



***A review on the consumers'  
benefits of district heating system***



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# 1. Introduction

## ~~To eliminates barrier to evaluating project of DHS~~

- *The Korean government established a public utility, the Korea District Heating Corporation (KDHC), in 1985 in order to expand the district heating system (DHS). The DHS is considered to be best for the supply of residential heat (RH) in urban areas with high population density.*

## ● ***What do we need to evaluate projects?***

- In the public arena, formal feasibility analysis is typically used for project evaluations.
- A new public project of DHS construction should be assessed in economic feasibility analysis framework.
- **Cost-benefit analysis (CBA)** is an analytical tool for judging the economic advantages or disadvantages of an investment decision by evaluating its costs and benefits.

## ● ***How, then, are the benefits and costs estimated?***

- The costs of a project should be measured in terms of opportunity cost.
- Valuing the benefits is more difficult job than measuring the costs
- In economics sense, the benefits ensuing from the consumption of a goods are measured by the area under the demand function for a goods.

# 1. Introduction

~~Information about economic benefits is highly necessary~~

## ● ***For efficient project evaluation and management***

- Scientific and academically sound information about the economic feasibility of a DHS project is widely needed.
- CBA can be a valuable and helpful tool to determine whether to implement the DHS project or not, though it is not the only tool for decision-making.
- To conduct a CBA of a project, we must value the benefits and costs of the project exactly.
- The economic benefits of consuming 1Gcal of heat produced through DHS means how beneficial to the consumers the DHS is.

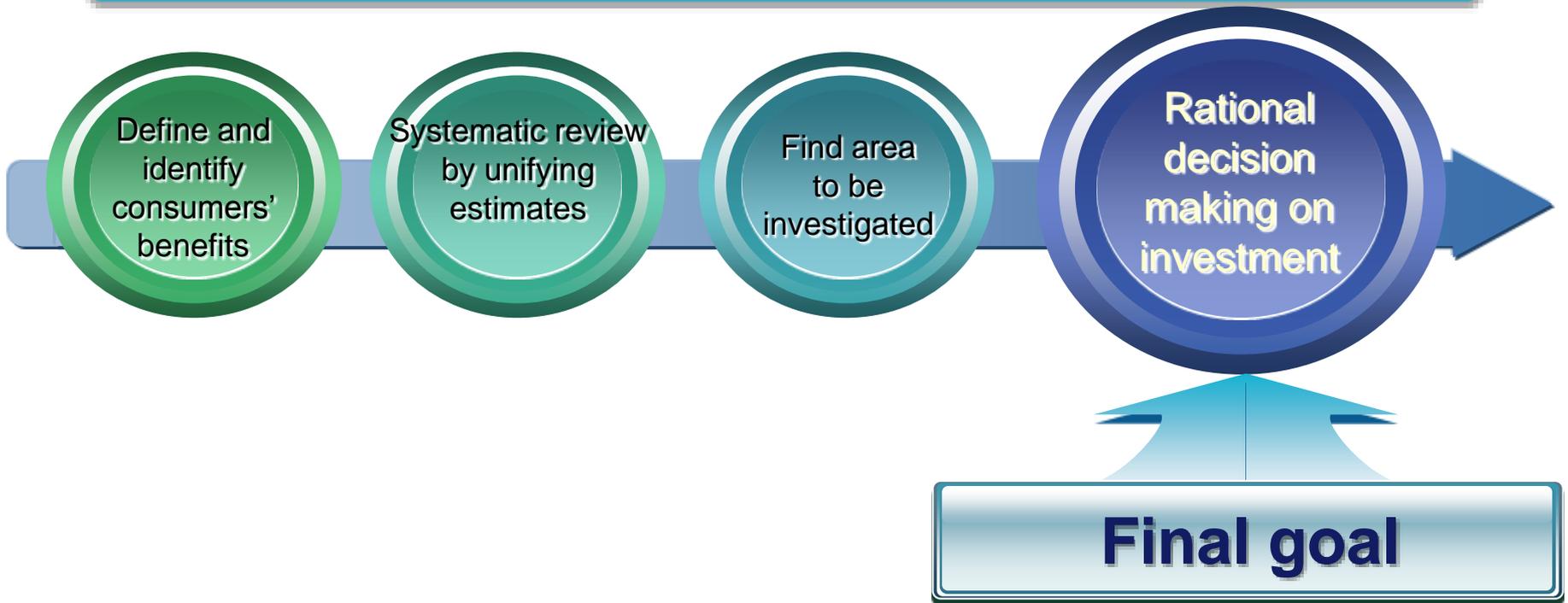
## ● ***For developing demand and marketing strategies***

