MRV Demonstration Study using model project - Replacement of Coal-Fired Boiler by Geo-Thermal Heat Pump for Heating

31st January, 2013

Shimizu Corporation

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1. Project activity and objective of this study

- **<u>Project activity</u>**: Installing geo-thermal heat pump to buildings for heating, especially, to public buildings in local cities, for the purpose of emission reduction and reducing air pollution.
- **<u>Objective of this study</u>**: Demonstrating proposed MRV system (including proposed methodology, etc) can work well.

1. Project activity and objective of this study

A kindergarten in Zuunmod (north latitude: 47.699765, east longitude: 106.990512) and a school in Zuunmod (north latitude: 47.699841, east longitude: 106.988275)

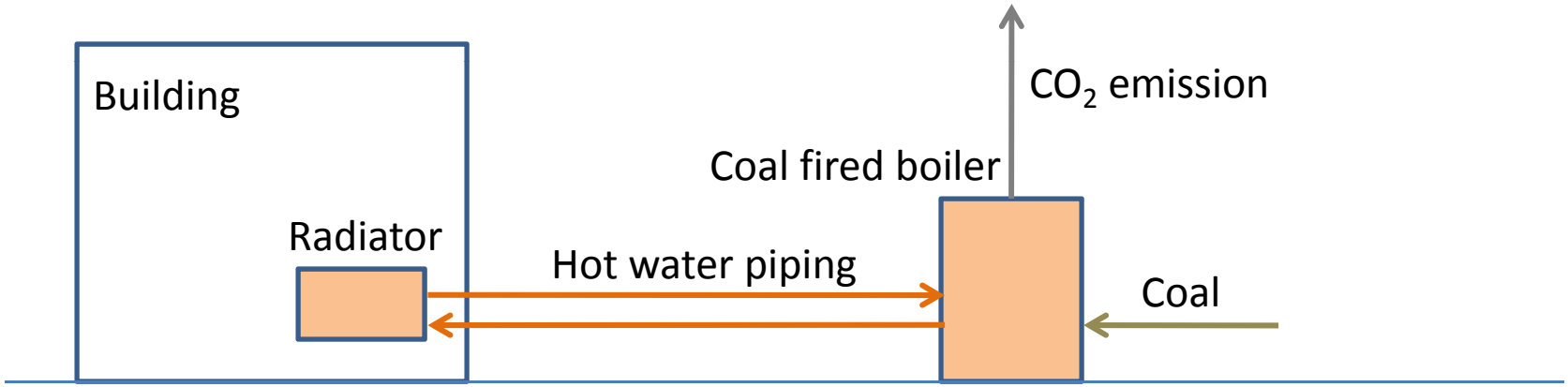
Location of Zuunmod Aimag

A kindergarten
in Zuunmod Aimag

A school
in Zuunmod Aimag

1. Project activity and objective of this study

Present general situation (Reference scenario)
= Heating by low efficient coal fired boilers

