CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

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Switching of fuel from Low Sulphur Waxy Residue fuel oil to natural gas at Gangnam branch Korea District Heating Corporation Project

- Version number of the document: 1.04
- Date of the document: 15/06/2012

A.2. Description of the project activity:

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Description of the project activity

The project activity is switching Low Sulphur Waxy Residue fuel oil (LSWR) to natural gas at Suseo heat source facility, Gangnam branch, Korea District Heating Corporation (KDHC)
The project is developed, financed and implemented by KDHC.
In the project activity, the existing four LSWR heat-only boilers would be replaced by three natural gas heat-only boilers until the end of 2007. The project activity primarily aims at reducing greenhouse gas emission by the boilers' fuel from LSWR to natural gas.

KDHC has been serving customers for 18 years since it was established in November 1985 by the Korea Government, for the purpose of dealing effectively with the United Nations Framework Convention on Climate Change (UNFCCC), promoting energy conservation and improving living standards, through the efficient use of district heating.

The purpose of the project activity

The purpose of the project activity is reducing greenhouse gas and producing heat by replacing fuel from LSWR to natural gas.
LSWR is a kind of bunker-C fuel oil which has less 0.3 percent sulphur content.
As a consequence of the project activity, the greenhouse gas emission of 63,988 tons of CO2e per year will be mitigated. The project has the capacity to reduce 639,880 tons of CO2 equivalent over the crediting period.

Contribution of the project activity to sustainable development

The project activity contributes to sustainable development for following reasons:

- Natural gas is less carbon intensive when compared to other fossil fuels, like LSWR. So using natural gas contributes to the mitigation of greenhouse gases emissions
- The project activity would reduce emission of sulphur oxides, particulate matter and carbon monoxide by using natural gas and contribute to improve local air quality.
- The transportation of natural gas to the site by using pipelines is safer and more environmentally friendly than LSWR because it avoids the use of road trucks carrying LSWR.
- As a good practice for environmental improvement, the project activity could be replicated across other district heating companies or heat suppliers in Korea.

A.3. Project participants:

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Korea District Heating Corporation (Project host)

Eco-Frontier Co. (Project developer and CDM consultant retained for CDM project activity)

Name of Party involved (host) indicates a host Party)	Private and/or public entity(ies) project participants	Kindly indicates if the Party involved wish to be considered a project participant (yes/no)
The Republic of Korea (host Party)	Korea District Heating Corporation	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

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The Republic of Korea

A.4.1.2. Region/State/Province etc.:

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Seoul

A.4.1.3. City/Town/Community etc:

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732 Suseo-Dong, Gangnam-Gu

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

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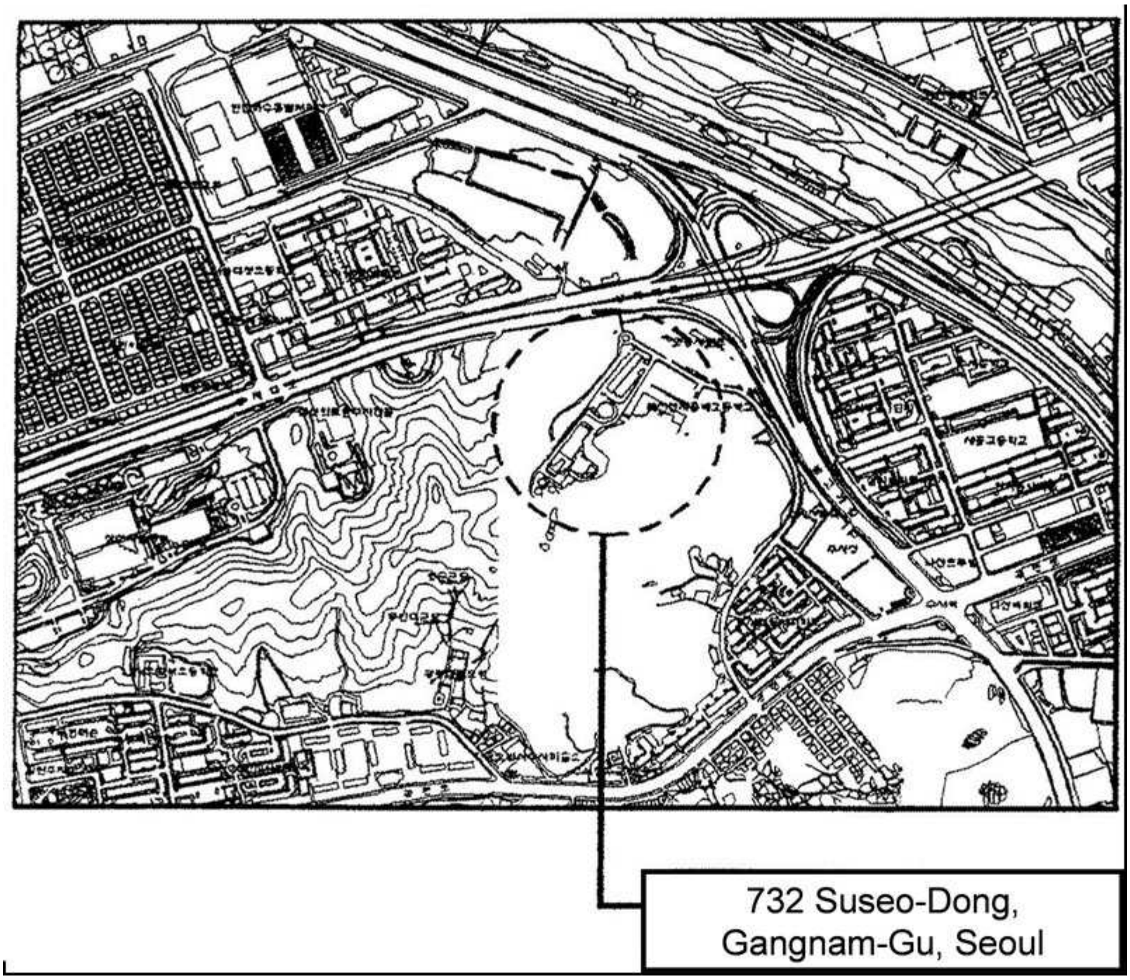
The project site is located in the KDHC Gangnam branch, which is located in the residential area at Suseo-Dong, Gangnam-Gu, Seoul.

There are three apartment complexes, a general hospital, some high schools around the site. And there are Yangjae highway and Suseo interchange and two subway lines.

The project site is 19,575 ㎡



A.4.2. Category(ies) of project activity:

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Sectoral scope 1 – Energy industries (renewable- / non-renewable sources)

A.4.3. Technology to be employed by the project activity:

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There are heat-only boilers which generate steam at Suseo heat source facility in KDHC Gangnam branch. They have been used since 1992 and 1993. They have generated only steam without electricity.

The Suseo heat source facility in KDHC Gangnam branch has a total of six heat-only boilers now. Four heat-only boilers using LSWR as a fuel (LSWR HOBs) have been used for a base load year-around except for the summer season.
Other two heat-only boilers using natural gas as a fuel (NG HOBs) have been used temporarily for preparing peak load in winter season e.g. January, February, December. The heat production capacity of NG HOBs is smaller than that of LSWR HOBs. The capacity of each NG HOB is 34 Gcal/hour.

The specification of the current LSWR HOBs are shown in the table below.

Table 1: Technical data of the existing LSWR HOBs #1 and #2

Type	Natural circulation steam heat-only boiler
Capacity	100 tons/hour (= 51 Gcal/hour)
Operating pressure	10 kg/㎠ g
Steam temperature	183℃
Fuel used	Low Sulphur Waxy Residue fuel oil
Draft type	Forced Draft
Efficiency	88%

Table 2: Technical data of the existing LSWR HOBs #3 and #4

Type	Natural circulation steam heat-only boiler
Capacity	200 tons/hour (=102 Gcal/hour)
Operating pressure	10 kg/㎠ g
Steam temperature	183.2 ℃
Fuel used	Low Sulphur Waxy Residue fuel oil
Draft type	Forced Draft
Efficiency	88%

New facilities would consist of three NG HOBs those generate hot water and supplementary installations — stack, burner, gas static pressurer, pipeline and heat care facility.
Korea does not possess enough technology for designing large scale natural gas hot water boiler, therefore it was designed jointly with Finland’s NOVITOR Oy Co. During this process, design technology was transferred to Korea.

The specifications of the new NG HOBs are shown in the table below.

Table 3: Technical data of the new NG HOBs #1 to #3

Type	Novita type hot water heat-only boiler
Capacity	103.2 Gcal/hour
Designed Pressure	16 kg/㎠ g
Fuel used	Natural gas
Efficiency	more than 95.0%
Draft type	Forced Draft
Life expectancy	30 to 35 years

The natural gas to NG HOBs is supplied from Daehan city gas Co.,Ltd.
In Korea, Korea Gas Corporation (KOGAS) has imported liquefied natural gas (LNG) from Indonesia, Malaysia, Qatar etc. KOGAS imported LNG is vaporized and supplied to retailers such as Deahan City Gas. KDHC Gangnam office already possessed natural gas pipeline, and will newly establish distributing pipeline connecting main pipeline and NG HOBs. Therefore does not face any barriers of pipeline extension for connecting the gas network.

