Methodologies for efficiency improvement of HOB and CHP through JCM scheme

Advisory committee on 7th October in 2013

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Current state of developing methodology for JCM HOB project in Mongolia

JCM HOB project in Mongolia
(Expected 1st project of JCM scheme in the world)

<u>Project Name</u>

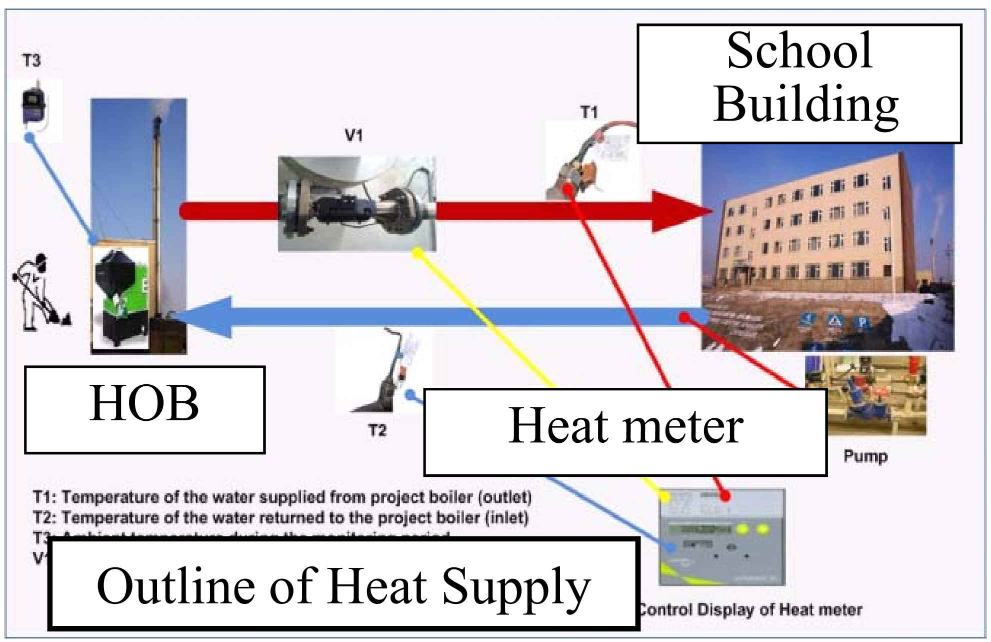
Upgrading and Installation of Centralized Control System of High-Efficiency Heat Only Boiler in Mongolia

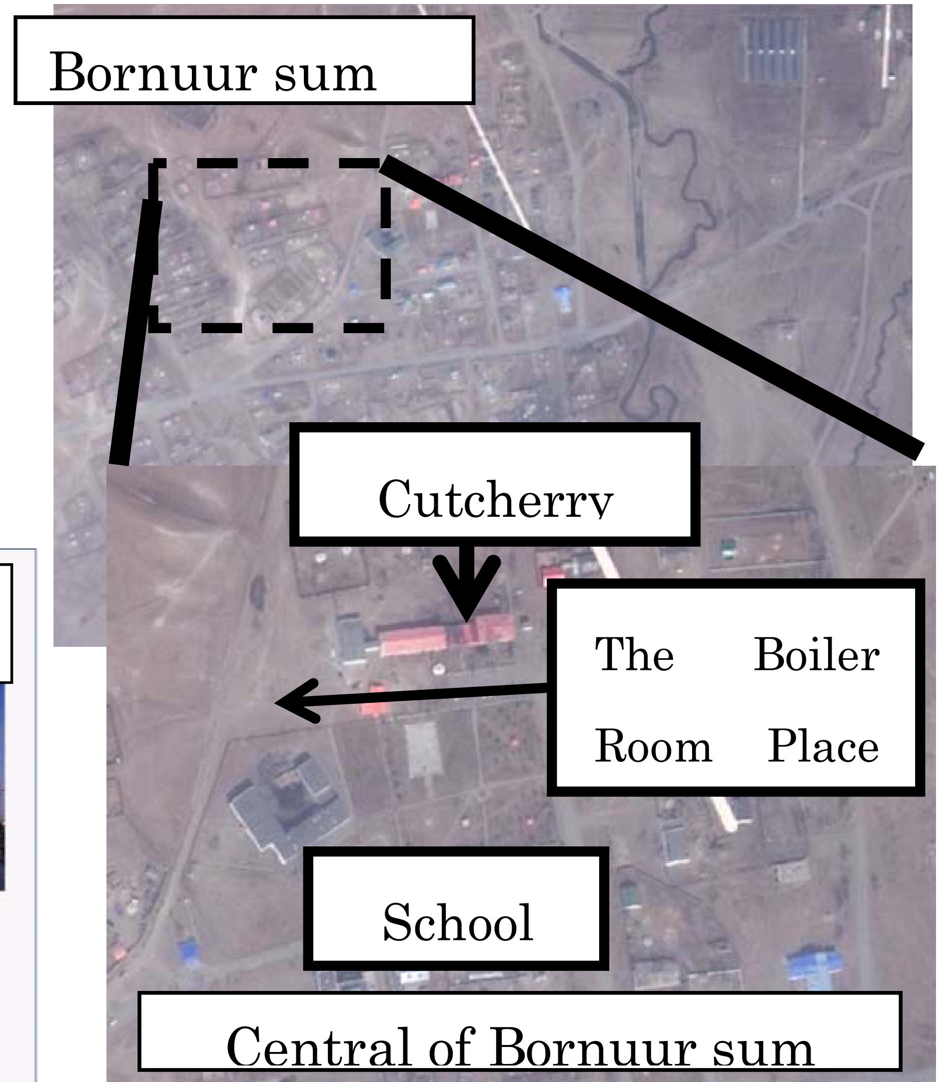
<u>Project site</u>

- Bornuur sum
- 18th school of Ulaanbaatar City")