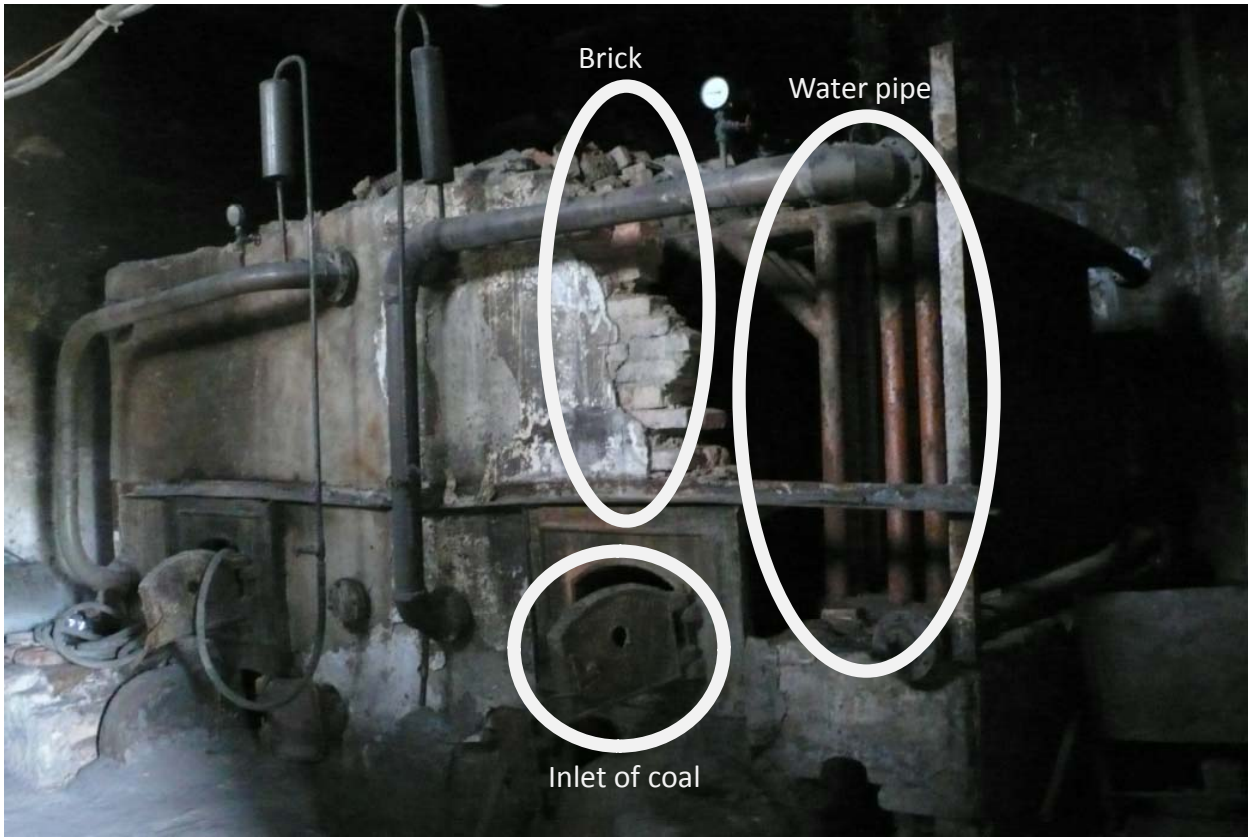


1. Project activity and objective of this study

Present general situation (Reference scenario)
= Heating by low efficiency coal fired boilers

