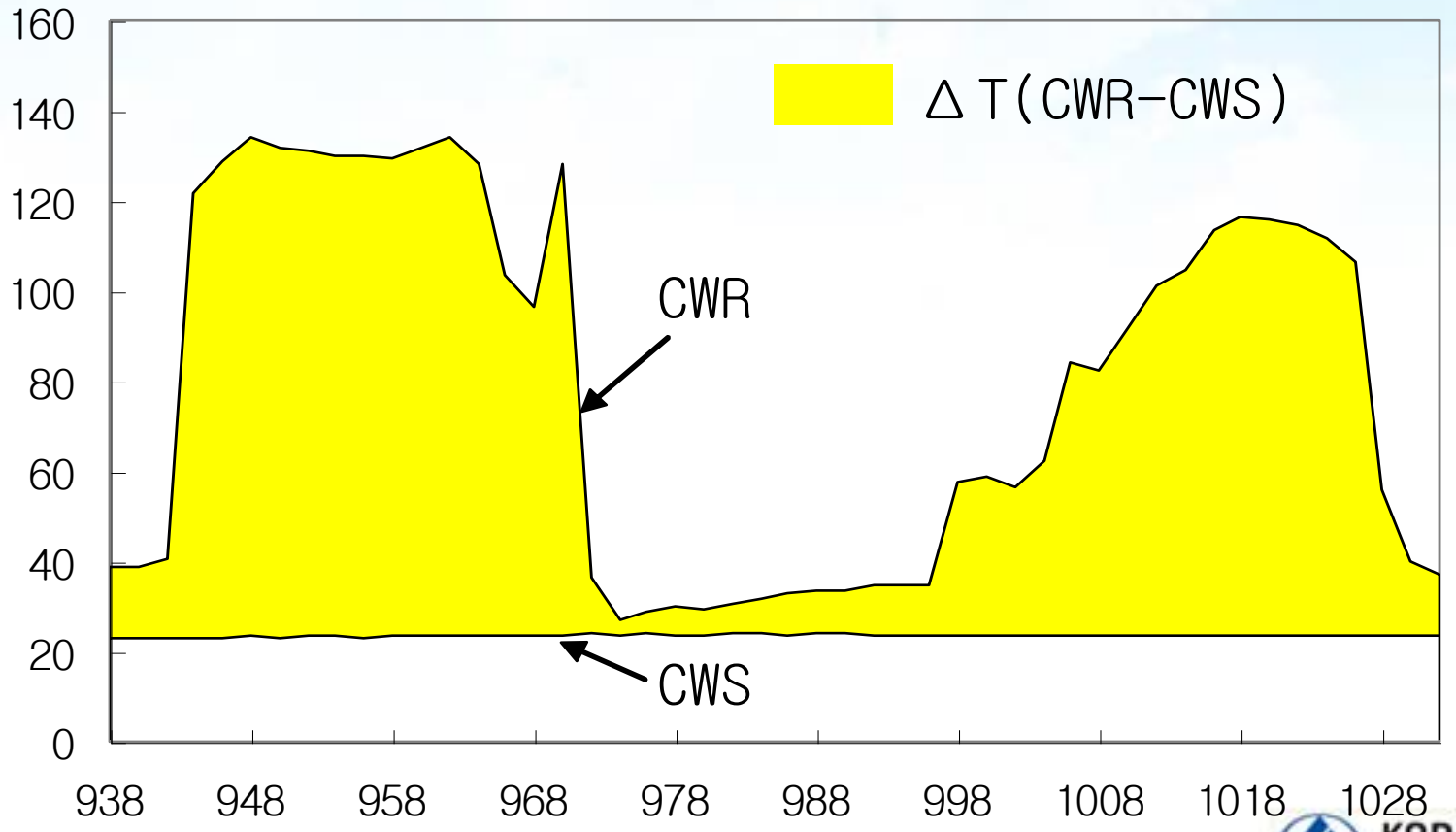
◇ CWS , CWR Temperature Profile When Reactor is Internally Cooling(938~1,030min)