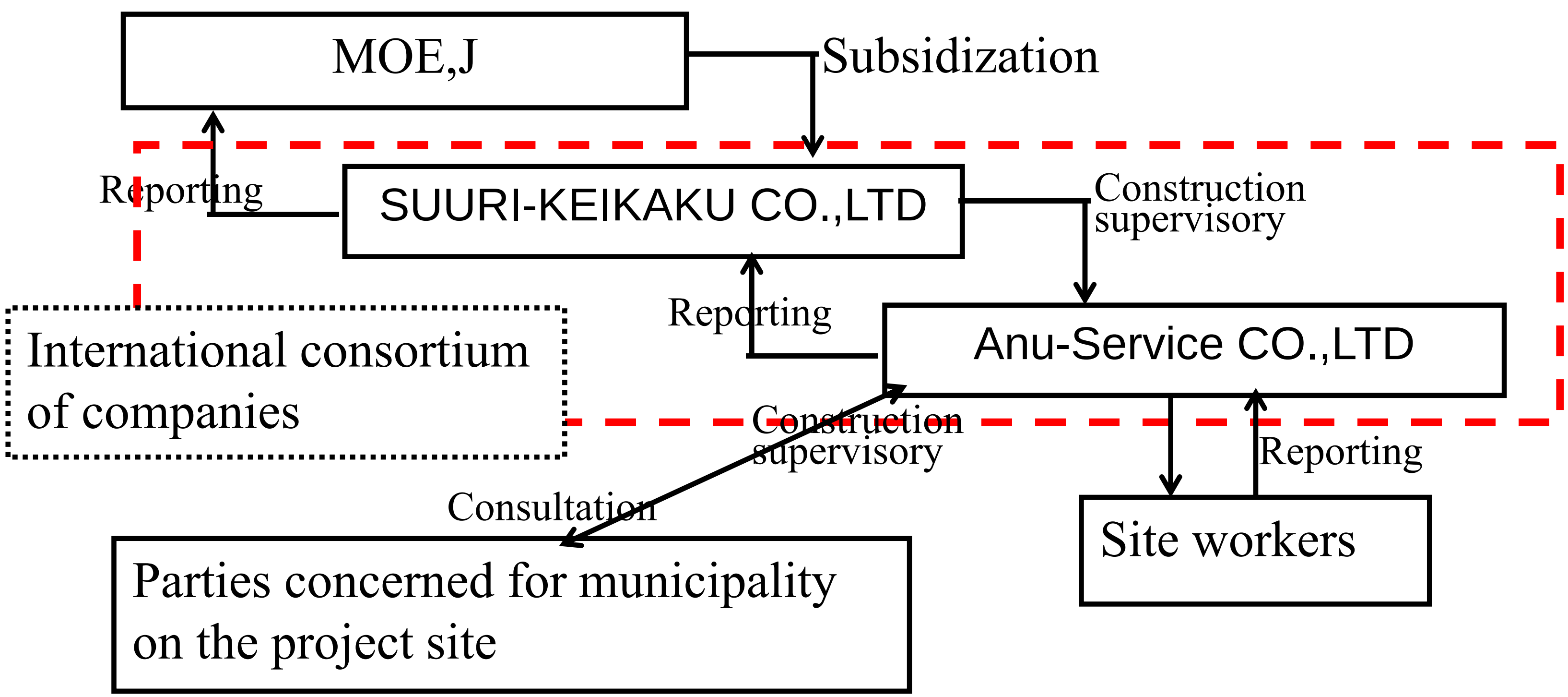
<u>Employed HOB</u>

EKOEFFECT

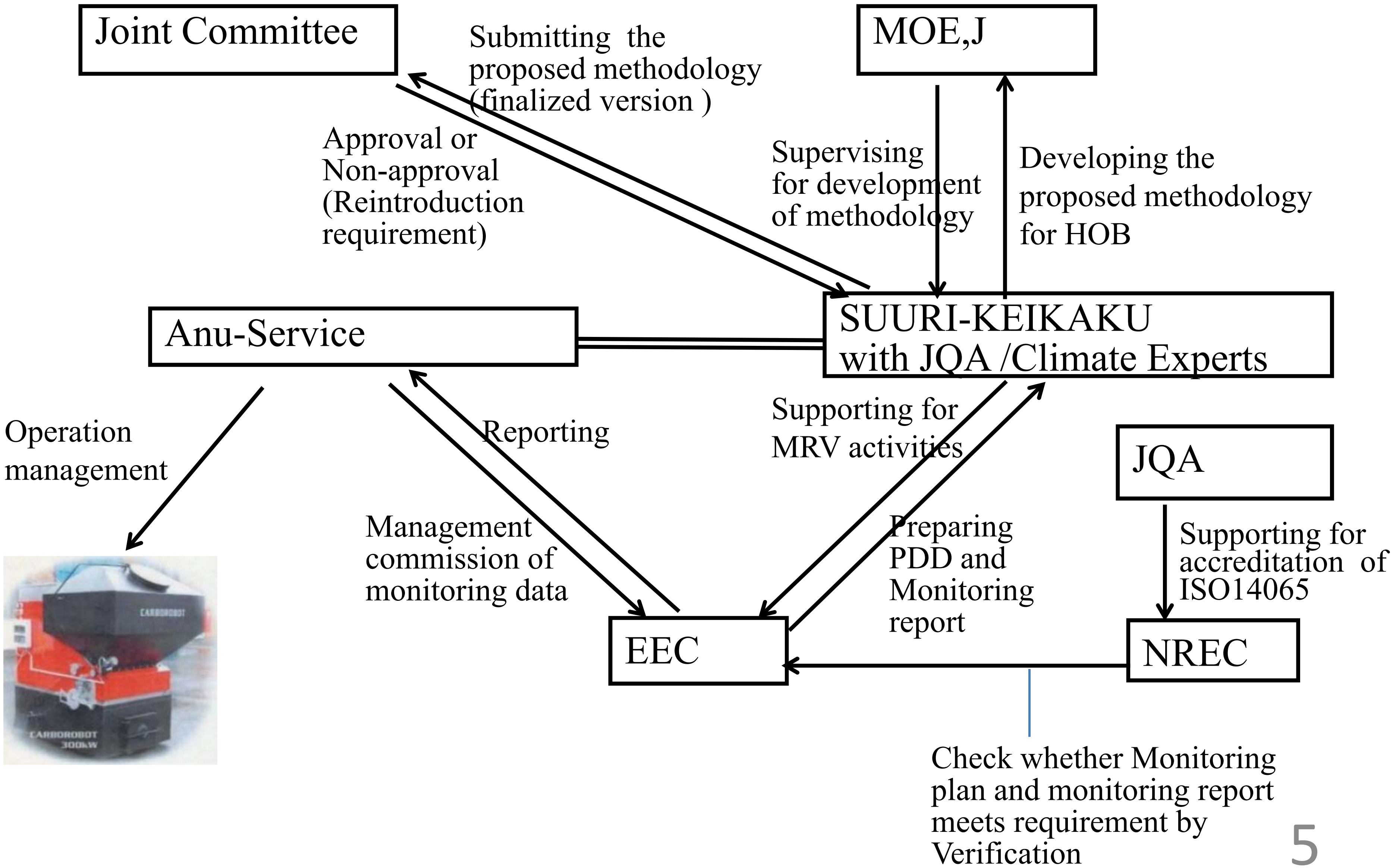




JCM HOB project implementation structure in Mongolia



Outline of MRV activities for HOB project in Mongolia



Equation of Emission Reductions

This parameter is measured actually by **heat meter with verification in accordance with MNS** for the purpose of **securing accurate measurement (*up to PP*)**

These **default values** are provided by the methodology **(*up to JCM scheme owner (=JC)*)**

By provision of default value , measuring coal consumption by the project HOB is not needed.

=0.101 tCO_2/GJ (Default value) according to "Lignite" from 2006 IPCC Guidelines for National Greenhouse ← This value will be confirmed by actual laboratory analysis of the used coal .

=Max MW value for specification Ø Total operating hours of the project HOB

=1.103 tCO_2/MWh (Default value) according to "Combined margin CO_2 emission factor for central energy system in Mongolia (According to CDM National Bureau of Mongolia)

$$ER_p = \mathbf{PH_p} \text{ Ø } (1/\eta_{RE\ BM} - 1/\eta_{PJ\ HOB}) \text{Ø } EF_{CO2,coal} - EC_p \text{Ø } EF_{CO2,grid}$$

Net heat quantity supplied by the Project HOB during the monitoring period p [GJ/p]

Benchmark value for boiler efficiency of reference HOB [−]

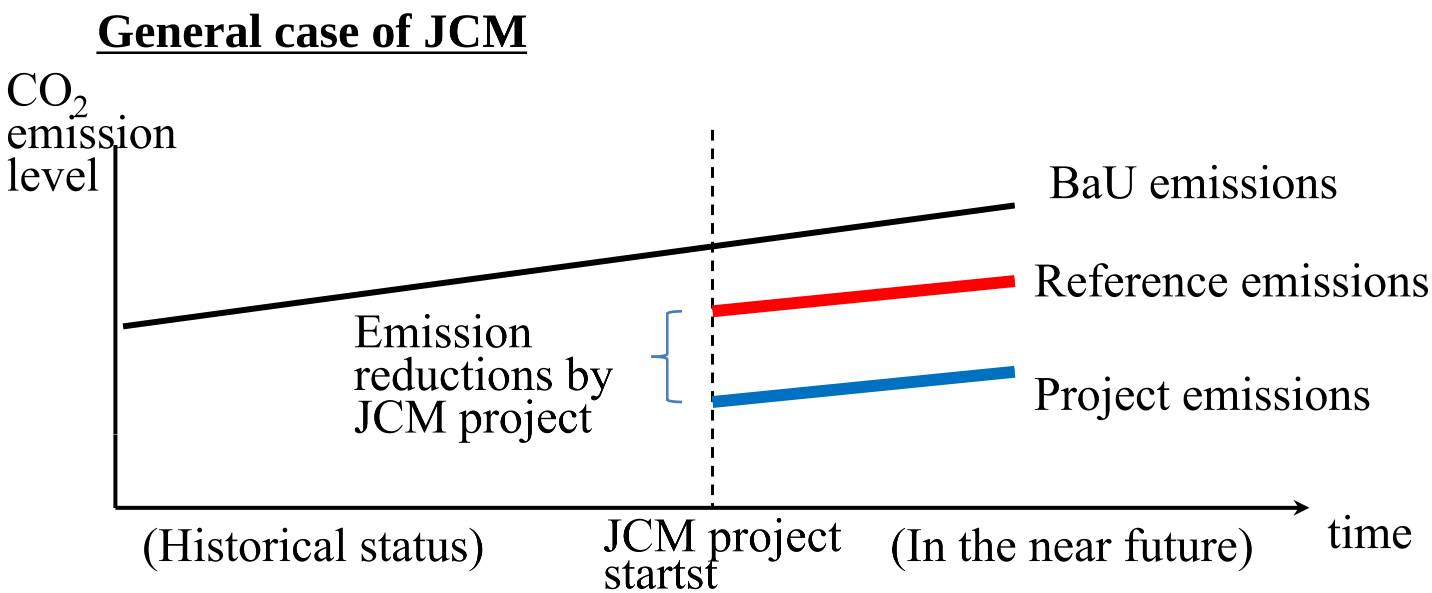
Default value for boiler efficiency of reference HOM[−]