Boiler plant in Zuunmod

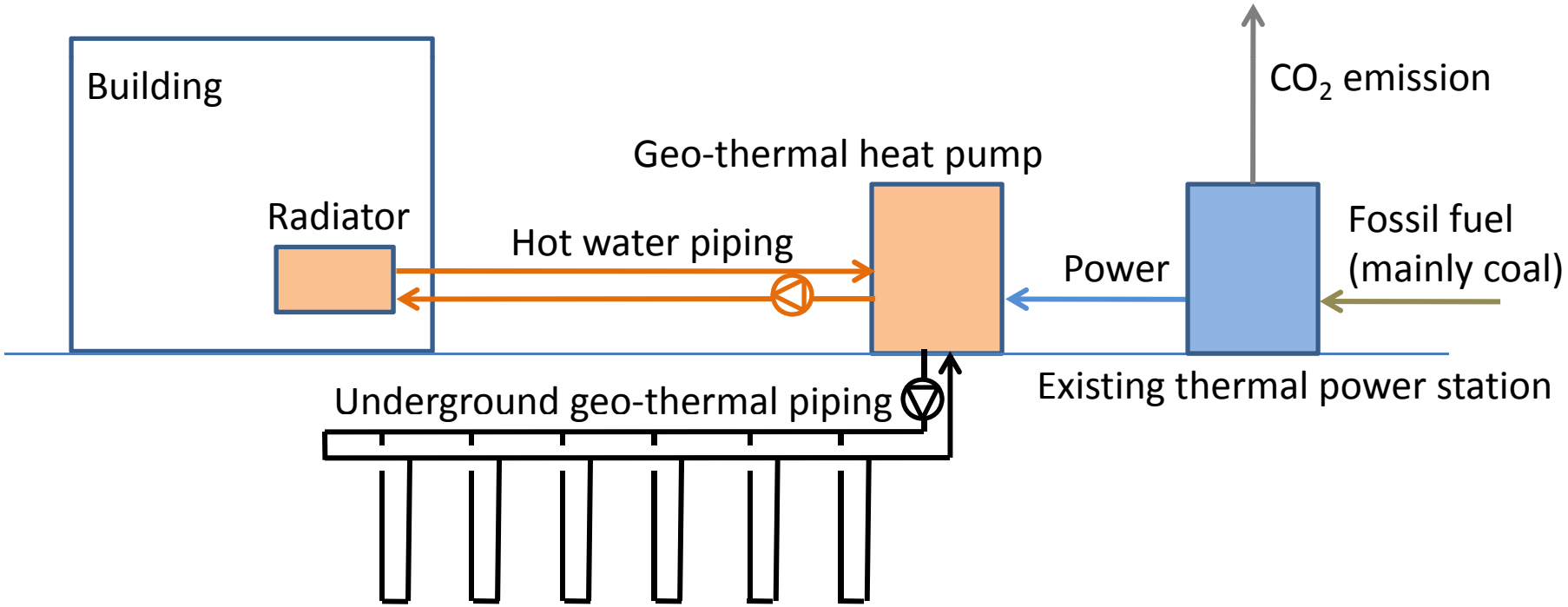
Radiator



Boiler in Zuunmod

1. Project activity and objective of this study

Planned technology to be applied (Project Scenario)
= Heating by high efficiency geo-thermal heat pumps



1. Project activity and objective of this study

Planned technology to be applied (Project Scenario)
= Heating by high efficiency geo-thermal heat pumps