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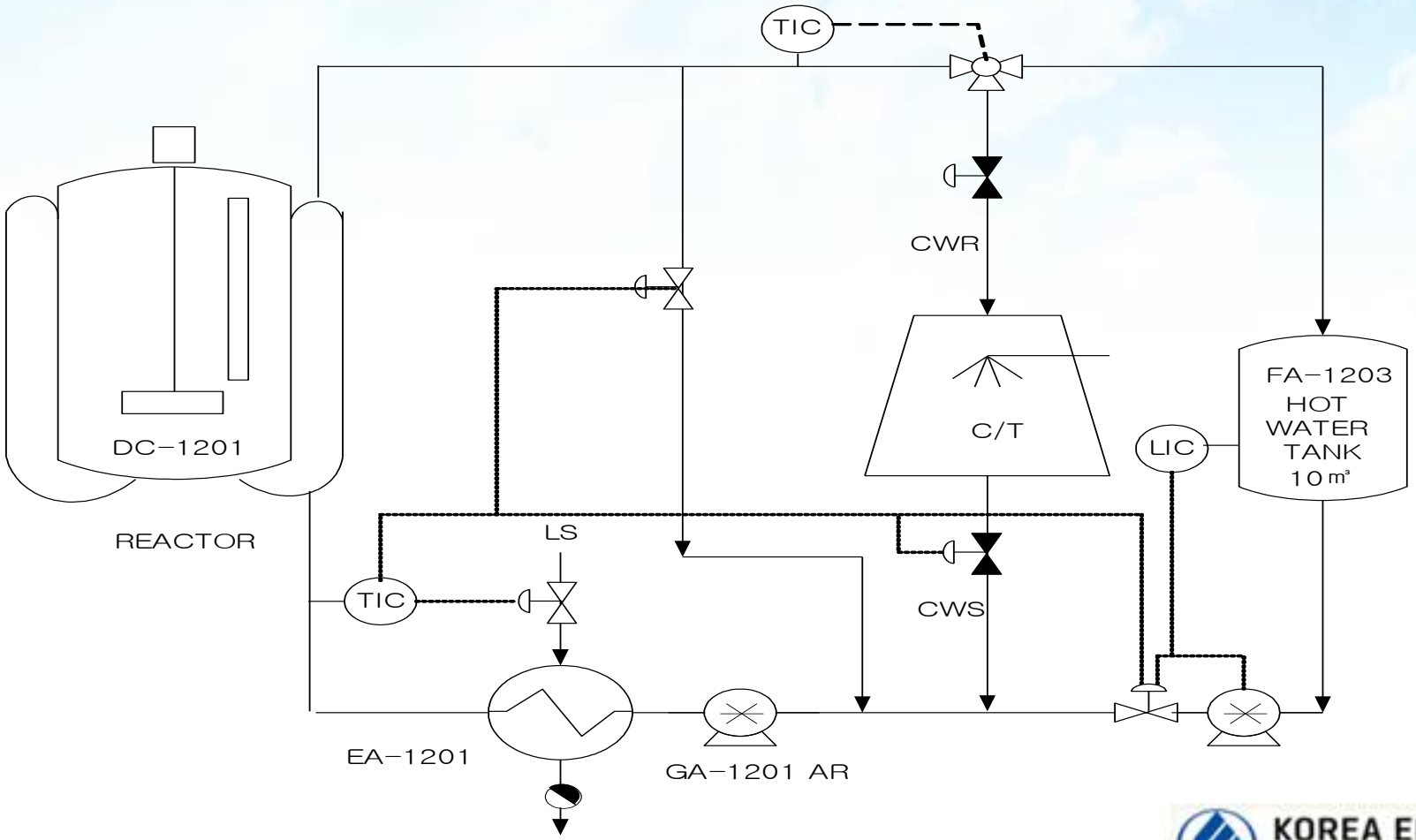
◇ Improvement Ideas