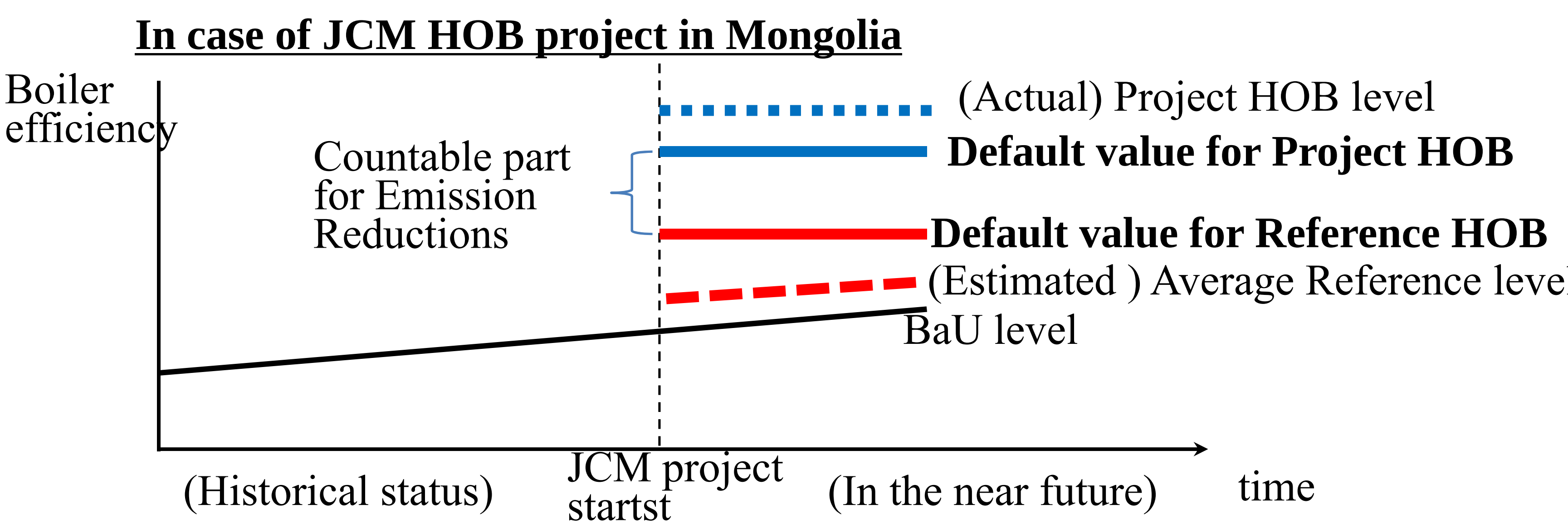
CO_2 Emission Factor of the consumed coal [tCO_2/GJ]

Electricity consumption of the project HOB during the monitoring period p [MWh/p]

CO_2 Emission Factor of electricity consumed by the project HOB [tCO_2/MWh]

BaU and Reference emissions in JCM scheme





What is project HOB ?

Boiler type which coal is continuously fed into conveyor type fire grate from stoker.

Type : CARBOROBOT, EKOEFFECT

Eligibility criteria for Project HOB

(1) The built in sensors of Project HOB control the autonomous operation while there is fuel in the container.

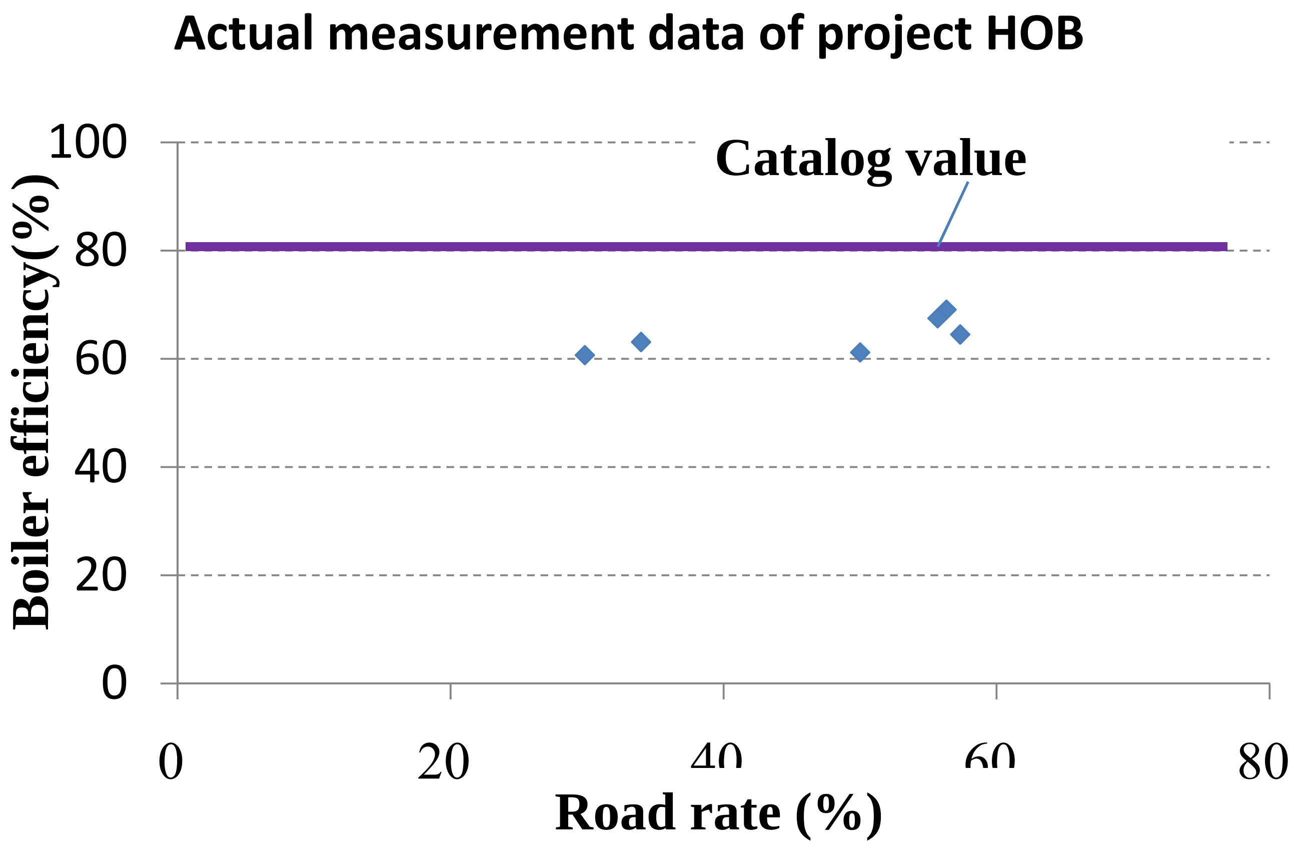
(2) The project HOBs have the boiler efficiency equal to or higher than 80% as the manufacturer's specification value.