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

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The estimated amount of emission reductions are as follows:

Please indicate the chosen crediting period and provide the total estimation of emission reductions as well as annual estimates for the chosen crediting period. Information on the emission reductions shall be indicated using the following tabular format.	
Years	Annual estimation of emission reductions in tonnes of CO_2e
2008	63,988
2009	63,988
2010	63,988
2011	63,988
2012	63,988
2013	63,988
2014	63,988
2015	63,988
2016	63,988
2017	63,988
Total estimated reductions (tonnes of CO_2e)	639,880
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	63,988

A.4.5. Public funding of the project activity:

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This project does not include any public funding or a diversion of ODA funding.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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Version 03 of ACM0009 "Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas"
Version 03 of ACM0009 "Consolidated monitoring methodology for fuel switching from coal or petroleum fuel to natural gas"

B.2 Justification of the choice of the methodology and why it is applicable to the project activity:

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The chosen methodology is applicable to project activities that switch in one or several element processes from coal or petroleum fuel to natural gas. The fuel switching is undertaken in processes for heat generation that are located at and directly linked to an industrial process with a main output other than heat or that provide heat to a district heating system by means of heat-only boilers. Furthermore, the following conditions apply:

- Prior to the implementation of the project activity, only coal or petroleum fuel (but not natural gas) have been used in the element processes;
- Regulations/programs do not constrain the facility from using the fossil fuels being used prior to fuel switching;
- Regulations do not require the use of natural gas or any other fuel in the element processes;
- The project activity does not increase the capacity of thermal output or lifetime of the element processes during the crediting period (i.e. emission reductions are only accounted up to the end of the lifetime of the relevant element process), nor is there any thermal capacity expansion planned for the project facility during the crediting period;
- The proposed project activity does not result in integrated process change;

The project activity satisfies applicability condition of ACM0009 ver 3 as following:

- Prior to the implementation of the project activity, only LSWR have been used in the element processes;
- Under current regulations, there is no regulation or program that constrain the use of LSWR for district heating sector in Korea. And there is no regulation that requires the use of natural gas or any other fuels.

Regulations and/or programs related to the project activity are those as follows:
- Ministry of Environment, "The Special Act on Metropolitan Air Quality Improvement"

- Ministry of Environment, "Bylaw No.2002-52 Using clean fuel etc"
- Seoul metropolitan ordinance, "Standard for permitting air pollution emission"

In December 2004, Ministry of Environment enacted "The Special Act on Metropolitan Air Quality Improvement". The law contains cap-and-trade scheme for air pollutants, commercialization of clean vehicles, VOC reduction.
According to "The Special Act on Metropolitan Air Quality Improvement", all facilities whose annual emission of nitrogen oxide, sulphur oxide, particles exceed 30 tonnes, 20 tonnes, 1.5 tonnes each are regulated by cap-and-trade scheme. However the law does not inhibit any kind of fuel use.

Ministry of environment's "Bylaw No.2002-52 Using clean fuel etc" stipulates the standards on solid and fluid fuel use. However this project will be conducted in area where the use of LSWR is permitted, therefore the use of fuel is not inhibited by the current law.

In January 2005, Seoul Metropolitan City enacted "Standard for permitting air pollution emission". The regulation sets the standard for nitrogen oxide emission concentration at power plant and boiler facility within the Seoul metropolitan area. However is does not inhibit the use of LSWR or enforces the use of natural gas.

Therefore, there exists no law or policy that inhibits the use of LSWR or enforces the use of natural gas.

• The project activity does not increase the capacity of thermal output or lifetime of the element process during the crediting period, nor is there any thermal capacity expansion planned for the project facility during the crediting period;

The sum capacity of the existing four LSWR boilers, i.e. 306 Gcal/hour (51 Gcal/h×2 and 102 Gcal/h×2), is almost equal to that of new three natural gas boilers, i.e. 309.6 Gcal/hour (103.2 Gcal/h×3). So, the project activity does not increase the capacity of total thermal output and there is no thermal capacity expansion planned for the project facility during the crediting period.
The lifetime of the existing LSWR heat only boilers is about thirty years. Because the LSWR boilers have been operating since 1992 or 1993, the end of lifetime is longer than the crediting period. Thus there is no extension lifetime during crediting period.

• The project activity does not result in integrated process change.

The project activity aims to switch heat only boilers using LSWR to heat only boilers using natural gas. Therefore there is no change in the process such as heat supply system except for switching the fuel for heat production from LSWR to natural gas.

B.3. Description of the sources and gases included in the project boundary

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Based on the ACM0009, the project boundary covers CO_2 emissions associated with fuel combustion in each heat only boiler subject to the fuel switching from LSWR(baseline emissions) to natural gas(project emissions). The project boundary is applicable to both baseline emissions and project emissions.

	Source	Gas	Included?	Justification / Explanation
Baseline	LSWR burning	CO_2	Yes	Main emission source
		CH_4	No	Minor source
		N_2O	No	Minor source
Project activity	Natural gas burning	CO_2	Yes	Main emission source
		CH_4	No	Minor source
		N_2O	No	Minor source

The spatial extent of the project boundary encompasses the physical, geographical site of the Suseo heat source facility in KDHC Gangnam branch.

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

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Based on the ACM0009, the most plausible baseline scenario is determined through the application of the following steps.

Step 1: Identify all realistic and credible alternatives for the fuel use in the element process

Scenario 1 – Continuation of the current practice of using LSWR without pollution reduction facility, Selective Catalytic Reduction (SCR), Flue Gas Desulfurization (FGD) and etc.
Scenario 2 – Continuation of the current practice of using LSWR with pollution reduction facility, SCR, FGD and etc.
Scenario 3 – Switching from LSWR to a different fuel than natural gas (such as biomass)
Scenario 4 – The project activity not undertaken under the CDM (switching from LSWR to natural gas) without nitrogen oxide reduction facility SCR
Scenario 5 – The project activity not undertaken under the CDM (switching from LSWR to natural gas) with nitrogen oxide reduction facility SCR
Scenario 6 – Switching from LSWR to natural gas at a future point in time during the crediting period

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations.

There are no mandatory laws, regulations, or public policies requiring the fuel switching for the project activity in Korea.

For scenario 1:
However, scenario 1 can violate air pollutant regulation, therefore should be eliminated.
As explained in Section B.2, there exist 3 regulations relevant to this project activity.
- Ministry of Environment, “The Special Act on Metropolitan Air Quality Improvement”
- Ministry of Environment, “Bylaw No.2002-52 Using clean fuel etc”
- Seoul metropolitan ordinance, “Standard for permitting air pollution emission”

Designated in January 2005, Seoul metropolitan ordinance “Standards for permitting air pollution emission” prescribed the standard for permitting nitrogen oxide emissions regarding power generation facilities, facilities which using boilers etc. in Seoul.

Revised permission standard for air pollution emission is as following:

	Application period and standard for emission permission		
Fluid fuel using facility: general boiler	From July, 1, 2006	From January, 1, 2008	From January, 1, 2009
(a) facility emitting amount exceeding 100,000 ㎥/h	Under 70 (4) ppm	-	Under 50 (4) ppm
(b) facility emitting amount under 100,000 ㎥/h	-	100 (4) ppm under	-

※ Number in the parenthesis stands for standard oxygen concentration rate(percentage of O_2)

4 heat only boilers using LSWR at Suseo heat source are regulated by the Seoul Metropolitan City's enhanced "Standard for permitting air pollution emission". Therefore KDHC should reduce nitrogen oxide emission concentration rate.

In addition, according to "The Special Act on Metropolitan Air Quality Improvement" Cap and trade scheme on air pollutants will be implemented from July, 1, 2007. However, Korean Ministry of Environment has not yet determined detailed pollution permit allocation plan for the scheme. Regulation enforcement will encounter hardship unless any preparation for legal implementation.

Therefore using LSWR without facility to prevent air pollutants (nitrogen oxide) like SCR (Selective Catalytic Reduction) has to risk violating 2 regulations mentioned above. As a result, Scenario 1 should be eliminated.

For scenario 4:
Scenario 4 also can violate air pollutant regulation and should be eliminated.
According to "The Special Act on Metropolitan Air Quality Improvement", cap and trade scheme on air pollutants that will launch in July, 1, 2007 also regulates natural gas using facility.
Although natural gas is relatively clean fuel that emits less air pollutants like SOx and particles, it does not emit far less NOx than other fuels.
However, Korean Ministry of Environment has not yet determined detailed pollution permit allocation plan for the scheme. Regulation enforcement will encounter hardship unless any preparation for legal implementation.
Therefore switching to natural gas without facility to reduce NOx emission, SCR, low NOx burner will hardly satisfy cap and trade scheme. As a result, Scenario 4 should be eliminated.

Scenario 2, 3, 5 and 6 are in compliance with applicable laws and regulations in Korea.

Step 3: Eliminate alternatives that face prohibitive barriers

According to the ACM0009, scenarios that face prohibitive barriers should be eliminated by applying step 3 of the latest version of the "Tool for demonstration assessment and additionality" agreed by CDM Executive Board.