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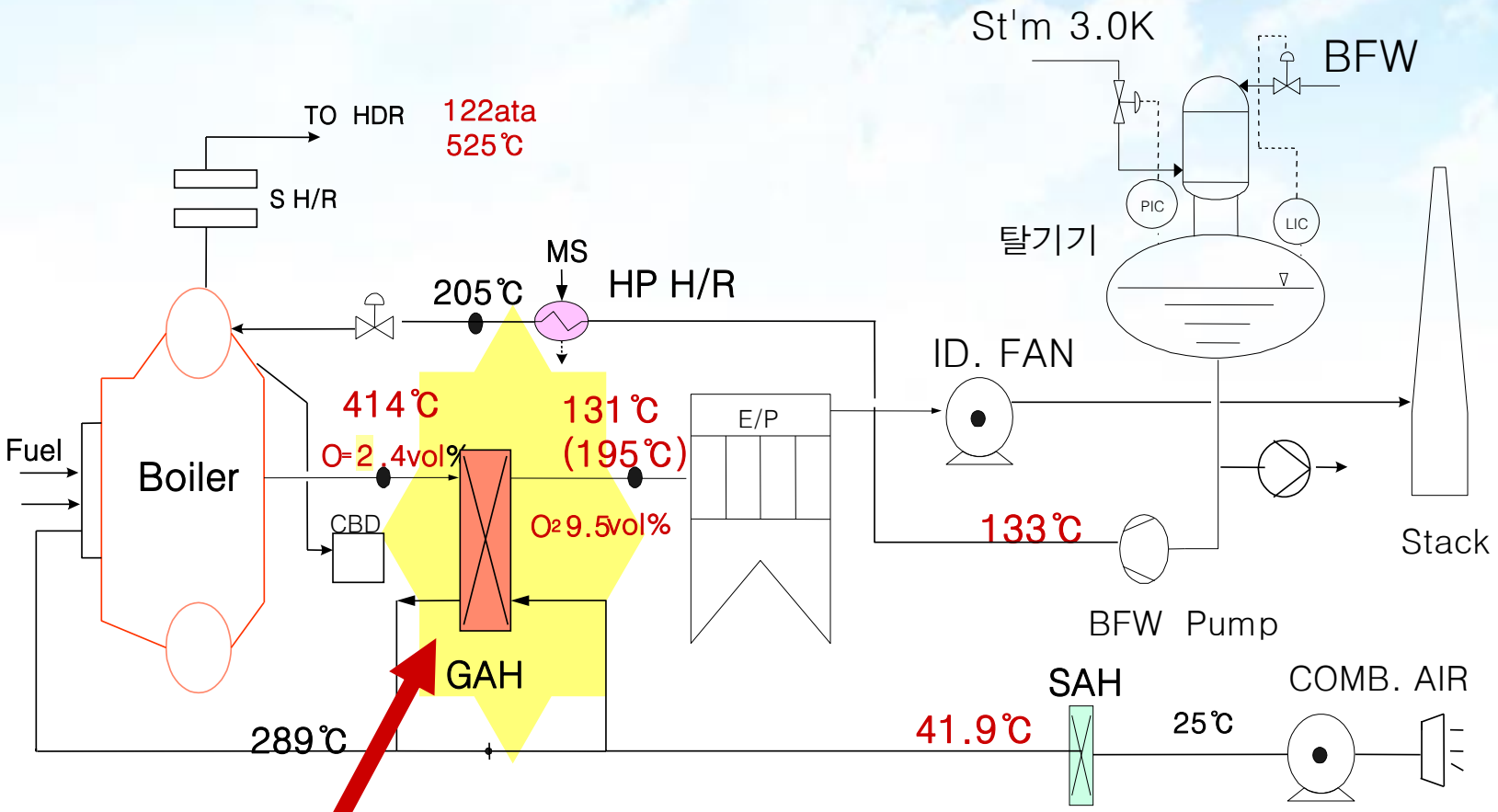
Retrieving Boiler Emission Gas Heat

◈ System Operating Status



Air leak % : 38% (Ljungstrom model GAH)

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Retrieving Boiler Emission Gas Heat