(3) *The project HOBs obtain the international certification.*

←Catalog value for boiler efficiency is generally free-wheeling one by the maker

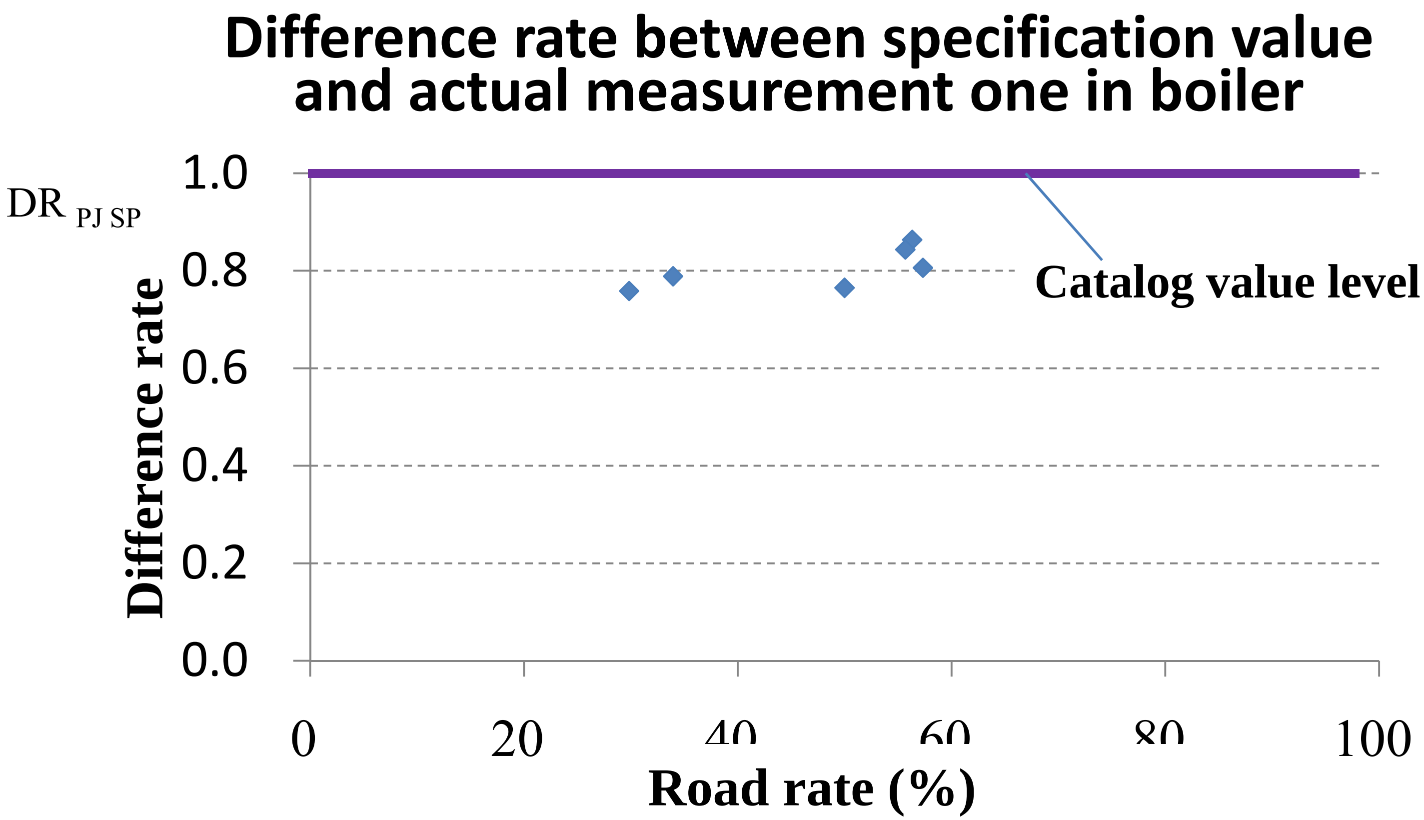
(4) The project HOBs have dust collectors.

How to set default value for boiler efficiency of project HOB ($\eta_{PJ\ HOB}$) ?



How to set default value for boiler efficiency of project HOB ($\eta_{PJ\ HOB}$) ?

$$\eta_{PJ\ HOB} = \underbrace{\eta_{SP\ PJ}}_{\text{Boiler efficiency of the project HOB as the manufacturer's specification value [Fraction] } =0.8} \ Ø \ \underbrace{DR_{PJ\ SP}}_{\text{Difference rate between specification value and actual measurement one in boiler efficiency of project HOB [fraction]}}$$



What is BaU HOB ? What is Reference HOB ?

Boiler type which coal is fed into fixed fire grate by the hand?

		Boiler efficiency(%)						
		Catalog value	Actual measurement data					
Portrait style	CLSG	75	53.4	42.8	40.1	40.6	49.6	
	HP10-60	60						Portrait style
	HP18/27	75	40.7	43.6				
Old type prevailed in past days	BZUI	45-60						Design in the Soviet period.
	HP18/54	55-60	40.7					
	MDZ							Brick construction
	DZL	74-83	69.1	83.4	59.0			Chinese chain store
	MUHT 0.4-1.2	75 -78	71.6					Mongolian-made type based on (KB3) design in the Soviet period.
	КВЗ-06							Russian-made
	M↑↑ 3-1500,							Mongolian-made
	VIADRUS	45-60						Czech-made
	MWB, МОНГОЛ							Mongolian-made
	К итурами,	65-75						Korean-made
	Others							

Brick construction type HOB

Old type of candidates for reference HOB.

Although this type was major HOB type in past days, recently, the occupancy has been decreasing.

Can we say that this falls under the category of reference HOB?

HP 18/54

BZUI

Portrait style HOB

This type has kept high occupancy until now.

Maybe we can that this is typical type of reference HOB….

CLSG

HP 10-60

Advanced type HOB

High-efficient type of candidates for reference HOB?
However, these types were often subsidized by foreign assistances (e.g. millennium challenge projects by Word Bank).

Although these types may be project HOB rather than reference HOB….
should we include these types in the category of reference HOB?

DZL

MUHT

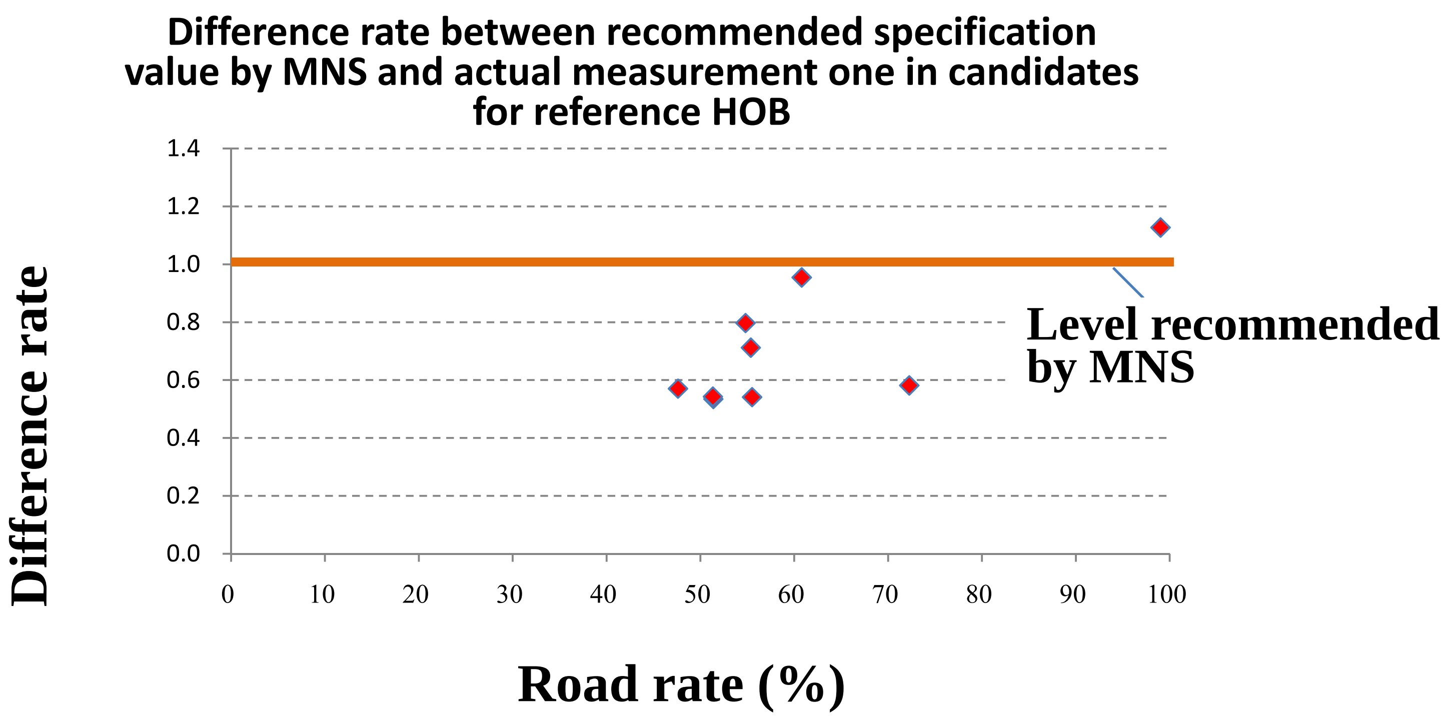
How to set default value for boiler efficiency of reference HOB ($\eta_{PJ\ HOB}$) ?