For scenario 3;
Scenario 3 faces prohibitive barriers. Technology to substitute LSWR with biomass in order to generate heat only boilers is not commercialized in Korea. In addition, due to biomass' low calorific value, it is not suitable for the use for boilers with annual capacity of 900 thousand Gcal. Furthermore, supply of biomass in the area is unreliable. Therefore Scenario 3 is not realistic alternative scenario.

Step 4: Compare economic attractiveness of remaining alternatives

According to ACM0009 the economic attractiveness without revenues from CERs for all remaining scenarios (Scenario 2, 5, 6) should be estimated by net present value (NPV) analysis.

	Scenario 2	Scenario 5	Scenario 6
NPV (million Won)	-420,438	-477,658	-477,658

Major assumptions:
(a) When estimating NPV, expected heat sales profit is not considered because heat sales profit from all the scenarios are same.
(b) Investment requirements
Building cost per each scenario is estimated as following
Scenario 2 is expected to spend total 35,062,400,000 Won for the purchase of SCR and flue gas desulfurization.
Scenario 5, 6 will spend total 25,403,781,000 Won for the design, purchase, construction of natural gas heat only boiler and SCR purchase.
(c) Discount rate
Discount rate according to NPV analysis is defined as 5.52% according to 3-year corporate bond (AA-) circulation profit rate by the end of year 2005.
(d) Efficiency of each element process
Scenario 2's boiler efficiency is assumed at 88% according to average rate of year 2005 operation result.
Scenario 5 and 6's boiler efficiency is assumed to be 95% according to planned efficiency.
(e) Current price and expected future price of each fuel
Comparison of LSWR and natural gas price per unit energy at Korean district heating industry for the last 6 years shows that natural gas price is higher than LSWR's. (higher calorific value)

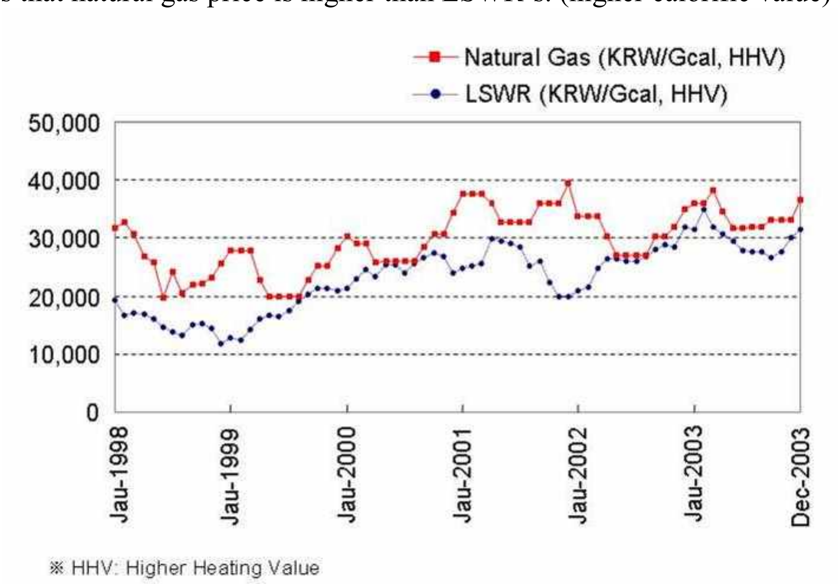

Figure 1. LSWR vs LNG price

LSWR, LNG price used for NPV analysis is average price of year 2005, and each are 35,543 KRW/Gcal (323.33 KRW/ℓ), 46,262 KRW/Gcal (441.80 KRW/N ㎥).

(f) Operating costs for each fuel

Scenario 2 consumes 39,567,201,084 won for SCR, flue gas desulfurization, electro static precipitator, boiler maintenance fee and fuel use fee. Scenario 5,6 consumes 51,214,405,436 won for natural gas heat only boiler and SCR maintenance fee and natural gas fee.

(g) Lifetime of the project activity: 10 years

(h) Residual value of the new equipment
According to Korean Tax law Enforcement ordinance article 26, scrap value is defined as 5% of purchase price.

(i)_For scenario 6-1~3, inflation rate in accordance with the start year of each Scenario (Price index, nominal wage increase etc.) is not considered as a conservative approach to NPV and sensitivity analysis.

Sensitivity analysis:

Case 1: LSWR price will be 5% higher than expected and natural gas price will be constant.

	Scenario 2	Scenario 5	Scenario 6
NPV (million Won)	-438,739	-477,658	-477,658

Case 2: Initial investment costs will be 10% lower than expected.

	Scenario 2	Scenario 5	Scenario 6
NPV (million Won)	-417,136	-475,192	-475,192

In all cases Scenario 2 is the most economically viable. Therefore scenario 2 will be defined as the baseline scenario.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality): >>

As stipulated in ACM0009, additionality of the project activity will be assessed by the following three steps.

Step 1: Investment and sensitivity analysis
Mentioned above

Step 2: Common practice analysis
According to KDHC, 2005, 2004 Operation result statistics and Korea Energy Management Corporation, "FY2005 Collective Energy Project Databook", district heating facility producing only heat such as in the proposed project activity mainly use LSWR and kerosene, LNG is used as peak load reserve or in small scale facility.

Region	Operator	Base heat supply year	Heat supply scale	fuel
Gangnam	KDHC	1991	818 Gcal/h	LSWR, LNG, kerosene
Yangsan Mulgeum	KDHC	1999	298 Gcal/h	Kerosene, LNG, refined oil
Yongin	KDHC	1994	721 Gcal/h	LSWR, LNG, kerosene
MapoSangam	KDHC	2001	174 Gcal/h	LFG
Gimhae	KDHC	2001	187 Gcal/h	LNG
Goyang	KDHC	1992	963 Gcal/h	LSWR, Kerosene
Hwasung	KDHC	2003	679 Gcal/h	Kerosene
Busan(Haeundae)	Busan Metro politan City	1996	240 Gcal/h	LNG
Gwanju Sangmu	Korea CES Co.	1999	51 Gcal/h	LNG

Source: KDHC, 2006, "Operation result statistics in FY2005"
Source: Korea Energy Management Corporation, "FY2005, Collective Energy Project Databook"

As consumption amount and converted calorific value for each fuel, in 2004 natural gas constitutes 23%, LSWR 69% among consumed energy fuels for heat generation.

Year	LSWR	Natural gas	Boiler kerosene	Refined oil	LFG
2000	1,305,234,234	41,769,000	1,237,356	0	0
2001	1,225,832,454	263,634,000	1,422,036	37,455,769	5,981,215
2002	1,211,108,274	571,530,603	19,566,846	23,204,217	126,530,491
2003	1,486,667,844	527,562,420	29,521,098	0	123,479,849
2004	1,600,241,670	534,796,500	54,037,368	0	105,816,365

Therefore, it is common practice to use natural gas as large scale base load at heat only generation facility in Korean district heating sector.

Step 3: Impact of CDM registration

The expected NPV for the proposed Project activity is too low to justify implementation on a business-as usual basis.
The expected additional financial benefit from CERs sales can lead KDHC to further progress with the planning and development of the proposed project.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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Establishment of element process

According to ACM0009, An "element process" is defined as fuel combustion in a single equipment at one point of an industrial facility or of a district heating system, for the purpose of providing thermal energy.
Examples of an element process are steam generation by a boiler and hot air generation by a furnace. Each element process should generate a single output (such as steam or hot air) by using mainly a single fuel (not plural energy sources).

The project activity aims to switch 4 heat only boiler using LSWR to 3 heat only boiler using natural gas. Therefore there is no change in generation capacity although the number of boilers is reduced from 4 to 3.

Baseline scenario consists of 4 heat only boiler using LSWR. The sum capacity of the existing four LSWR boilers is 306 Gcal/hour (51 Gcal/h×2 and 102 Gcal/h×2). All heat only boilers use same fuel, LSWR and produce same output(steam), which exactly matches element process defined by ACM0009. Therefore baseline scenario possesses 4 element processes.

Although the proposed project activity switch 4 boilers to 3 boilers, it does not increase the capacity of total thermal output.