- Various heating systems, such as DHS, individual heating system (IHS), central heating, and etc., is competing with each other in the market of Korea.
- Selecting one heating system among them should be based on the public consensus, which can be promoted through the CBA of a DHS project.

# 1. Introduction

***The goal is to define consumers' benefits and provide standard for data***

This study attempts to present a literature review on the consumers' benefits of DHS in Korea and summarize the findings from the review using systematic method.



# 1. Introduction

## Definition of benefits

- ***Benefits are approached from a national perspective, not from the individual business, it should be distinguished between benefit from economic feasibility and financial profitability.***
- ***Benefit : Project's contribution to national production or social welfare***
- ***Therefore, the distinction between price and value is important.***
- ***Depending on who enjoy the benefits, the benefits are divided into consumer and producer benefits.***
- ***Consumer benefits are incremental amount comparing a scenario with-the-project with a counterfactual baseline scenario without-the-project.***
- ***In general, district heating system (DHS) is known to provide consumers with much more benefits than other heating system. However, there are still small number of studies that deal with the quantitative measurement of the consumers' benefits of DHS.***

# 1. Introduction

## Economic approach

- **The benefit can be estimated in possible alternate way**

### Alternate Approach

#### Economic Approach

A technique for collecting data based on economic theory and then evaluating values through statistical analysis

Revealed  
Preference  
Method

Stated  
Preference  
Method

Benefit  
transfer

#### Non-economic Approach

A technique for evaluating values based on engineering or accounting costs, not on economic theory

Replacement  
cost  
approach

Control  
cost  
approach

Restoration  
cost  
approach

The benefits can be estimated based on an economic approach first, but only if the economic approach is not easy to apply the non-economic approach can be applied.

## 2. Classification of the benefits of DHS

### ● Types of the benefits

Type	Benefit	Main information
Value-added creation	Residential heat Consumption benefits	Using heat for heating by consumer
	Convenience benefits	Improving the convenience of facility repair and management by administrator Avoiding the risk of accidents due to individual heating boilers
	Increase in property value	Increasing value of house and extending free space compared to individual heating system
Cost reduction	Cost reduction benefits	Supplying compared to other heating methods, such as reducing investment cost, operation & maintenance cost, rate, and etc.
	Non-market external benefits	Reducing greenhouse gases and pollutant emissions produced by the energy sector by substituting with district heating, which is more efficient and sustainable energy

# 3. Review on the consumers' benefits of DH

## Residential heat consumption benefits

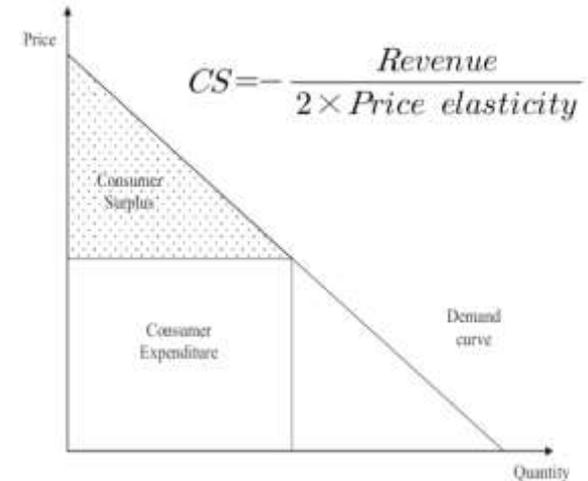
### ● Approach adopted here

➤ *The economic theory implies that the economic benefit of the RH consumed is the sum of consumer surplus (CS) and consumer expenditure for the consumption.*