MNS5043 : 2001"Total specification regarding heat boiler from 0.1MW to 3.15MW in rating capacity "

$$\eta_{RE\ BM} = \underbrace{\eta_{RE\ ST}} \times \underbrace{DR_{RE\ SP}}$$

Boiler efficiency (for specification value base) recommended by MNS[Fraction] **=0.75**

Difference rate between specification value and actual measurement one in boiler efficiency of reference HOB [fraction]



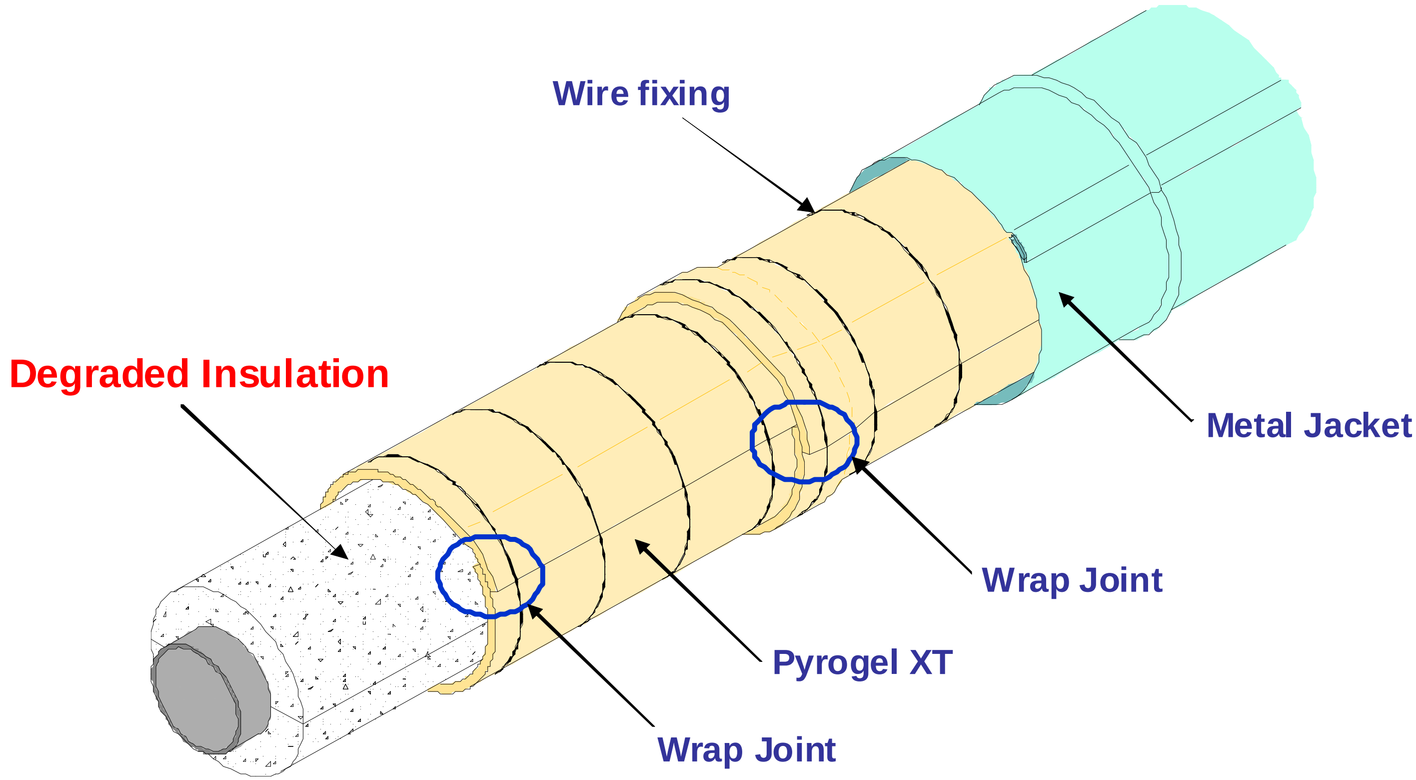
How to quantify emission reductions by heat-retention wearing project at CHP in Mongolia?

Pyrogel XT

Summary of the e ‘ – AIM Method of Maintenance (Patent of NICHIASU CO.)

Easy installation just by wrapping around piping or equipments.

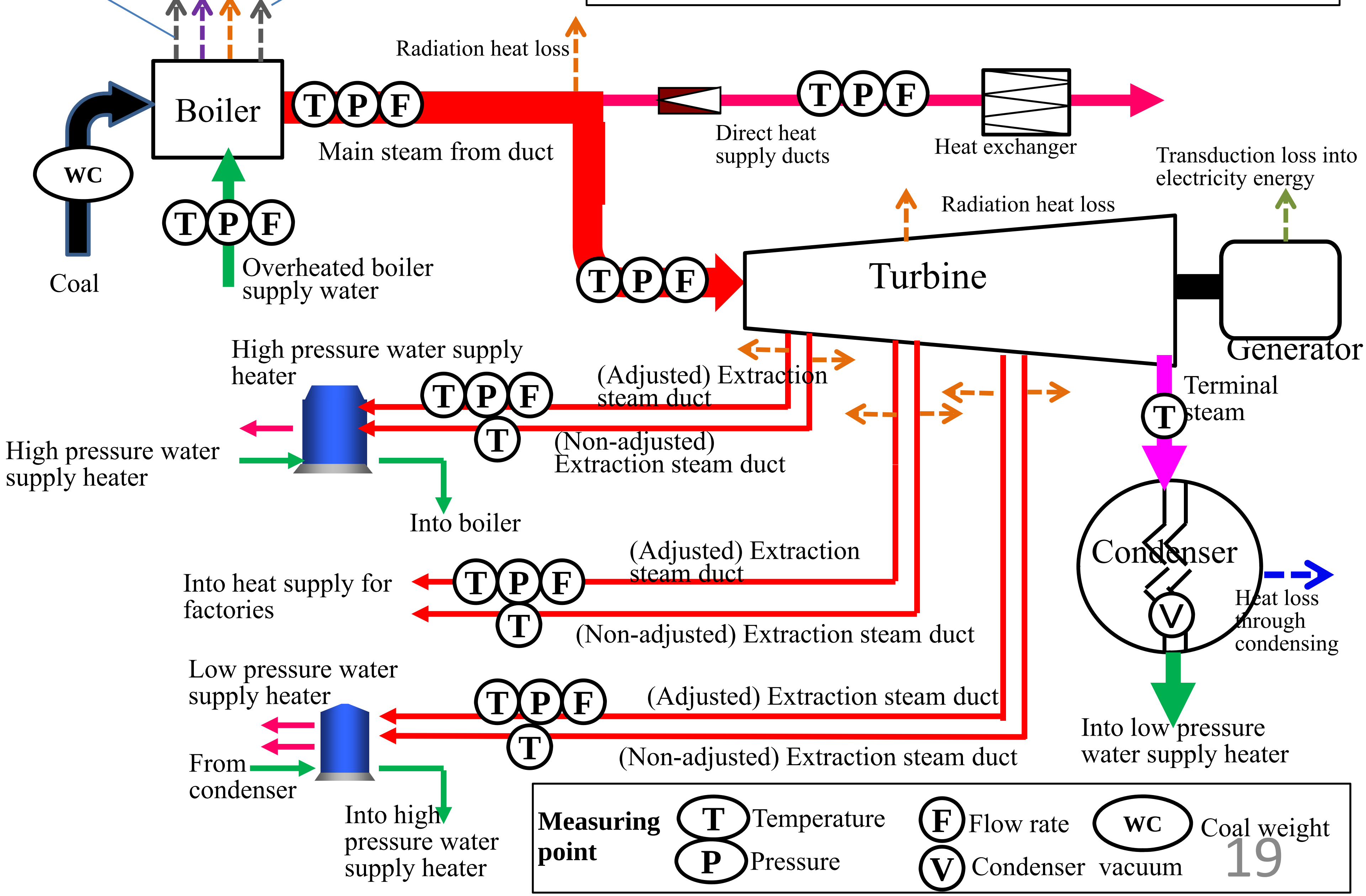
(Increase thermal insulation method of maintenance)