Heat pump at kindergarten

Storage tanks at kindergarten

Geo-thermal piping at kindergarten

Heat pumps and storage tanks at school

Underground geo-thermal piping at school under construction

Underground geo-thermal piping at school under construction

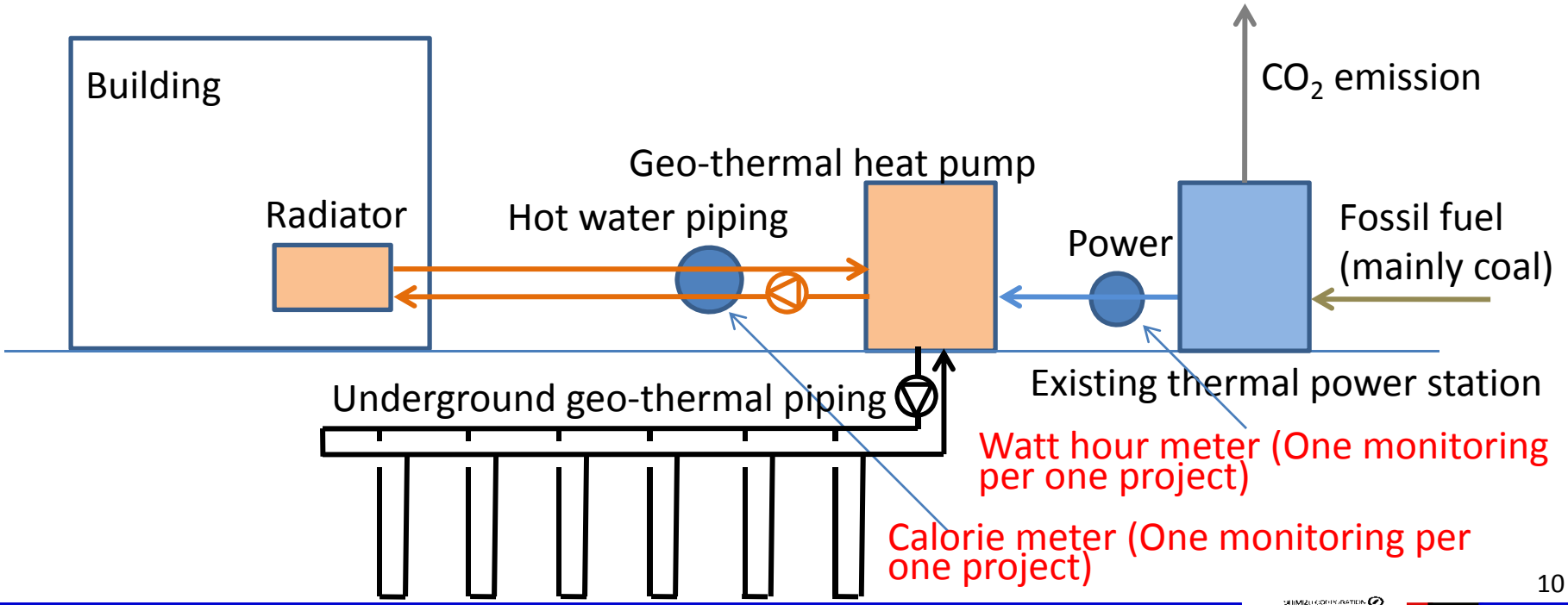
2. How to monitor emission reduction

Shimizu proposed 4 monitoring plans. D is the most favorable one.

Name of monitoring plan	Abstract of monitoring plan
A: Strictest monitoring Most accurate, but most expensive (We don't recommend this plan.)	Monitoring calorie of heat pump output and gird power consumed by heat pump at all sites
B: Easiest monitoring Most inaccurate, but cheapest	Emission reduction is as same as application documents (No actual monitoring is implemented)
C: Moderate monitoring Less accurate, but better than B	Monitoring outdoor temperature at each climate zone Emission reduction is calculated based on "degree day"
D: C modified by A Less accurate, but better than C	Emission reduction is calculated based on plan C, but is modified conservatively based on the monitored data (plan A and C) at a certain site in each climate zone