✓ *Alexander et al. (2000) suggested a simple formula for CS that is based on only two values: the revenue from a commodity sale and the price elasticity of demand for the commodity.*

### ● Methodology and data

Methodology and data	Details
Methodology	Demand function approach
Model	Lagged dependent variable model
Data	Residential heat consumption and sales covering the period 1988-2013



### 3. Review on the consumers' benefits of DH

#### ~~Residential heat consumption benefits~~

- **Estimation results of consumer surplus and economic benefit of residential heat (RH) consumption in 2013**

Sales of RH (Million Korean won)	Amount of RH sold (Gcal)	Average price of RH (Korean won per Gcal)	Price elasticity of RH	Economic benefit of RH (Million Korean won)	Unit economic benefit of RH (Korean won per Gcal)	Ratio of economic benefit to price
1,071,555 (USD 1,025 million)	12,194,782	87,870 (USD 84.1)	-0.700	1,836,951 (USD 1,758 million)	150,634 (USD 143.8)	<b>1.71</b>

- **The CS for RH consumption in 2013 is computed to be KRW 765 billion (USD 732 million).**
- **This value corresponds to KRW 62,764 (USD 60.1) per Gcal.**
- **The consumption benefit for RH in 2013 is calculated to be KRW 1,837 billion (USD 1758 million).**
- **This value amounts to KRW 150,634 (USD 143.8) per Gcal in 2013.**

The exchange rate was USD 1.0 to approximately KRW 1045.

### **3. Review on the consumers' benefits of DH**

#### **~~Residential heat consumption benefits~~**

#### **● Case study**

- ***We can incorporate the value into the economic benefits of a DHS facility construction project and compare it with the economic costs of the project.***
- ***Application : The project of 1000 Gcal of RH supply***
  - ✓ ***The present value of the consumption benefits : 1.97 billion***
  - ✓ ***The economic benefits : KRW 150.6 million***
  - ✓ ***(=87,870 per Gcal x 1.71 x 1000 Gcal)***
  - ✓ ***The present value of total costs : KRW 1.0 billion***
  - ✓ ***The benefit-cost ratio : 1.97 (greater than 1.0)***
- ***The new DHS project is socially profitable and should be immediately implemented.***

# 3. Review on the consumers' benefits of DH

## Convenience benefits

- **Korean residents prefer DHS to IHS because DHS provides convenience and safety in their living environment.**
- **The DHS does not demand an individual boiler, which can significantly increase consumer convenience and safety.**
- **Occasionally, individual boilers may explode. Over the period 2008–2012, for example, 16 people were killed and 110 people were wounded when individual boilers exploded.**
- **For these reasons, some 200,000 households have voluntarily changed their heating system from IHS to DHS, even though the change meant considerable cost.**