Two 51 Gcal/h boilers that consist baseline scenario are manufactured by the same company and use same fuel (LSWR) and produce same output (steam). There was negligible change in annual heat generation and average load, utilization rate for the last 5 years.
In addition, during the project activity two 51 Gcal/h boilers are switched to one103.2Gcal/h boiler with identical capacity.
Therefore the proposed project activity defines two 51 Gcal/h boilers as one element process. The only thing is that, when calculating efficiency we chose more efficient one between #1, #2 51 Gcal/h boilers for conservative assumption

	Baseline Scenario	Project Activity
Element process 1	51 Gcal/h heat only boiler #1 & #2 (51 Gcal/h * 2 = 102 Gcal/h)	103.2 Gcal/h natural gas heat only boiler #1
Element process 2	102 Gcal/h heat only boiler #3	103.2 Gcal/h natural gas heat only boiler #2
Element process 3	102 Gcal/h heat only boiler #4	103.2 Gcal/h natural gas heat only boiler #3

Past heat production rate of Suseo heat source heat only boiler

Year	2001	2002	2003	2004	2005
Heat only boiler #1	151,005	174,355	142,449	157,142	120,803
Heat only boiler #2	144,365	180,287	178,818	159,575	115,512
Heat only boiler #3	289,936	240,488	330,160	305,820	353,889
Heat only boiler #4	348,281	257,049	290,425	284,852	340,092
Sum	933,586	852,179	941,852	907,389	930,296

Unit: Gcal
#1 & #2 Heat only boilers: 51 Gcal/h
#3 & #4 heat only boilers: 102 Gcal/h
Source: KDHC, 2006, "Operation performance statistics in FY2005"

Project emissions

According to ACM0009, Project emissions (PE_y) include CO_2 emissions from the combustion of natural gas in all element process *i*. Project emissions are calculated based on the quantity of natural gas combusted in all element process in and respective net caloric value and CO_2 emission factors for natural gas ($EF_{NG, CO2}$), as follow:

$$PE_y = FF_{project,y} \times NCV_{project,y} \times EF_{NG,CO2,y}$$

with $FF_{project,y} = \sum_i FF_{project,i,y}$

where:

PE_y	Project emissions during the year y in tCO_2e
$FF_{project, y}$	Quantity of natural gas combusted in all element process during the year y in ㎥
$FF_{project, i, y}$	Quantity of natural gas combusted in the element process *i* during the year y in ㎥
$NCV_{NG, y}$	Average net calorific value of the natural gas combusted during the year y in MWh/㎥
$EF_{NG, CO2, y}$	CO_2 emission factor of the natural gas combusted in all element processes in the year y in tCO_2/MWh

<u>For the proposed project:</u>

Project emissions are calculated using the following equations:

$$FF_{project, y} = FF_{project, 1, y} + FF_{project, 2, y} + FF_{project, 3, y}$$

$$PE_y = FF_{project, y} \cdot NCV_{NG, y} \cdot EF_{NG, CO2, y}$$

where:

PE_y	Project emissions during the year y in tCO_2e
$FF_{project, y}$	Quantity of natural gas combusted in all element process during the year y in ㎥
$FF_{project, 1, y}$	Quantity of natural gas combusted in the 1st element process(i.e. Heat onl y boiler #1 using natural gas as a fuel) during the year y in ㎥
$FF_{project, 2, y}$	Quantity of natural gas combusted in the 2nd element process(i.e. Heat onl y boiler #2 using natural gas as a fuel) during the year y in ㎥
$FF_{project,3, y}$	Quantity of natural gas combusted in the 3rd element process(i.e. Heat onl y boiler #3 using natural gas as a fuel) during the year y in ㎥
$NCV_{NG, y}$	Average net calorific value of the natural gas combusted during the year y in MWh/㎥
$EF_{NG, CO2, y}$	CO_2 emission factor of the natural gas combusted in all element processes in the year y in tCO_2/MWh

Baseline emissions

Baseline emissions (BE_y) include CO_2 emissions from the combustion of the quantity of coal or petroleum fuel that would in the absence of the project activity be used in all element processes *i*. Baseline emissions are calculated based on the quantity of coal or petroleum fuel that would be combusted in each element processes i in the absence of the project activity and respective net calorific values and CO_2 emission factors. The quantity of coal or petroleum fuel that would be used in the absence of the project activity in an element process *i* ($FF_{baseline,i,y}$) is calculated based on the actual monitored quantity of natural gas combusted in this element process ($FF_{project, i, y}$) and the relation of the energy efficiencies and the net calorific values between the project scenario (use of natural gas) and the baseline scenario (use of coal or petroleum fuel).

$$BE_y = \sum_i (FF_{baseline,i,y} \times NCV_{FF,i} \times EF_{FF,CO2,i})$$

with

$$FF_{baseline,i,y} = FF_{project,i,y} \times \frac{NCV_{NG,y} \times \varepsilon_{project,i}}{NCV_{FF,i} \times \varepsilon_{baseline,i,y}}$$

where:

BE_y	Baseline emissions during the year y in tCO_2e
$FF_{baseline, i, y}$	Quantity of coal or petroleum fuel that would be combusted in the absence of the project activity in the element process *i* during the year y in a volume or mass unit
$FF_{project, i, y}$	Quantity of natural gas combusted in the element process *i* during the year y in m^3
$NCV_{NG, y}$	Average net calorific value of the natural gas combusted during the year y in MWh/ m^3
$NCV_{FF, y}$	Average net caloric value of the coal or petroleum fuel that would be combusted in the absence of the project activity in the element process *i* during the year y in MWh per volume or mass unit
$EF_{FF, CO2, i}$	CO_2 emission factor or the coal or oil type that would be combusted in the absence of the project activity in the element process *i* in tCO_2e/MWh
$\varepsilon_{project, i, y}$	Energy efficiency of the element process *i* if fired with natural gas
$\varepsilon_{baseline, i, y}$	Energy efficiency of the element process *i* if fired with coal or oil respectively

For the proposed project, Baseline emissions expressed as:

$$BE_y = \sum_{i=1}^{3} \{FF_{baseline,i,y} \times NCV_{FF,i} \times EF_{FF,CO2,i}\}$$

$$BE_y = (FF_{baseline,1,y} \times NCV_{FF,1} \times EF_{FF,CO2,1}) + (FF_{baseline,2,y} \times NCV_{FF,2} \times EF_{FF,CO2,2}) + (FF_{baseline,3,y} \times NCV_{FF,3} \times EF_{FF,CO2,3})$$

with

$$FF_{baseline,i,y} = FF_{project,i,y} \times \frac{NCV_{NG,y} \times \varepsilon_{project,i,y}}{NCV_{FF,y} \times \varepsilon_{baseline,i,y}}$$

where:

BE_y	Baseline emissions during the year y in tCO_2e
$FF_{baseline, i, y}$	Quantity of LSWR that would be combusted in the absence of the project activity in the element process *i* during the year y in a volume or mass unit
$FF_{project, i, y}$	Quantity of natural gas combusted in the element process *i* during the year y in m^3
$NCV_{NG, y}$	Average net calorific value of the natural gas combusted during the year y in MWh/ m^3
$NCV_{FF, y}$	Average net caloric value of LSWR that would be combusted in the absence of the project activity in the element process *i* during the year y in MWh per volume or mass unit
$EF_{FF, CO2, i}$	CO_2 emission factor or the LSWR that would be combusted in the absence of the project activity in the element process *i* in tCO_2e/MWh
$\varepsilon_{project, i, y}$	Energy efficiency of the element process *i* if fired with natural gas
$\varepsilon_{baseline, i, y}$	Energy efficiency of the element process *i* if fired with LSWR

Leakage

Leakage may result from fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of fossil fuels outside of the project boundary. This includes mainly fugitive CH_4 emissions and CO_2 emissions from associated fuel combustion and flaring. In this methodology, the following leakage emission sources shall be considered:

- Fugitive methane emissions

Fugitive CH_4 emissions associated with fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of natural gas used in the project plant and fossil fuels used in the grid in the absence of the project activity.

- CO_2 emissions from LNG

In the case LNG is used in the project plant: CO_2 emissions from fuel combustion or electricity consumption associated with the liquefaction, transportation, re-gasification and compression into a natural gas transmission or distribution system. Thus, leakage emissions are calculated as follows:

$$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}$$

where:

LE_y	Leakage emission during the year y in tCO_2e
$LE_{CH4, y}$	Leakage emission due to fugitive upstream CH_4 emissions in the year y in tCO_2e
$LE_{LNG, CO2, y}$	Leakage emission due to fossil combustion/ electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in tCO_2e

For the proposed project:
In the proposed project, natural gas from LNG would be used. CO_2 emissions from associated with LNG should be considered.

Therefore, according to the definition of ACM0009 leakage emissions are calculated as follows:

$$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}$$

where:

LE_y	Leakage emission during the year y in tCO_2e
$LE_{CH4,y}$	Leakage emission due to fugitive upstream CH_4 emissions in the year y in tCO_2e
$LE_{LNG,CO2,y}$	Leakage emission due to fossil combustion/ electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in tCO_2e

- Fugitive methane emissions

For the purpose of determining fugitive methane emissions associated with the production – and in case of natural gas, the transportation and distribution of the fuels – We multiplied the quantity of natural gas consumed in all element processes i with a methane emission factor for these upstream emissions ($EF_{NG,upstream,CH4}$), and subtract for LSWR which would be used in the absence of the project activity the fuel quantities multiplied with respective methane emission factors ($EF_{LSWR,upstream,CH4}$), as follows:

$$LE_{CH4,y} = (FF_{project,y} \times NCV_{NG,y} \times EF_{NG,upstream,CH4} - FF_{baseline,LSWR,y} \times NCV_{LSWR} \times EF_{LSWR,upstream,CH4}) \times GWP_{CH4}$$

with

$$FF_{project,y} = \sum_{i=1}^{3} FF_{project,i,y}$$, and, $$FF_{baseline,LSWR,y} = \sum_{i=1}^{3} FF_{baseline,i,LSWR,y}$$

where:

$LE_{CH4,\ y}$	Leakage emission due to upstream fugitive CH_4 emissions in the year y in tCO_2e
$FF_{project,\ y}$	Quantity of natural gas combusted in all element processes during the year y in m^3
$FF_{project,\ i,\ y}$	Quantity of natural gas combusted in the element process i during the year y in m^3
$NCV_{NG,\ y}$	Average net calorific value of the natural gas combusted during the year y in MWh/ m^3
$EF_{NG,\ upstream,\ CH4}$	Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in tCH_4 per MWh fuel supplied to final consumers
$FF_{baseline,\ LSWR,\ y}$	Quantity of LSWR that would be combusted in the absence of the project activity in all element processes during the year y in a volume or mass unit
$FF_{baseline,\ i,\ LSWR,\ y}$	Quantity of LSWR that would be combusted in the absence of the project activity in the element process i during the year y in a volume or mass unit
NCV_{LSWR}	Average net calorific value of the LSWR that would be combusted in the absence of the project activity during the year y in MWh per volume or mass unit
$EF_{LSWR,\ upstream,\ CH4}$	Emission factor for upstream fugitive methane emissions from production of the fuel LSWR in tCH_4 per MWh fuel produced
GWP_{CH4}	Global warming potential of methane valid for the relevant commitment period

• CO_2 emissions from LNG

The leakage emissions from LNG are expressed as:

Where applicable, CO_2 emissions from fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system ($LE_{LNG,\ CO2,\ y}$) should be estimated by multiplying the quantity of natural gas combusted in the project with an appropriate emission factor, as follows:

$$LE_{LNG,CO2,y} = FF_{project,y} \times EF_{CO2,upstream,LNG}$$

where:

$LE_{LNG, CO2, y}$	Leakage emission due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in tCO_2e
$FF_{project, y}$	Quantity of natural gas combusted in all element processes during the year y in m^3
$EF_{CO2, upstream, LNG}$	Emission factor for upstream CO_2 emission due to fossil fuel combustion/ electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system .

B.6.2. Data and parameters that are available at validation:

- Data and parameters relavant to project emissions

Data / Parameter	***$NCV_{NG,y}$***
Data unit:	Kcal/N㎥
Description:	Average net calorific value of the natural gas combusted during the year y
Source of data used:	Korean Ministry of Commerce, Industry and Energy
Value applied:	9,550
Justification of the choice of data or description of measurement methods and procedures actually applied:	ACM0009 uses the 2000 IPCC Good Practice Guideline in determining net calorific value or use local or national data, if available. We used the net calorific value defined in "Energy policy law" or "Annual Energy Statistic Report" published by Korean Ministry of Commerce, Industry and Energy.
Any comment:	

Data / Parameter	***$EF_{NG,CO2,y}$***
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor of the natural gas combusted in all element processes in the year y
Source of data used:	IPCC
Value applied:	56.1
Justification of the choice of data or description of measurement methods and procedures actually applied:	IPCC value will be used since there is no reference for CO_2 emission factor in Korea. $EF_{NG,CO2,y}$ is obtained from the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2- Module 1. Energy, Section 1.2.1, Table 1-2, Carbon Emission Factor, Natural gas(dry)" $EF_{NG,CO2,y}$ = 15.3 tC/TJ * 3.6667 tCO_2/tC = 56.1 tCO_2/TJ
Any comment:	

• Data and parameters relevant to baseline emissions

Data / Parameter	$NCV_{FF, y}$
Data unit:	Kcal/ℓ
Description:	Average net caloric value of LSWR that would be combusted in the absence of the project activity in the element process *i* during the year y
Source of data used:	Korean Ministry of Commerce, Industry and Energy
Value applied:	9,350
Justification of the choice of data or description of measurement methods and procedures actually applied:	ACM0009 uses the 2000 IPCC Good Practice Guideline in determining net calorific value or use local or national data, if available. We used the net calorific value defined in "Energy policy law" or "Annual Energy Statistic Report" published by Korean Ministry of Commerce, Industry and Energy.
Any comment:	

Data / Parameter	$EF_{FF, CO2, y}$
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor or the LSWR that would be combusted in the absence of the project activity in the all element processes in tCO_2e/TJ
Source of data used:	IPCC
Value applied:	77.3667
Justification of the choice of data or description of measurement methods and procedures actually applied:	IPCC value will be used since there is no reference for CO_2 emission factor in Korea. $EF_{FF, CO2, y}$ is obtained from the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2- Module 1. Energy, Section 1.2.1, Table 1-2, Carbon Emission Factor, Residual Fuel Oil" $EF_{FF, CO2, y} = 21.1\ tC/TJ * 3.6667\ tCO_2/tC = 77.3667\ tCO_2/TJ$
Any comment:	

Data / Parameter	$\varepsilon_{baseline,1,y}$
Data unit:	%
Description:	Energy efficiency of the element process 1 if fired with LSWR
Source of data used:	KDHC
Value applied:	88%
Justification of the choice of data or description of measurement methods and procedures actually applied:	Fuel efficiency in element 1 is calculated by LSWR consumption and heat production. The estimation is calculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operating, Shut-down. Fuel efficiency is calculated on the base of Normal operating which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat production and fuel consumption and operator at Center Control Room record it on the Log sheet paper for each day (24 hours).
Any comment:	

Data / Parameter	$\varepsilon_{baseline,2,y}$
Data unit:	%
Description:	Energy efficiency of the element process 2 if fired with LSWR
Source of data used:	KDHC
Value applied:	88%
Justification of the choice of data or description of measurement methods and procedures actually applied:	Fuel efficiency in element 2 is calculated by LSWR consumption and heat production. The estimation is calculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operating, Shut-down. Fuel efficiency is calculated on the base of Normal operating which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat production and fuel consumption and operator at Center Control Room record it on the Log sheet paper for each day (24 hours).
Any comment:	

Data / Parameter	$\varepsilon_{baseline,3,y}$
Data unit:	%
Description:	Energy efficiency of the element process 3 if fired with LSWR
Source of data used:	KDHC
Value applied:	88%
Justification of the choice of data or description of measurement methods and procedures actually applied:	Fuel efficiency in element 3 is calculated by LSWR consumption and heat production. The estimation is calculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operating, Shut-down. Fuel efficiency is calculated on the base of Normal operating which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat production and fuel consumption and operator at Center Control Room record it on the Log sheet paper for each day (24 hours).
Any comment:	

• Data and parameters relevant to leakage emission

Data / Parameter	***$EF_{NG, upstream, CH4}$***
Data unit:	t CH4 / PJ
Description:	Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in tCH4 per MWh fuel supplied to final consumers
Source of data used:	ACM0009
Value applied:	296
Justification of the choice of data or description of measurement methods and procedures actually applied:	IPCC value will be used since there is no reference for CO2 emission factor in Korea.
Any comment:	

Data / Parameter	***$EF_{LSWR, upstream, CH4}$***
Data unit:	t CH4 / PJ
Description:	Emission factor for upstream fugitive methane emissions from production of the fuel LSWR in tCH4 per MWh fuel produced
Source of data used:	ACM0009
Value applied:	4.1
Justification of the choice of data or description of measurement methods and procedures actually applied:	IPCC value will be used since there is no reference for emission factor in Korea.
Any comment:	

Data / Parameter	***GWP_{CH4}***
Data unit:	t CO2e / t CH4
Description:	Global warming potential of methane valid for the relevant commitment period
Source of data used:	the Revised 1996 IPCC Guideline
Value applied:	21
Justification of the choice of data or description of measurement methods and procedures actually applied:	IPCC value will be used since there is no reference for Global Warming Potential factor in Korea.
Any comment:	

Data / Parameter	***$EF_{CO2, upstream, LNG}$***
Data unit:	t CO2 / TJ
Description:	Emission factor for upstream CO_2 emission due to fossil fuel combustion/ electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system.
Source of data used:	ACM0009
Value applied:	6
Justification of the choice of data or description of measurement methods and procedures actually applied:	Where reliable and accurate data on upstream CO_2 emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system is available, project participants should use this data to determine an average emission factor. Since there is no such data that is available, we assumed a default value of 6 t CO_2/TJ as a rough approximation.
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

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Ex-ante baseline emissions

To estimate ex-ante baseline emission, we projected expected LSWR consumption rate during the crediting period on the base of past LSWR consumption rate. Suseo heat source will maintain the heat generation capacity and heat generation rate at the current rate. Therefore we projected LSWR consumption rate from 2008 to 2017 based on the average of past LSWR consumption for the last 3 years.