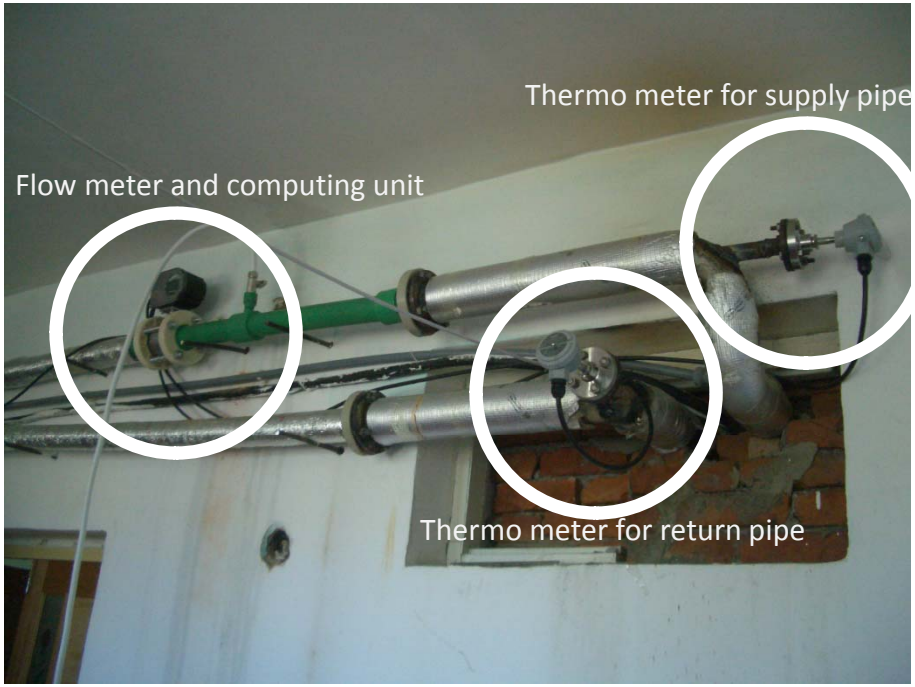
2. How to monitor emission reduction

Monitoring plan A: Strictest monitoring



2. How to monitor emission reduction

Monitoring plan A: Strictest monitoring

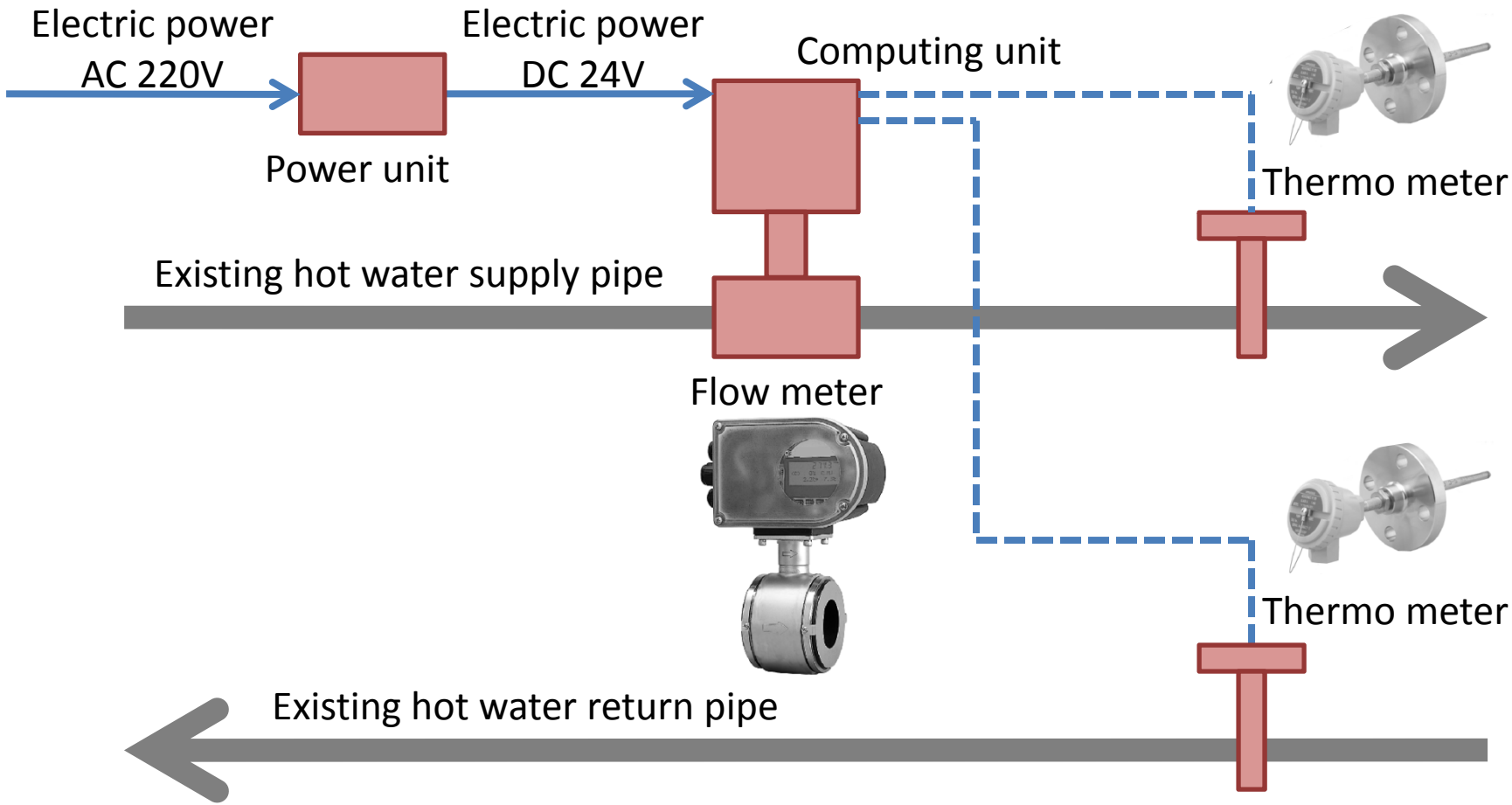


Calorie meter at school

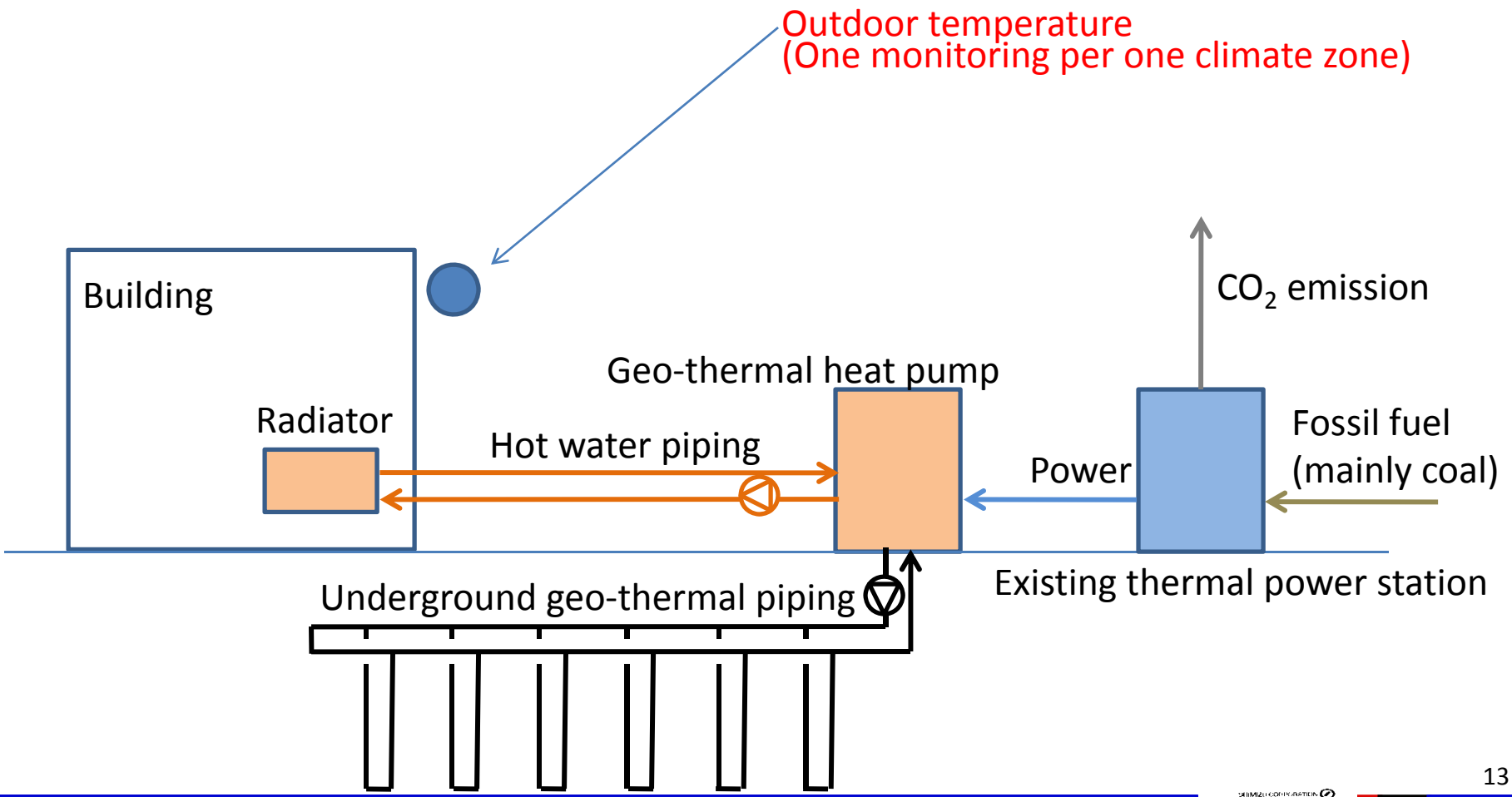
Watt hour meter at kindergarten

2. How to monitor emission reduction

Monitoring plan A: Strictest monitoring



Monitoring plan C: Moderate monitoring



2. How to monitor emission reduction

Monitoring plan C: Why can we know emission by this method?

Heating load ∝ ∑(indoor temperature - outdoor temperature)

Energy consumption of heating system ∝ Heating load

Emission ∝ Energy consumption of heating system

Hence,
Emission ∝ ∑(indoor temperature - outdoor temperature) ∝ Degree day

This means that emission is proportional to degree day!

2. How to monitor emission reduction

Monitoring plan C: Why can we know emission by this method?