### Individual boiler



Risk of gas leakage, explosion



Management in person

### **3. Review on the consumers' benefits of DH**

#### **Convenience benefits**

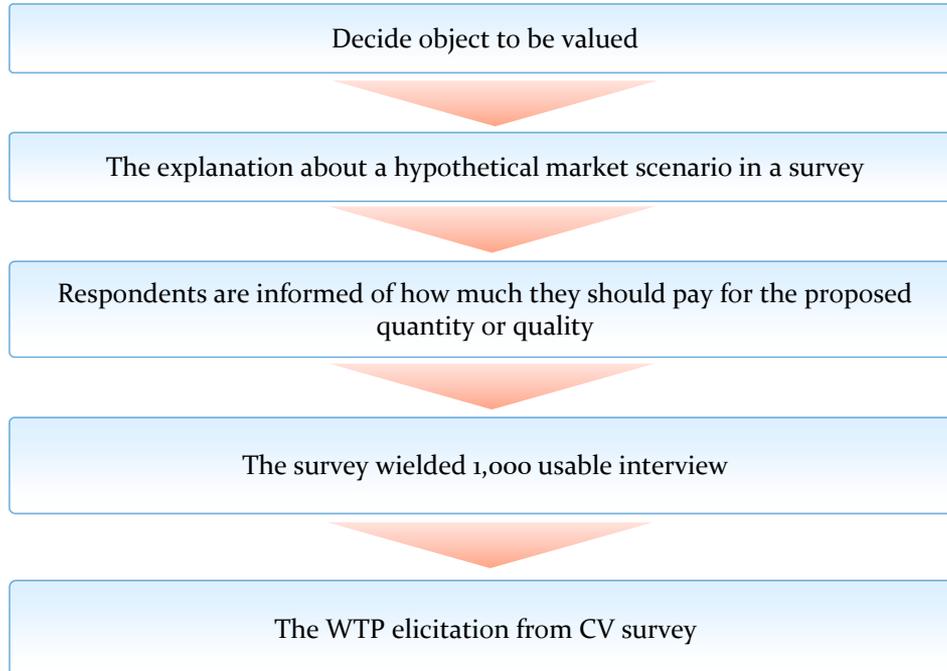
- **Consumers can utilize the space formerly taken up by a boiler as storage space, and so converting IHS into DHS can substantially expand living space.**
- **Consumers using IHS are sometimes confronted with trouble in their boilers, and particularly during the winter season, this can cause great inconvenience. A boiler usually requires operation and maintenance costs, as well as repair cost.**
- **However, the costs required in the DHS are included in the DHS bill, and thus the DHS-based RH consumers pay just the RH charges.**
- **In summary, it is expected that the DHS will be expanded in Korea to meet the increasing demand of residents and to implement the national plan of increasing the DHS. The Korean government thus requires information about the Convenience benefits of DHS over IHS for consumers.**
- **This study is to assess Korean households' willingness to pay (WTP) for DHS over IHS, for residential heat.**

# 3. Review on the consumers' benefits of DH

## Convenience benefits

- **Procedures of applying the contingent valuation (CV)**

- **CV is a standardized and widely used survey method for estimating WTP**



### CV (contingent valuation)

- A **survey**-based value elicitation approach
- queries consumers in systematic ways to estimate their WTP for a **proposed policy or environmental management program**.
- By applying the CV method, it is possible to recover non-use or existence values that cannot be assessed through market mechanisms.

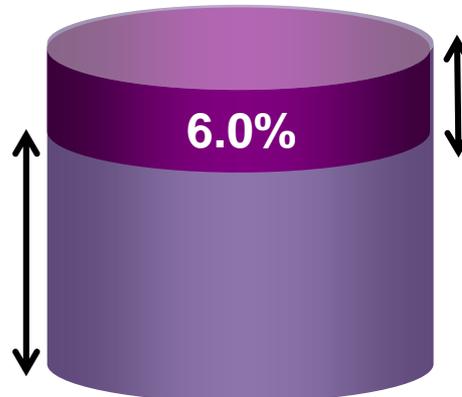
### 3. Review on the consumers' benefits of DH

#### Convenience benefits

## ● Results

- ***This value can be interpreted as the consumer's convenience benefits of DHS over IHS, and amounts to approximately 6.0% of the average price: KRW 96,510 (USD 92.4) per Gcal in 2013, for IHS-based RH.***
- ***This information is useful for evaluating changes to the method used for supplying RH from IHS to DHS.***

the average price of  
IHS based RH in 2013  
: KRW 96,510 (USD 90.4)  
per Gcal



the mean additional WTP  
: KRW 5,775 (USD 5.5) per Gcal

The exchange rate was USD 1.0 to approximately KRW 1045.