LSWR consumption rate during the last 5 years is shown on the table:

Year	2001	2002	2003	2004	2005	Average(‘03~’05)
LSWR consumption	114,853	104,122	114,652	110,744	113,726	113,041

Unit: kℓ

Source: KDHC, 2006, “Operation result statistics in FY2005”

Expected LSWR consumption rate during the crediting period is as following:

Year	Expected LSWR consumption (Unit: kℓ)
2008	113,041
2009	113,041
2010	113,041
2011	113,041
2012	113,041
2013	113,041
2014	113,041
2015	113,041
2016	113,041
2017	113,041

Ex-ante baseline emissions are expressed as following:

$$BE_y = FF_{baseline,y} \times NCV_{FF} \times EF_{FF,CO2}$$

(a) Expected LSWR consumption during the year *y*(unit: kℓ)
- Expected LSWR consumption = 113,040 kℓ

(b) Expected LSWR consumption (unit: ℓ)
- Expected LSWR consumption = 113,040,667 ℓ

(c) NCV_{FF} (unit: kcal/ℓ)
- NCV_{FF} = 9,350 kcal/ ℓ

(d) Expected LSWR consumption (unit: kcal)
- Expected LSWR consumption = 113,040,667 ℓ * 9,350 kcal/ ℓ = 1,056,930,233,333 kcal

(e) Expected LSWR consumption (unit: J)
- Expected LSWR consumption = 1,056,930,233,333 kcal * 4,200 J/kcal = 4,439,106,980,000,000 J

(f) Expected LSWR consumption (unit: TJ)
- Expected LSWR consumption = 4,439,106,980,000,000 J / 1,000,000,000,000 = 4,439 TJ

(g) CO_2 emission factor of the LSWR combusted in all element processes during the year y (unit: tCO_2/TJ)
- $EF_{LSWR,\ CO2,\ y}$ = 77.3667 tCO_2/TJ

(h) CO2 emissions during the year y (unit: tCO2)
- BE_y = Expected LSWR consumption * $EF_{LSWR,\ CO2,\ y}$ = 4,439 TJ * 77.3667 tCO_2/TJ = 343,439 tCO_2

Ex-ante project emissions

To estimate ex-ante baseline emission, we projected expected natural gas consumption rate during the crediting period on the base of past heat generation rate. Suseo heat source will maintain the heat generation capcaticy and heat generation rate at the current rate. Heat generation rate will remain identical even in case of fuel-switching from LSWR to natural gas.

The table shows heat generation result at Suseo heat source for the last 5 years.

Year	2001	2002	2003	2004	2005
Heat only boiler #1	151,005	174,355	142,449	157,142	120,803
Heat only boiler #2	144,365	180,287	178,818	159,575	115,512
Heat only boiler #3	289,936	240,488	330,160	305,820	353,889
Heat only boiler #4	348,281	257,049	290,425	284,852	340,092
Sum	933,586	852,179	941,852	907,389	930,296
Average (FY2003~2005)	926,512				

Unit: Gcal
#1 & #2 Heat only boilers: 51 Gcal/h, #3 & #4 heat only boilers: 102 Gcal/h
Source: KDHC, 2006, "Operation performance statistics in FY2005"

We projected heat generation using natural gas from 2008 to 2017 based on the average of past heat generation result for the last 3 years.
Suppose fuel efficiency of each natural gas boiler 3 to be 95%, natural gas consumption from 2008 to 2017 is as following:

(a) Expected heat production (Unit: Gcal): 926,512 Gcal
(b) Fuel efficiency (%, assumed): 95%
(c) Expected heat production including fuel efficiency (Unit: Gcal)
- Expected heat production including fuel efficiency = Expected heat production / fuel efficiency = 926,512 Gcal / 95% = 975,275.79 Gcal

(d) Net Calorific Value of the natural gas NCV_{NG} (unit: kcal/N m³) : 9,550 kcal/ N m³
(e) Expected natural gas consumption $FF_{project, y}$ (unit: N m³)
- $FF_{project, y}$ = (Expected heat production including fuel efficiency / NCV_{NG}) * 10^6
  = (975,275.79 Gcal / 9,550 kcal/N m³) * 10^6 = 102,123,119 N m³

Expected natural gas consumption during the crediting period is shown in the following table:

Year	Expected natural gas consumption(Unit: N㎥)
2008	102,123,119
2009	102,123,119
2010	102,123,119
2011	102,123,119
2012	102,123,119
2013	102,123,119
2014	102,123,119
2015	102,123,119
2016	102,123,119
2017	102,123,119

Ex-ante project emissions is expressed as following:
$PE_y = FF_{project, y} \cdot NCV_{NG, y} \cdot EF_{NG, CO2, y}$

(f) Expected natural gas consumption (unit: Gcal): 975,275.79 Gcal
- Expected natural gas consumption (unit: Gcal)= Expected heat production including fuel efficiency (unit: Gcal)

(g) Expected natural gas consumption (unit: TJ): 4,096.16 TJ
- Expected natural gas consumption (unit: TJ)={ Expected natural gas consumption (unit:Gcal) * 4.2 } / 1000 = (975,275.79 Gcal * 4.2) / 1000 = 4,096.16 TJ

(h) CO_2 emission factor of the natural gas combusted in all element processes during the year y (unit: tCO_2/TJ)
- $EF_{NG, CO2, y}$ = 56.1 tCO_2/TJ

(i) CO_2 emissions during the year y (unit: tCO_2)
- PE_y = Expected natural gas consumption (unit: TJ) * $EF_{NG, CO2, y}$ = 4,096.16 TJ * 56.1 tCO_2/TJ = 229,794 tCO_2

Ex-ante leakage emissions

Leakage emissions are calculated as follows:

$$LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}$$

where:

LE_y	Leakage emission during the year y in tCO_2e
$LE_{CH4,\ y}$	Leakage emission due to fugitive upstream CH_4 emissions in the year y in tCO_2e
$LE_{LNG,\ CO2,\ y}$	Leakage emission due to fossil combustion/ electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year y in tCO_2e

(1) Fugitive methane emissions

Leakage emissions due to fugitive upstream CH_4 emissions in the year y are calculated as follows:

$$LE_{CH4,y} = (FF_{project,y} \times NCV_{NG,y} \times EF_{NG,upstream,CH4} - FF_{baseline,LSWR,y} \times NCV_{LSWR} \times EF_{LSWR,upstream,CH4}) \times GWP_{CH4}$$

a) Quantity of natural gas combusted in all element processes during the year y $FF_{project,\ y}$
- $FF_{project,\ y}$ = 102,123,119 N ㎥

b) Average net calorific value of the natural gas combusted during the year y $NCV_{NG,\ y}$
- $NCV_{NG,\ y}$ = 9,550 kcal/N ㎥

c) Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas $EF_{NG,\ upstream,\ CH4}$
- $EF_{NG,\ upstream,\ CH4}$ = 296 tCH_4 / PJ

d) Quantity of LSWR combusted in all element processes during the year y $FF_{baseline,\ y}$
- $FF_{baselinet,\ y}$ = 113,040,667 ℓ

e) Average net calorific value of the LSWR combusted during the year y $NCV_{LSWR,\ y}$
- $NCV_{LSWR,\ y}$ = 9,350 kcal/ℓ

f) Emission factor for upstream fugitive methane emissions from production of the fuel LSWR produced $EF_{LSWR,\ upstream,\ CH4}$
- $EF_{LSWR,\ upstream,\ CH4}$ = 4.1 tCH4 / PJ

g) Global warming potential of methane valid for the relevant commitment period GWP_{CH4}
- GWP_{CH4} = 21 tCO2e / tCH4

h) Leakage emission due to fugitive upstream CH_4 emissions $LE_{CH4,\ y}$
- $LE_{CH4,\ y}$ = 25,080 tCO2e / tCH4

(2) CO_2 emissions from LNG

The leakage emissions from LNG are expressed as:

$$LE_{LNG,CO2,y} = FF_{project,y} \times EF_{CO2,upstream,LNG}$$

i) Emission factor for upstream CO_2 emission due to fossil fuel combustion/ electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system $EF_{CO2, upstream, LNG}$

- $EF_{CO2, upstream, LNG}$ = 6 tCO2e / TJ

j) Leakage emissions from LNG

- $LE_{LNG, CO2} = FF_{project, y} * EF_{CO2, upstream, LNG}$ =4,096.16 TJ * 6 tCO2e / TJ = 24,577 tCO_2

B.6.4 Summary of the ex-ante estimation of emission reductions:

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Summarize the results of the ex-ante estimation of emission reductions for all years of the crediting period, using the table below.