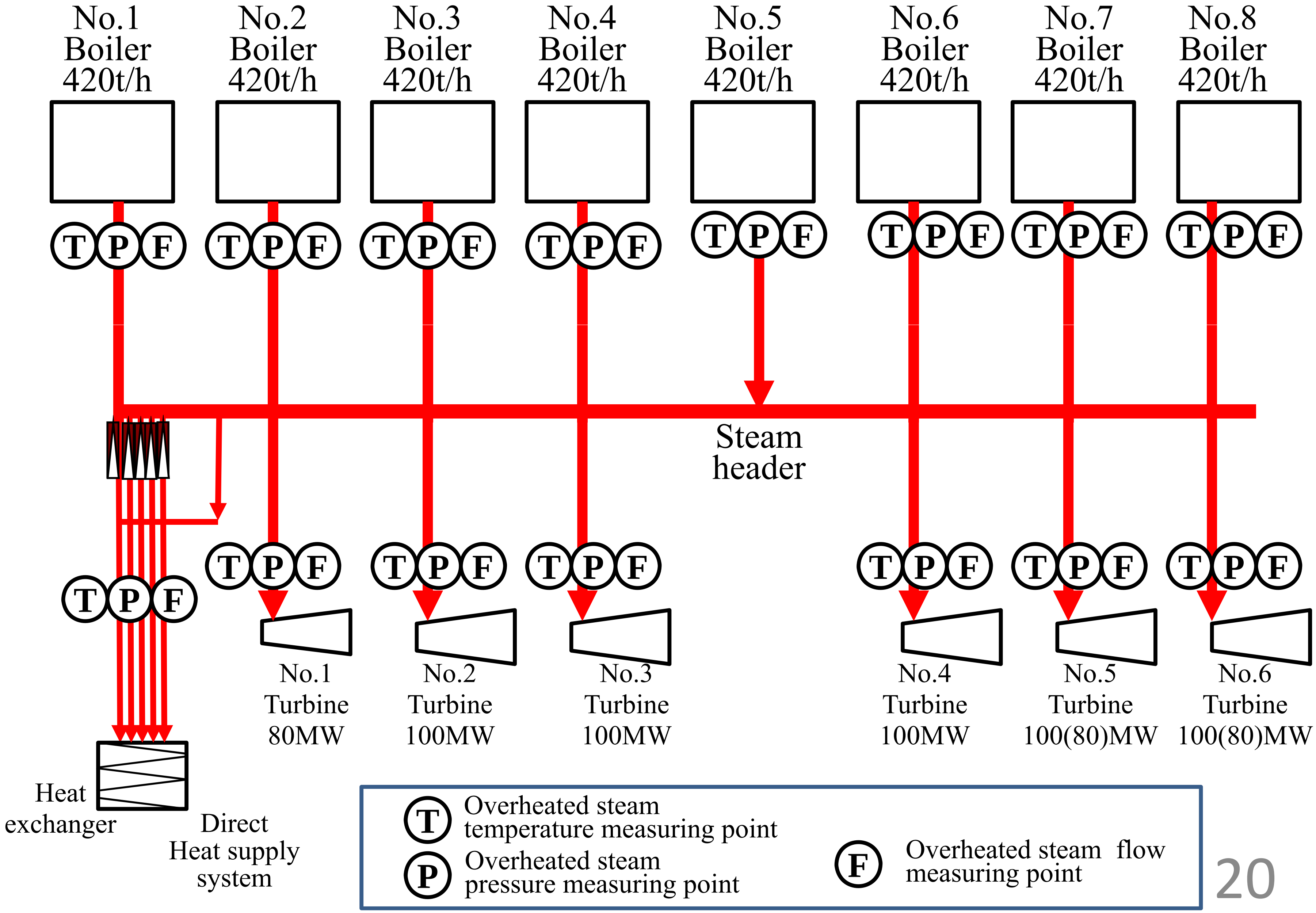
Candidate areas for heat-retention wearing

- Boiler
- **Main steam duct**
- Turbine
- Extraction steam duct

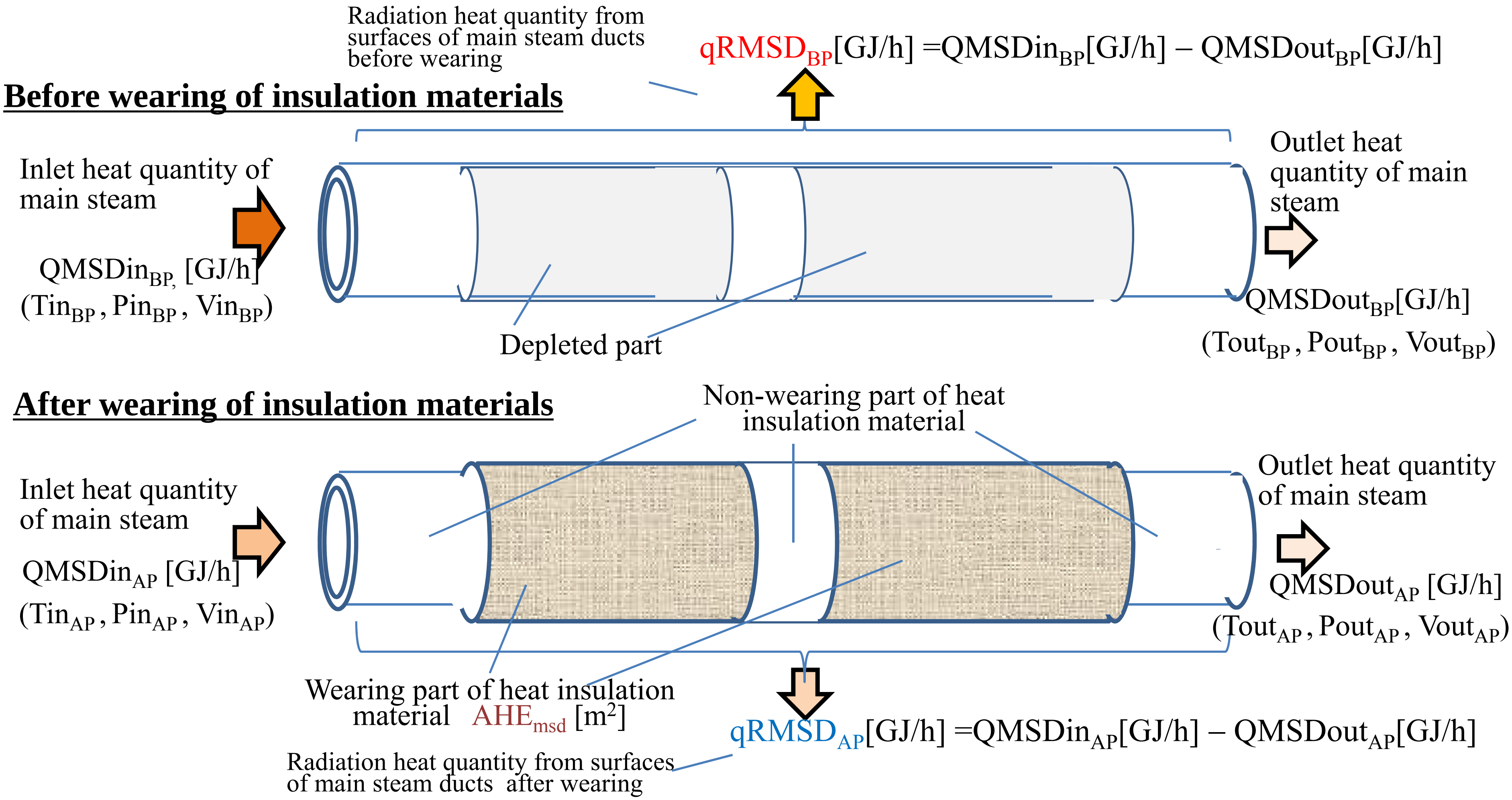
Outline drawing of process flow at thermal power plant in Mongolia



Main steam ductwork and measuring points of steam heat energy at CHP4



Quantification of adiabatic effect by heat-retention on the surfaces of main steam ducts



Heat quantity saved by heat-retention [GJ/h] = $qRMSD_{BP}$[GJ/h] – $qRMSD_{AP}$[GJ/h]

Specific adiabatic effect by heat-retention [GJ/m^2/h] = ($qRMSD_{BP}$[GJ/h] – $qRMSD_{AP}$[GJ/h]) / AHE_{msd}[m^2]

Emission Reductions by heat-retention on the surfaces of main steam ducts

Heat quantity saved by heat-retention in main steam ducts [GJ/h] $= qRMSD_{BP}$[GJ/h] $-$ $qRMSD_{AP}$[GJ/h]

$$\underbrace{ER_{msd,y}}_{\text{Emission reductions due to adiabatic effect by heat-retention on the surfaces of main steam ducts } [tCO_2/y]} = \underbrace{\sum (qRMSD_{BP} - qRMSD_{AP})}_{\text{Yearly value of heat quantity saved by heat-retention } [GJ/y]} \; / \; \underbrace{\eta_{boiler}}_{\text{Boiler efficiency of the CHP [Fraction]}} \; Ø \; \underbrace{EF_{CO2,\,coal}}_{CO_2 \text{ Emission factor of coal consumed by the CHP } [tCO_2/GJ]}$$

1.0 (Default value) is applied in conservative manner, although this value is actually lower than 0.9.
← For simplification and avoiding monitoring works for coal consumption

=**0.101** tCO_2/GJ **(Default value)** according to "Lignite" from 2006 IPCC Guidelines for National Greenhouse
← This value will be confirmed by actual laboratory analysis of the used coal .

Although 0.101 tCO_2/GJ (for $EF_{CO2,\,coal}$) may not be conservative , conservativeness will be secured through 2 default values of $EF_{CO2,\,coal}$ and η_{boiler} . Because 1.0 of η_{boiler} is conservative value by a large margin.

How to identify adiabatic effect by heat-retention on boiler, turbine and extraction steam duct?

Using thermo-viewer owned by CHP4, do difficult task by the following procedure

Implement sampling measurement of temperatures on 4 surfaces of facilities such as main steam ducts, boiler , turbine and extraction steam ducts by thermo-viewer before and after wearing of insulation materials and estimate radiation heat quantity from these facilities.