### **3. Review on the consumers' benefits of DH**

#### **Convenience benefits**

#### **● Implication**

- ***Economic evaluation is important because it helps ascertain whether the public favors a proposed DHS project for RH supply, as well as estimating the degree to which it is willing to pay for such a benefit.***
- ***This study seeks to utilize the CV approach to show that the mean additional WTP for DHS-based RH over IHS-based RH is estimated to be KRW5,775 (USD 5.5) per Gcal.***

*The exchange rate was USD 1.0 to approximately KRW 1045.*

### 3. Review on the consumers' benefits of DH

#### Increase in property value

- **Korean government is seeking to investigate consumers can utilize the space formerly taken up by a boiler as storage space, and so converting IHS into DHS can substantially expand living space.**

#### Methodology

Methodology	Hedonic Price Method
Estimation method	Least absolute deviations estimation
Data	Information on real estate sale and statistical yearbook

#### Boiler room



Demand space for Boiler room

### **3. Review on the consumers' benefits of DH**

#### **Increase in property value**

#### **● Hedonic Price Method**

- ***With regard to the property market, houses can be described through their structural characteristics (e.g. number of rooms), locational characteristics (e.g. proximity to schools), neighborhood characteristics (e.g. crime rates) and environmental characteristics (e.g. road traffic noise).***
- ***The hedonic price method should identify the contribution of each significant determinant of house prices in order to estimate the marginal WTP for each characteristic.***
- ***The economic benefits from one heating system over other heating system can be captured by the expected increase/decrease in property values.***
- ***Through statistical techniques the method tries to isolate the implicit price of each of these characteristics.***
- ***The total increase of the estate value is a good proxy of the socioeconomic benefit of the project.***

### 3. Review on the consumers' benefits of DH

#### Increase in property value

- *The procedures of applying the hedonic price technique*

Gathering the data on the apartments for sale in the study area

Setting Hedonic price function of a bundle of characteristics

Estimating the housing price equation using some statistical methods

Hedonic price equation:  $P_H = f(Q_1, \dots, Q_k, \dots, Q_K)$

Marginal implicit price of  $Q_k$  :  $\frac{\partial P_H}{\partial Q_k}$

Deriving the implicit value of heating system from the estimated equation

Measuring the economic benefits of DHS over IHS from the perspective of housing price

### 3. Review on the consumers' benefits of DH

#### Increase in property value

##### ● Premium for DHS

- *The premium for DHS over IHS is KRW 50.2 million (USD 48,035), which is KRW 3.13 million per year (USD 2995).*
  - ✓ *This information can be beneficially utilized in evaluating a new project to change the heating system of supplying RH.*



*Increase of comfort of DHS compared to IHS due to the reduction of boiler room and stovepipe*

The exchange rate was USD 1.0 to approximately KRW 1045.

# 4. Overview of the case studies

## Summary

- *The quantitative information about consumers' benefits, which is reported in this paper, can be utilized in developing and evaluating a project of supplying a DHS. Some topics to be investigated in the future study are also offered.*
- **Value added**
  - **Residential Heat Consumption benefit**
    - ✓ **Ratio of economic benefit to price is 1.71.**
      - ☞ *This value corresponds to KRW 62,764 (USD 60.1) per Gcal.*
  - **Convenience benefits**
    - ✓ **This value amounts to approximately 6.0% of the average price:**
      - ☞ *KRW5,775 (USD 5.5) per Gcal*
  - **Increase in property value**
    - ☞ *The premium for DHS over IHS is KRW 502 million, which is KRW 3.13 million per year.*

The exchange rate was USD 1.0 to approximately KRW 1045.

## 4. Overview case studies

### Case studies

- **Application : The *new* project of 1000 Gcal of RH supply**
  - **Economic benefit of Residential Heat Consumption :  
KRW 150 million (USD 143.8)**
    - ✓ **KRW 87,870 per Gcal x 1.71 x 1000 Gcal**

## 4. Overview case studies

### Case studies

- **Application : The *heating system change* project of 1000 Gcal of RH supply**
  - **Convenience benefits :**  
**KRW 5.7 million (USD 5.5 thousand)**
    - ✓ **KRW 96,510 per Gcal x 6% x 1000 Gcal**
  - **Increase in property value :**  
**KRW 3.13 million/year (USD 2995/year)**

# ***Thank You for Your Attention!***

## ***Any Questions?***

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