Standard emission ∝ Standard degree day

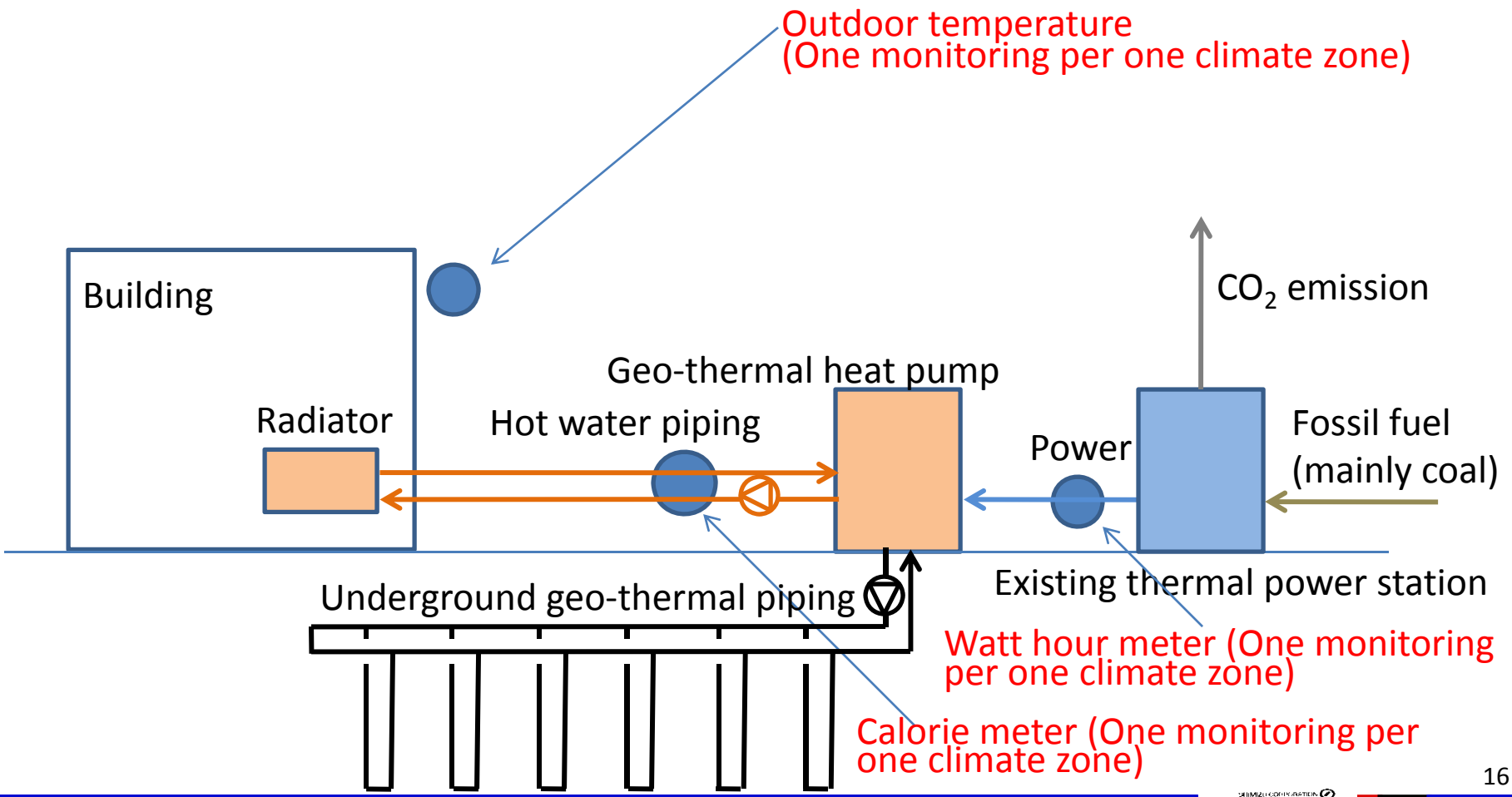
Emission ∝ Degree day

Hence,
Emission = Standard emission × Degree day ÷ Standard degree day

This means that you can calculate emission by using degree day if you can calculate standard emission in advance!

2. How to monitor emission reduction

Monitoring plan D: C modified by A



2. How to monitor emission reduction

How to modify

ER1 = emission reduction at one site in one climate zone that is calculated based on A (The site is called “reference project”.)