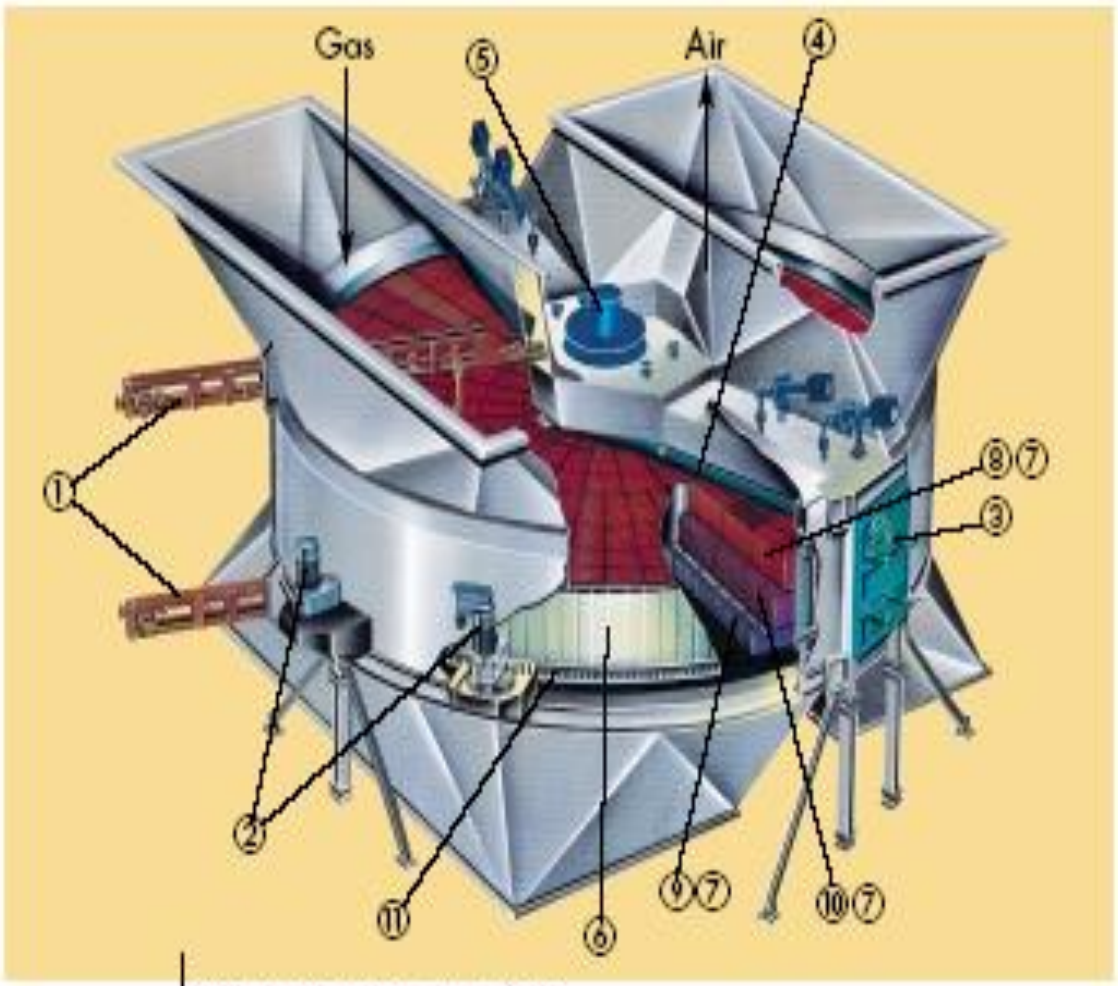
◈ Focus Point

- obsolete equipment of GAH and structural leak gives decreased heat exchanger capacity
- Retrieving most Emission Gas heat can be achieved through switching old one to Economizer, which is without air leak.

◈ Improvement Idea Review

- Switch to Economizer, one without air leak.
- Additional Installation of corrosion resistance heat exchanger Behind Electric Precipitator (EP) to retrieve emission Gas heat (combustion air warm up heating source)

Ljungstrom model GAH Structure



Typical air preheater - design AGT

① Combined cleaning device for blowing with steam or compressed air and washing with water
② Rotor Drives
③ Axial Seal – adjustable during boiler operation
④ Radial Seal – adjustable during boiler operation
⑤ Guide Bearing
⑥ Rotor
⑦ Heating Elements in Containers
⑧ Hot Layer (Material: steel)
⑨ Cold Layer (Material: steel, "Corten" or enameled steel)
⑩ Intermediate Layer (Material: steel)
⑪ Pin Rack

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Ljungstrom model GAH Leak cases and reasons

◇ Leak Cases

- Carry-in Leakage : As Rotor rotates, fluid left in the rotor is mixed in with other fluids in the rotor, causing leakage (Entertained Leakage)
- Direct Leakage : Because of pressure difference between two Heat exchangeable fluids, High pressured fluid is inserted into low pressure liquids through seals located between rotor and outside surface casing (70% ~80% of leak cases)