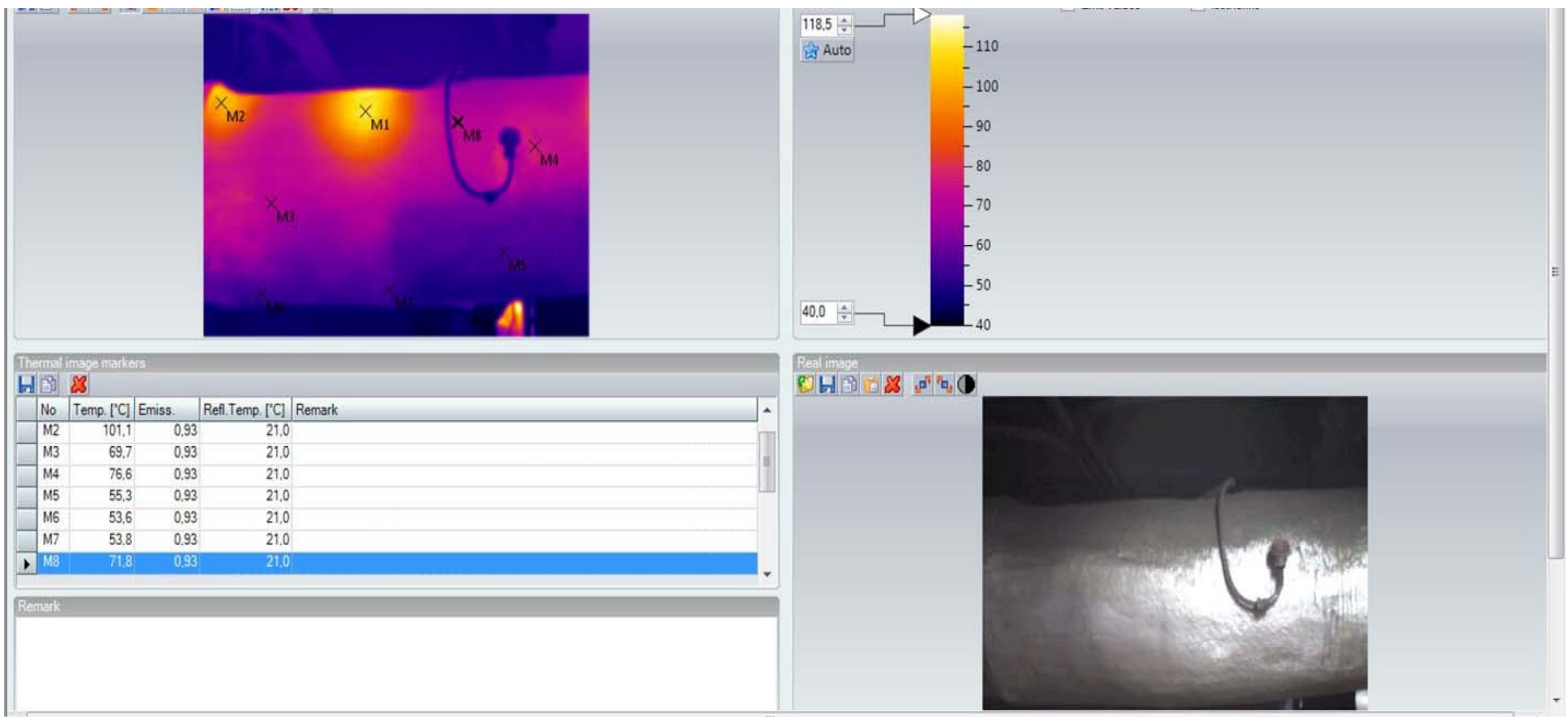
For main steam ducts, comparing the adiabatic effect for heat-retention identified by actual measuring data of stem heat quantity and the one estimated by surface temperatures measured by thermo-viewer, identify correlation (difference co-efficient) between both results

Apply correlation (difference co-efficient) between the adiabatic effect identified by actual measurement data and the estimated by thermo-viewer to estimation equations of the adiabatic effect on boilers, turbines and extraction steam ducts. In such case, for securing conservativeness(avoiding overestimation of emission reductions), discount rate are considered.

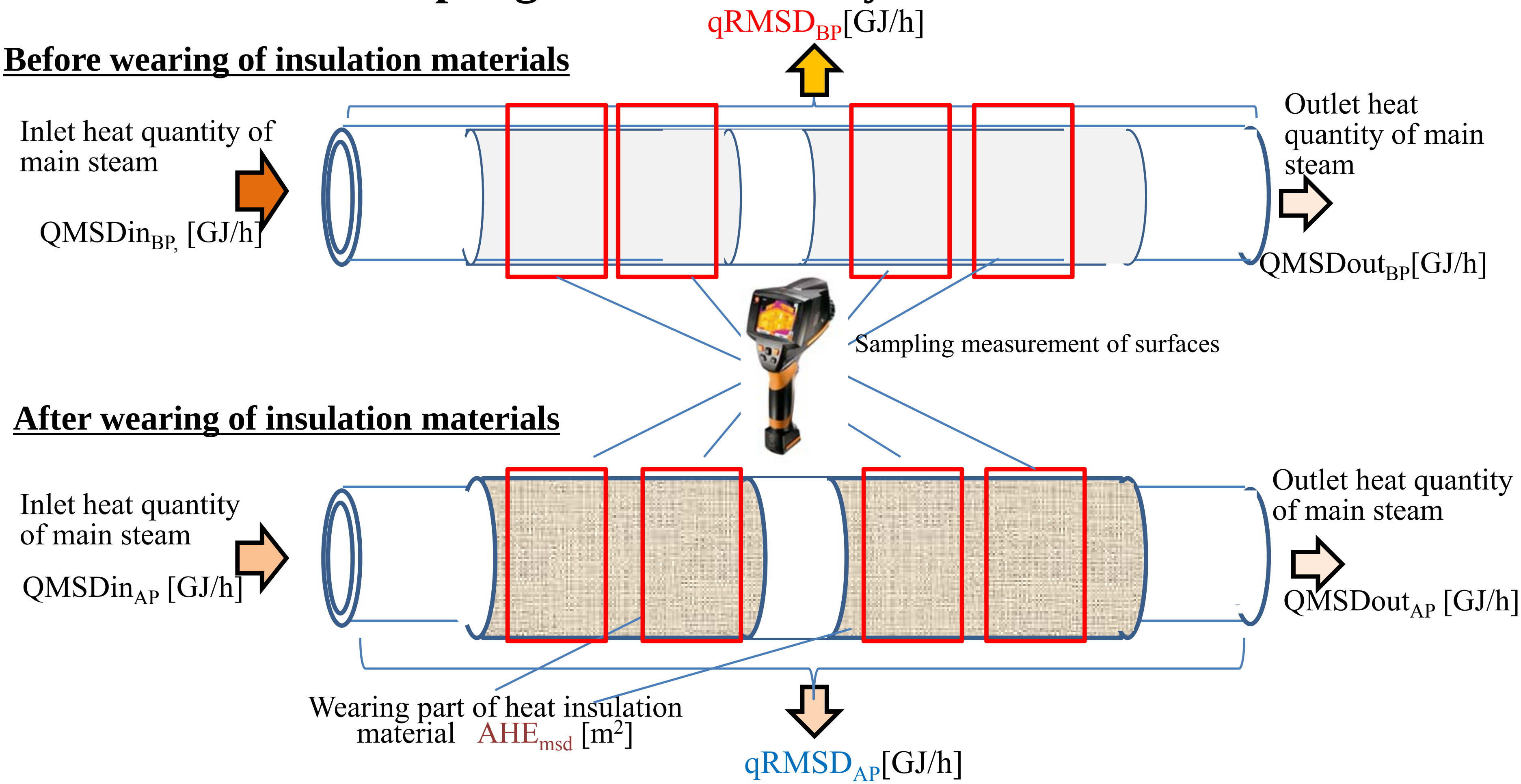
Thermal imagery by thermo-viewer

(On main steam duct at inlet of No.2 turbine in CHP4)

Steam temperature: 556°C
Steam pressure: $130 kg_f/cm^2$
Steam flow: 400-406 ton/h according to monitoring screen in control room



Sampling measurement by thermo-viewer



In case of flat surface

Radiated heat quantity estimated by surface temperature per wearing area [GJ/m^2/h] ={(Surface temperature)^4–(Surrounding temperature)^4}Ø ε Ø δØ 3.6Ø 10^{-6}

Compare with radiated heat quantity identified by actual measurement value of steam heat quantity (qRMSD$_{BP}$ / qRMSD$_{BP}$)

Unit [K]

Emissivity from surface [Fraction]

Stefan-Boltzmann constant =5.67*10^{-8} [W/ m^2/K^4]

Quantification flow of adiabatic effects on boiler, turbine and extraction steam duct