ER2 = emission reduction at one site in one climate zone that is calculated based on C

C (Conservativeness factor) = ER1/ER2 (If it is more than 1, then 1)

ER2i = emission reduction of any sites in the same climate zone that is calculated based on C

Modified ER2i = C*ER2i

3. How to calculate emission reduction

Name of monitoring plan	Formula to calculate emission reduction
A: Strictest monitoring Most accurate, but most expensive (We don't recommend this plan.)	Reference emission (RE tCO_2/y) =calorie (Q GJ)/boiler efficiency (EF -)*emission factor of coal (FEF tCO_2/GJ) Project emission (PE tCO_2/y) =consumed power (W MWh)*emission factor of grid (GEF tCO_2/MWh)
B: Easiest monitoring Most inaccurate, but cheapest	Equal to the emission reduction that is calculated ex-ante and indicated in the application form *(No actual monitoring is implemented)*
C: Moderate monitoring Less accurate, but better than B	Reference emission (RE tCO_2/y) =degree day (DD degday)*standard reference emission (SRE tCO_2/y)/standard degree day (SDD degday) Project emission (PE tCO_2/y) =degree day (DD degday)*standard project emission (SPE tCO_2/y)/standard degree day (SDD degday) *(Standard emission shall be calculated ex-ante.)*
D: C modified by A Less accurate, but better than C	If the emission reduction based on A (="ER1") is smaller than the emission reduction based on C (="ER2") at the certain site where both A and C are applied as the representing value of each climate zone, emission reduction of all the other sites in the same climate zone based on C (="ER2i") shall be reduced conservatively as is indicated below. (ER1/ER2=conservativeness factor) Reduced (Modified) emission reduction ERi=ER2i*ER1/ER2

4. Default values/Project specific values

Default values can be defined as the values that are specified in the applied methodology (Narrow definition of default values) and/or the values that are specific to the project but will not be monitored throughout the monitoring period (Project specific values).

Name of default values/Project specific values	How to determine default values/Sources	Default value to be applied
Boiler efficiency in the reference scenario	This value can be received from a specialist in this field.	40%
Emission factor of coal	IPCC Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories *http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html*	0.0258tonC/GJ
Indoor temperature	This value can be received from a specialist in this field.	18 degree C
Standard outdoor temperature	This value can be received from Climate Agency.	-

5. Monitoring and calculation results

Site	Emission reduction applying calculation method 1	Emission reduction applying calculation method 2 (Before applying conservativeness factor)	Emission reduction applying calculation method 2 (After applying conservativeness factor)	Conservativeness factor
Kindergarten	9.7 tonCO_2	14.8 tonCO_2	9.7 tonCO_2	0.65
School	14.1 tonCO_2	23.6 tonCO_2	14.1 tonCO_2	0.59

5. Monitoring and calculation results

Possible reasons why conservativeness factors are different from 1

✓Monitoring period was too short.
✓Some rooms are not heated.
✓Set indoor temperature (RT=8 degree C) was higher than actual in some rooms.
✓Calculated heating load from underground was higher than actual.
✓Sun shine that was not taken into account in the calculation of heating load was not negligible.
✓Received drawings and information were not accurate enough. For example, some rehabilitation was implemented.
✓Calculation of heating load includes some range of safety factor.

Even if the conservativeness factors were different from 1, they contributed to conservative emission reduction calculation.

6. Verification

Item	Contents
Monitoring period	2012/9/15-2012/10/31
Submission of monitoring report	2012/11/5
On-site investigation	2012/11/27-2012/11/29
Selected verifiers	JCI (a DOE in Japan) and BEEC (a verifier in Mongolia)
Submission of verification report	2012/12/21

6. Verification

Organization to be interviewed	Issues to be witnessed
NREC	✓ Construction and operation of the heat pumps ✓ Drawings of the kindergarten and the school ✓ Accuracy of monitoring equipments and its calibration ✓ Monitoring structure
Meteorology and Environment Monitoring Agency of Tuv Aimag	✓ Analysis of Measured outdoor temperature in school and kindergarten of Zuunmod site and data of the Meteorology Agency.
CDM National Bureau, Ministry of Environment and Green Development	✓ Emission factor of coal (0.0258tC/GJ) ✓ Emission factor of grid (1.15tonCO2/MWh)
Air quality Agency of Ulaanbaatar	✓ Efficiency of coal fired boiler (40%)

6. Verification

Interview at Meteorology and Environment Monitoring Agency of Tuv Aimag

On-site investigation at the kindergarten

Interview at Air quality Agency of Ulaanbaatar

On-site investigation at the school

7. How to contact us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