Year	Estimation of project activity emissions (tonnes of CO_2e)	Estimation of baseline emissions (tonnes of CO_2e)	Estimation of leakage (tonnes of CO_2e)	Estimation of overall emission reductions (tonnes of CO_2e)
2008	229,794	343,439	49,656	63,988
2009	229,794	343,439	49,656	63,988
2010	229,794	343,439	49,656	63,988
2011	229,794	343,439	49,656	63,988
2012	229,794	343,439	49,656	63,988
2013	229,794	343,439	49,656	63,988
2014	229,794	343,439	49,656	63,988
2015	229,794	343,439	49,656	63,988
2016	229,794	343,439	49,656	63,988
2017	229,794	343,439	49,656	63,988
Total (tonnes of CO_2e)	2,297,940	3,434,390	496,560	639,880

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

Data / Parameter	$FF_{project, 1, y}$
Data unit:	N㎥
Description:	Natural gas consumed in process element 1 in year y
Source of data to be u sed:	KDHC
Value of data applied for the purpose of ca lculating expected em ission reductions in s ection B.5.	34,041,039.7 (=102,123,119 N㎥ / 3)
Description of measu rement methods and procedures to be appl ied:	Natural gas consumption of boiler 1 is estimated in flow totalizer w ith indicating transmitter installed in the front rear at real time. Estimated consumption of natural gas is collected to Center Control Room(CCR) by Distributed Control System(DCS). The operator should record collected data on log sheet paper every hour. Boiler 1,2,3's total natural gas consumption matches with gas flow meter installed by natural gas supplier to impose fare.
QA/QC procedures to be applied:	Uses flow totalizer with indicating transmitter that authorized by K orea Standard Association(KSA)and Korea Institute of Science and Technology Information(KISTI). Flow totalizer with indicating transmitter is rectified by KSA before intial boiler operation. Though this mechanism exact natural gas consumption can be detec ted.
Any comment:	

Data / Parameter	$FF_{project, 2, y}$
Data unit:	Nm³
Description:	Natural gas consumed in process element 2 in year y
Source of data to be u sed:	KDHC
Value of data applied for the purpose of ca lculating expected em ission reductions in s ection B.5.	34,041,039.7 (=102,123,119 Nm³ / 3)
Description of measu rement methods and procedures to be appl ied:	Natural gas consumption of boiler 2 is estimated in flow totalizer w ith indicating transmitter installed in the front rear at real time. Estimated consumption of natural gas is collected to Center Control Room(CCR) by Distributed Control System(DCS). The operator should record collected data on log sheet paper every hour. Boiler 1,2,3's total natural gas consumption matches with gas flow meter installed by natural gas supplier to impose fare.
QA/QC procedures to be applied:	Uses flow totalizer with indicating transmitter that authorized by K orea Standard Association(KSA)and Korea Institute of Science and Technology Information(KISTI). Flow totalizer with indicating transmitter is rectified by KSA before intial boiler operation. Though this mechanism exact natural gas consumption can be detec ted.
Any comment:	

Data / Parameter	$FF_{project, 3, y}$
Data unit:	N㎥
Description:	Natural gas consumed in process element 3 in year y
Source of data to be u sed:	KDHC
Value of data applied for the purpose of ca lculating expected em ission reductions in s ection B.5.	34,041,039.7 (=102,123,119 N㎥ / 3)
Description of measu rement methods and procedures to be appl ied:	Natural gas consumption of boiler 3 is estimated in flow totalizer w ith indicating transmitter installed in the front rear at real time. Estimated consumption of natural gas is collected to Center Control Room(CCR) by Distributed Control System(DCS). The operator should record collected data on log sheet paper every hour. Boiler 1,2,3's total natural gas consumption matches with gas flow meter installed by natural gas supplier to impose fare.
QA/QC procedures to be applied:	Uses flow totalizer with indicating transmitter that authorized by K orea Standard Association(KSA)and Korea Institute of Science and Technology Information(KISTI). Flow totalizer with indicating transmitter is rectified by KSA before intial boiler operation. Though this mechanism exact natural gas consumption can be detec ted.
Any comment:	

Data / Parameter	$\varepsilon_{project, 1, y}$
Data unit:	%
Description:	Fuel efficiency of natural gas used at the process 1
Source of data to be used:	KDHC
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	95% (planned fuel efficiency)
Description of measurement methods and procedures to be applied:	Fuel efficiency in boiler 1 is calculated by estimation of natural gas consumption and heat production from boiler 3. The estimation is calculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operating, Shut-down. Fuel efficiency is calculated on the base of Normal operating which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat production and fuel consumption and operator at Center Control Room record it on the Log sheet paper for each day (24 hours).
QA/QC procedures to be applied:	Fuel efficiency is calculated on the base of estimated fuel consumption and heat production. Therefore Fuel efficiency's QA/QC procedure matches with fuel consumption and heat production of QA/QC procedure. About QA/QC procedure's data record, management and storage is explained in Section B.7.2
Any comment:	

Data / Parameter	$\varepsilon_{project,\ 2,\ y}$
Data unit:	%
Description:	Fuel efficiency of natural gas used at the process 2
Source of data to be u sed:	KDHC
Value of data applied for the purpose of ca lculating expected em ission reductions in s ection B.5.	95% (planned fuel efficiency)
Description of measu rement methods and procedures to be appl ied:	Fuel efficiency in boiler 2 is calculated by estimation of natural gas consumption and heat production from boiler 3. The estimation is c alculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operating, S hut-down. Fuel efficiency is calculated on the base of Normal opera ting which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat productio n and fuel consumption and operator at Center Control Room recor d it on the Log sheet paper for each day (24 hours).
QA/QC procedures to be applied:	Fuel efficiency is calculated on the base of estimated fuel consumpt ion and heat production. Therefore Fuel efficiency's QA/QC proced ure matches with fuel consumption and heat production of QA/QC procedure. About QA/QC procedure's data record, management and storage is explained in Section B.7.2
Any comment:	

Data / Parameter	$\varepsilon_{project, 3, y}$
Data unit:	%
Description:	Fuel efficiency of natural gas used at the process 3
Source of data to be used:	KDHC
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	95% (planned fuel efficiency)
Description of measurement methods and procedures to be applied:	Fuel efficiency in boiler 3 is calculated by estimation of natural gas consumption and heat production from boiler 3. The estimation is calculated as follows: Fuel efficiency(%) = heat production / fuel consumption Heat production is estimated by heat energy counter meter installed in each boiler for real time. Fuel efficiency is estimated on the base of each boiler's 100% load factor. Boiler's operational mode consists of Start-up, Normal operating, Shut-down. Fuel efficiency is calculated on the base of Normal operating which has the longest period of operational mode. Fuel efficiency is calculated on the base of real time heat production and fuel consumption and operator at Center Control Room record it on the Log sheet paper for each day (24 hours).
QA/QC procedures to be applied:	Fuel efficiency is calculated on the base of estimated fuel consumption and heat production. Therefore Fuel efficiency's QA/QC procedure matches with fuel consumption and heat production of QA/QC procedure. About QA/QC procedure's data record, management and storage is explained in Section B.7.2
Any comment:	

Data / Parameter	$NCV_{LSWR, y}$
Data unit:	Kcal/ℓ
Description:	Net calorific value of LSWR in year y
Source of data to be used:	Korea Ministry of Commerce, Industry, Energy
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	9,350
Description of measurement methods and procedures to be applied:	We used the net calorific value defined in "Energy policy law" or "Annual Energy Statistic Report" published by Korean Ministry of Commerce, Industry and Energy.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter	$NCV_{NG, y}$
Data unit:	Kcal/N㎥
Description:	Net calorific value of natural gas in year y
Source of data to be used:	Korea Ministry of Commerce, Industry, Energy
Value of data applied for the purpose of calculating expected emission reductions in section B.5.	9,550
Description of measurement methods and procedures to be applied:	We used the net calorific value defined in "Energy policy law" or "Annual Energy Statistic Report" published by Korean Ministry of Commerce, Industry and Energy.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter	$EF_{LSWR, CO2, y}$
Data unit:	tCO_2 / TJ
Description:	CO_2 emission factor of LSWR combusted in year y
Source of data to be u sed:	IPCC
Value of data applied for the purpose of ca lculating expected em ission reductions in s ection B.5.	77.3667
Description of measu rement methods and procedures to be appl ied:	IPCC value will be used since there is no reference for CO_2 emissio n factor in Korea. $EF_{FF, CO2, y}$ is obtained from the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2- Module 1. Energy, Section 1.2.1, Table 1-2, Carbon Emission Factor, Residual Fuel Oil" $EF_{FF, CO2, y}$ = 21.1 tC/TJ * 3.6667 tCO_2/tC = 77.3667 tCO_2/TJ
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter	$EF_{NG, CO2, y}$
Data unit:	tCO2 / TJ
Description:	average CO2 emission factor of the natural gas combusted in year y
Source of data to be u sed:	IPCC
Value of data applied for the purpose of ca lculating expected em ission reductions in s ection B.5.	56.1
Description of measu rement methods and procedures to be appl ied:	IPCC value will be used since there is no reference for CO_2 emissio n factor in Korea. $EF_{NG, CO2, y}$ is obtained from the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 2- Module 1. Energy, Section 1.2.1, Table 1-2, Carbon Emission Factor, Natural gas(dry)" $EF_{NG, CO2, y}$ = 15.3 tC/TJ * 3.6667 tCO_2/tC = 56.1 tCO_2/TJ
QA/QC procedures to be applied:	
Any comment:	

B.7.2 Description of the monitoring plan:

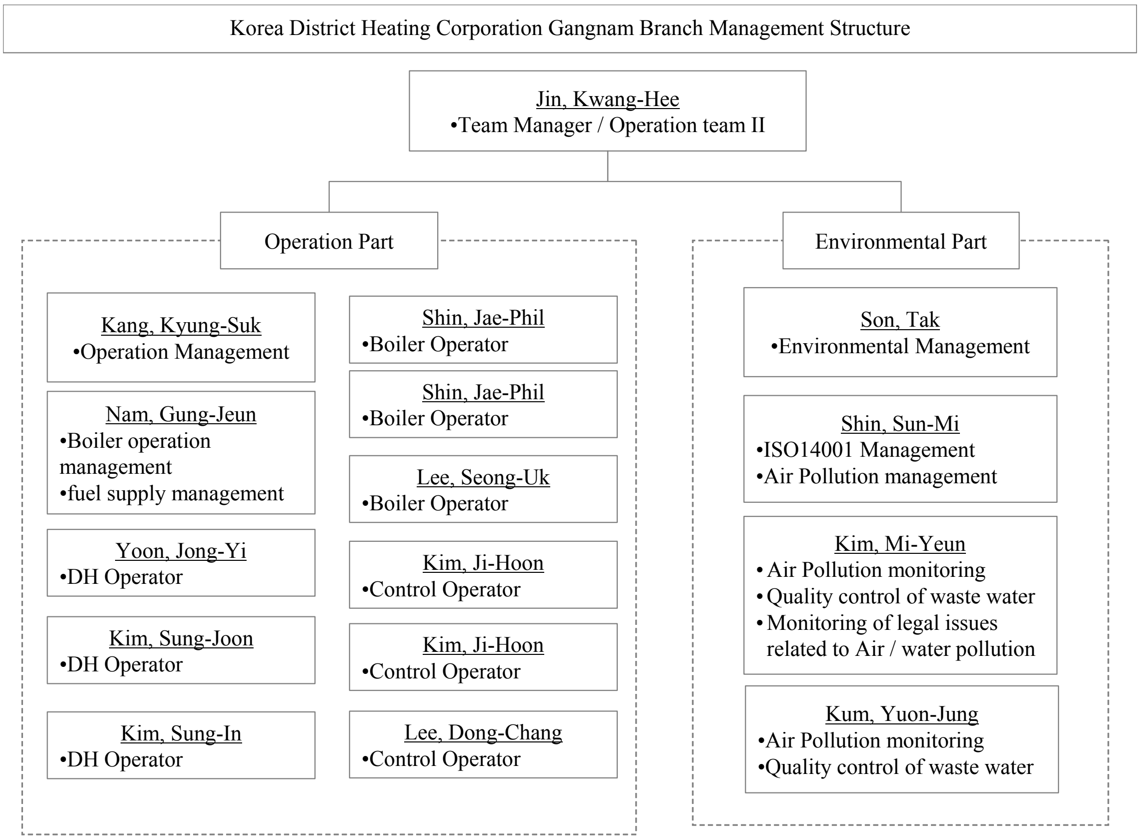
>>

<Description of the monitoring plan>

KDHC Gangnam district office Suseo source Center Control Room should collect information on all the activity.
KDHC Gangnam district office Suseo source Center Control Room estimates, records and manages heat production, fuel consumption, fuel efficiency, load factor all the day per each hour(24 hours) through distributed control system.
Center Control Room's Distributed control system also applies to new natural gas heat only boilers.

<Operational and management structure>

The proposed project will be operated and managed by Gangnam district office Suseo source Operation team which integrates Environmental team and Facility management team. The operation team consists of professional experts on boiler operation and maintenance. The operation team will conduct all work related to the calculation of all emission reductions parameters and monitoring and management of any leakage effects generated by the project activity.



<Training>
KDHC Gangnam district office Suseo source operating team will be trained for boiler operation and management from manufacturing company through operating simulation and pilot manufacturing program.
After the completion of construction in the end of 2007, Operating team will be trained for operation management education once per every quarter from KDHC Head office.

<Responsibilities for and institutional arrangements for data collection and archiving>

Center Control Room is in charge of data collection and KDHC's Head office is in charge of its storage.

- Data collection method

Data will be recorded every day(24 hour) per each hour by the operator in log sheet at Center Control Room.
Recorded data on the Log sheet will be inserted to the computer system every hour, the inserted value will be matched with the log sheet by another operator.
Gangnam district office will conduct the first review the matching of collected data for every 24 hours with inserted information in the computer system and later Head office will re-confirm.
Korea District Heating Corporation will collect computed data every year and publish annual operation result report.

- Data storage method

Insert into the computer system, and the log sheet paper will be stored permanently in Gangnam district office data storage room after confirmation.
Computer system data will be stored in the main server, and also in back-up file in 4 capital region offices of Korea District Heating Corporation. Back-up for each month will be stored permanently, and provides back-up system in order to prevent data loss in case of emergency like black-out.

Name of person is charge and their work is as following:

Person in charge	Team	Work
Gang Gyeong-suk	KDHC Gangnam district office Operation management team	Data collection and storage
Nam gung-jun	KDHC Gangnam district office Operation management team	Data collection and storage

<Quality Assurance and Quality Control>

Korea District Heating Corporation Gangnam district office obtained ISO14001 certification in December, 1996 and is operating continuous and systematic Environment management system.
Korea District Heating Corporation Gangnam district office Suseo source obtained monitoring and QA/QC process for all parameters related to proposed project activity monitoring through ISO14001 certification. Monitoring plan of the proposed project activity will be managed in integration and continuation with Environment management system through ISO14001.

B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)

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Date of completion: 28/08/2006

Contact information: Mr. Jungman Chung (jmchung@ecofrontier.co.kr) / Ecofrontier.co. (www.ecofrontier.co.kr) who is determining the baseline and participating in the project as a consultant.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

>>
01/11/2007

C.1.2. Expected operational lifetime of the project activity:

>>
More than 25 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

>>
Not applicable

C.2.1.2. Length of the first crediting period:

>>
Not applicable

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
01/01/2008

C.2.2.2. Length:

>>
10 years

SECTION D. Environmental impacts

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D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

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The project activity is allowed by Ministry of Commerce, Industry and Energy. According to the Act on Assessment of Impacts of Works on Environment, Traffic, Disasters, etc., the Republic of Korea does not require an EIA (Environmental Impact Assessment) for the project activity as regard District heating Though the government doesn't require an EIA, we considered environmental impact for the project activity – Air quality, water quality and noise etc. in the designing stage.

Eliminating LSWR use, there are environmental impacts from petroleum extraction, refining and transport. These are reduced by switching from LSWR to natural gas. Burning LSWR at the project site also produces gaseous and some particulate emissions, which are also substantially reduced when using natural gas

The project implementation involves the construction of a gas distribution network at the Kangnam plant site and the installation of equipment permitting the use of natural gas. The environmental impact of these activities is expected to be insignificant.

The substitution of LSWR by natural gas has positive environmental impact.
LSWR burning produces a number of gaseous and particulate emissions which are local air pollutants.
The particulate emissions are almost completely eliminated by switching to natural gas.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>

No significant negative environmental impact is expected from project activities.

SECTION E. Stakeholders' comments

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E.1. Brief description how comments by local stakeholders have been invited and compiled:

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Stakeholder comments of the project activity were carried out through a survey and public hearing for local stakeholders and residents

To receive official approval for switching fuel from LSWR to Natural gas, KDHC should obtain agreement of representatives of apartment-complex residents near the site.
KDHC Gangnam Branch held four public hearings for local stakeholders and residents. Detail information of public hearings is described in the table below.

Table 4. Detail information of public hearings

Date & Time	Place	Host
19/08/2005, 15:00~18:00	Suseo-dong Office	KDHC
25/08/2005, 16:00~17:30	Suseo-dong Office	KDHC
15/09/2005, 14:00~16:00	Suseo-dong Office	KDHC
04/11/2005, 14:00~15:00	Suseo-dong Office	KDHC

The attendances are representatives of apartment-complex residents near the project site and members of Gangnam-Gu assembly. KDHC put up a notice for public hearing and sent official notices to all attendance.
KDHC explained the purpose of fuel switching, background, construction schedule. The attendances welcomed the plan of fuel switching and agreed to the construction proposal. Especially, they were interested in environmental improvement e.g. reduction of greenhouse gases and air pollutants

Figure 2. Public hearing (19/08/2005)

E.2. Summary of the comments received:

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In general, local stakeholders and residents welcomed the project activity at several public hearings. They expected that the project activity would reduce greenhouse gases as well as air pollutants – SOx, particles and contribute local air quality. Some called on continuous management of local air quality after fuel-switching activity. . All stakeholders requested KDHC not to expand heat production capacity at the Suseo heat production facility

E.3. Report on how due account was taken of any comments received:

>>

All comments which have been received to this date were very positive for project implementation.
KDHC would invite comments from other stakeholders by valitator's website.
Depending on the comments, proper account will be taken.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Korea District Heating Corporation
Street/P.O.Box:	186 Bundang-dong, Bundang-gu,
Building:	
City:	Seongnam
State/Region:	Gyeonggi Province
Postfix/ZIP:	463-908
Country:	Republic of Korea
Telephone:	+82-31-780-4430
FAX:	+82-31-701-1008
E-Mail:	seoul@kdhc.co.kr
URL:	http://www.kdhc.co.kr/english/index_e.htm
Represented by:	Young-nam, Kim
Title:	CEO
Salutation:	Mr.
Last Name:	Kim
Middle Name:	-
First Name:	Young-nam
Department:	
Mobile:	+82-11-9048-1876
Direct FAX:	+82-31-701-1008
Direct tel:	+82-31-780-4430
Personal E-Mail:	seoul@kdhc.co.kr

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No funds from public national or international sources were used in any aspect of the proposed project.

Annex 3

BASELINE INFORMATION

Baseline information was presented in Section B. Please refer to that section.

Annex 4

MONITORING INFORMATION

Monitoring plan was presented in Section B. Please refer to that section.

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