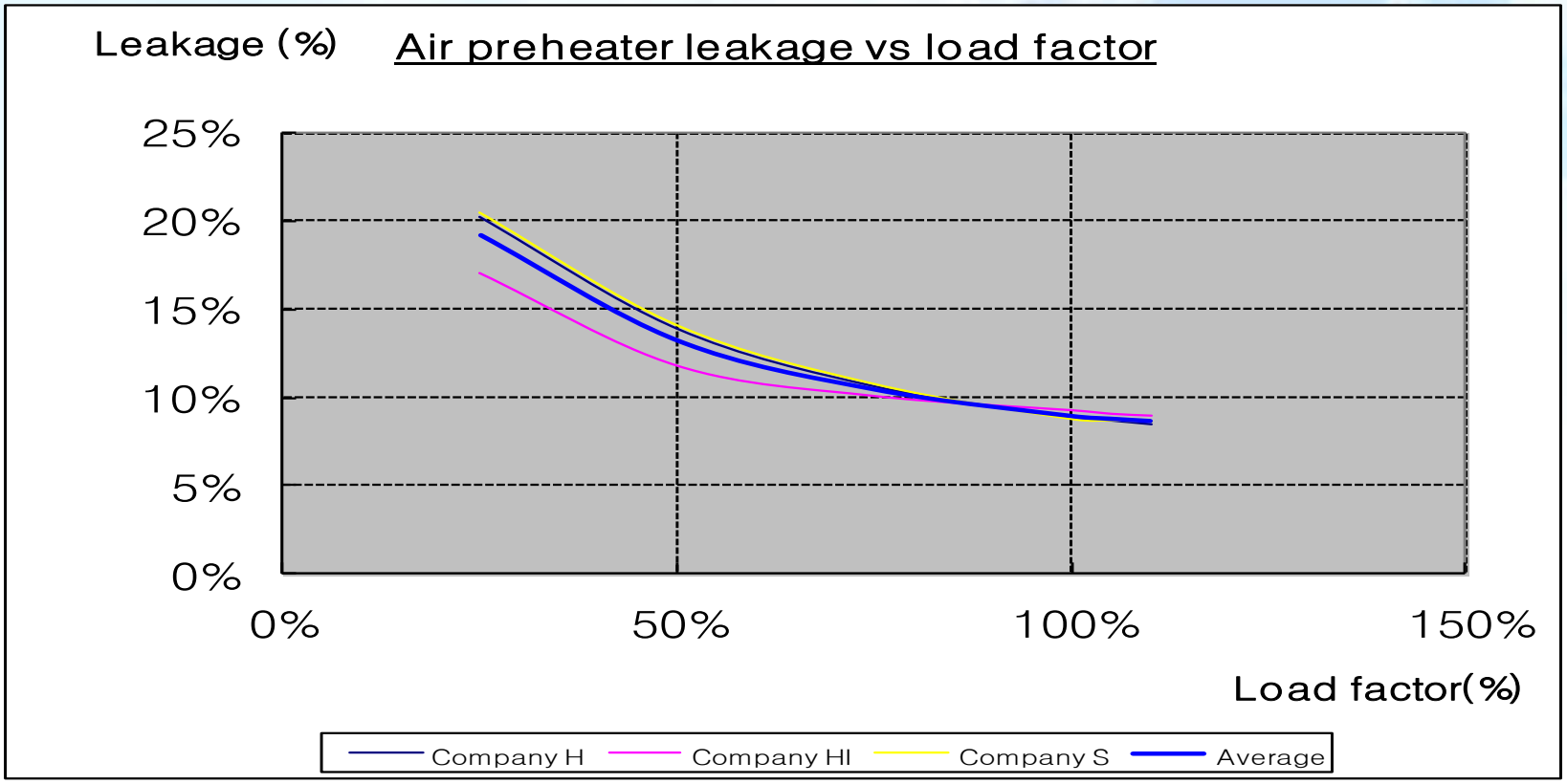
◇ Leak Reasons

- Disparity between Structural temperature conditions and actual operating condition causes over extended gap between each seals under Hot condition.

✓Difference Structural heat modification and actual heat modification causes wider gap

✓ Corrosion of Seal plate and surface area, heat modification, abrasion, Seal plate loss, causes wider gap

Ljungstrom model GAH AIR LEAK proportion (Structure)



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Boiler Emission Gas heat Retrieval

◈ Issues of increased GAH air leak

- Rise of emission heat loss (Weaken GAH Cooling End Temperature Management)
- Increasing Load of F.D FAN also increases electric usage load.
- Among Heated air from SAH(Steam Air Heater), Leakage air is not properly used, and emitted outside (Increased steam load)

Thank you for Your participation.

17 JAN 2018

KOREA ENERGY AGENCY
Mr. Kyung-soon Park

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