	Adiabatic effect identified by actual measurement of steam heat quantity [GJ/m²/h]	Adiabatic effect estimated by thermo-viewer [GJ/m²/h]	Adjustment factor for completing difference between actual measurement and thermo-viewer [Fraction]
Main steam duct	SAE_{msd}	$qREm_{BP} - qREm_{AP}$	$\mathbf{AF_{msd}} = SAE_{msd} / (qREmsd_{BP} - qREmasd_{AP})$

	Adiabatic effect transferred into actual measurement base	Adiabatic effect estimated by thermo-viewer [GJ/m²/h]	Setting adjustment factor for completing difference between actual measurement and thermo-viewer [Fraction]
Boiler	$SAE_{boiler} = AF_{boiler} * (qREb_{BP} - qREb_{AP})$	$qREb_{BP} - qREb_{AP}$	$AF_{boiler} = (1 - \mathbf{DR_{boiler}})$ Ø $\mathbf{AF_{msd}}$
Turbine	$SAE_{turbine} = AF_{turbine} * (qREt_{BP} - qREt_{AP})$	$qREt_{BP} - qREt_{AP}$	$AF_{turbine} = (1 - \mathbf{DR_{turbine}})$ Ø $\mathbf{AF_{msd}}$
Extraction steam duct	$SAE_{esd} = AF_{esd} * (qREe_{BP} - qREe_{AP})$	$qREe_{BP} - qREe_{AP}$	$AF_{esd} = (1 - \mathbf{DR_{esd}})$ Ø $\mathbf{AF_{msd}}$

Discount rate for the purpose of create creditable emission reductions

Some homework to do with challenge

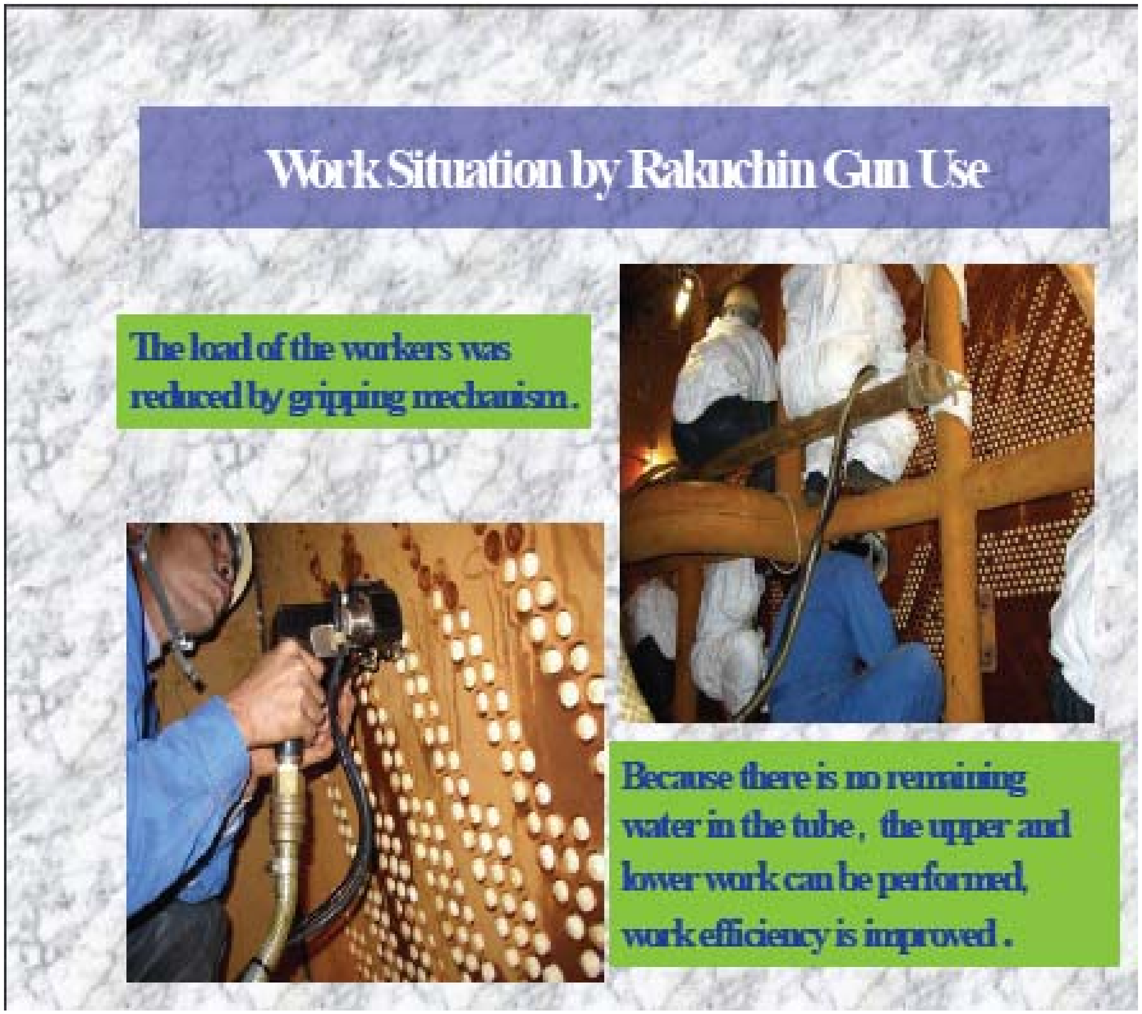
(1) **To what extent** we should consider conservativeness to set values of **discount rates** in order to **create creditable emission reductions** ?

Especially there are a **discrepancy (for surface shape)** between main steam duct and boiler/turbine.
So, we are needed to **consider conservative adjustment factor by this discrepancy** for setting discount rates

(2) How to set **ε (Emissivity from surface)**?
Because existing surfaces of 4 facilities are composed of a number of materials ?

(3) We shall justify that surface heat **transfer coefficient by convection flow is not considered** for simplification because of measuring in-house at the thermal power plant

Improvement of efficiency through condenser tube cleaning work during overhaul period at CHP in Mongolia



Reference emissions

$$RE_x = \sum_{i=1}^{m} EC_{RE,i} * EF_{CO2,grid}$$

Where;

RE_x	Reference emissions during the x^{th} overhaul period after the project starts	tCO_2/t
$EC_{RE,i}$	Reference electricity consumption for condenser tube cleaning work of No.i turbine	MWh/t
$EF_{CO2,grid}$	CO_2 Emission factor of the net electricity supplied to the electricity grid by the thermal power plant	tCO_2/MWh

Identification of $EC_{RE,i}$

Project participants shall measure electricity consumption (of cleaning water pump) for condenser tube cleaning by conventional method during overhaul period before the project starts. Measuring value of electricity consumption shall be identified for each turbine.

As the following equation, $EC_{RE,i}$ is set as the minimum value of measured ones of all turbines for the project in conservative manner.

$$EC_{RE,i} = \text{Minimum}(ECCM_{BP,1}, ECCM_{BP,2}, \ldots, ECCM_{BP,m})$$

$(i=1,m)$

Project emissions

$$PE_x = \sum_{i=1}^{m} ECx_{,i} * EF_{CO2,grid}$$

$$ECx_{,i} = ECWP_{x,i} + ECAC_{x,i}$$

Where;

PE_x	Project emissions during the x^{th} overhaul period after the project starts	tCO_2/t
$EC_{x,i}$	Electricity consumption for condenser tube cleaning work of No.i turbine by project method during the x^{th} overhaul period after the project starts	MWh/ t
$EF_{CO2,grid}$	CO_2 Emission factor of the net electricity supplied to the electricity grid by the thermal power plant	tCO_2/MWh
$ECWP_{x,i}$	Electricity consumption of cleaning water pump for condenser tube cleaning work of No.i turbine by project method during the x^{th} overhaul period after the project starts	MWh/ t
$ECAC_{x,i}$	Electricity consumption of air compressor for condenser tube cleaning work of No.i turbine by project method during the x^{th} overhaul period after the project starts	MWh/ t

Reduction effect of CO_2 emission by use of "Rachchin Gun"

(1) Electricity consumption for **cleaning water pump** can be reduced by reduction of cleaning water consumption.

(2) Electricity consumption for **effluent processing** for ash pond can be reduced by reduction of cleaning water consumption.

(3) **Power generation efficiency** can be increased by improvement effect of condenser vacuum

For now, it is impossible to identify creditable emission reductions

Adherence of impurities in condenser tube

Condenser tube is clogged by adherence of impurities because of hard water.

(At Darkhan thermal power plant)

At thermal power plants of Darkhan and Erdenet, condenser tubes have been cleaned by hydrochloric acid, because german cleaning method has no effect.

However, this acid cleaning method makes the lifetime of tube short.

Improvement effect of by increase of condenser vacuum

(In control room of CHP3)

Coal consumption of 2.7-3.6 g/kWh is saved by 1% increase of condenser vacuum.

Photography of Milky Way starfields in Mongolia byMr. Yamamoto, JQA