

Clean Fuel Supply Project

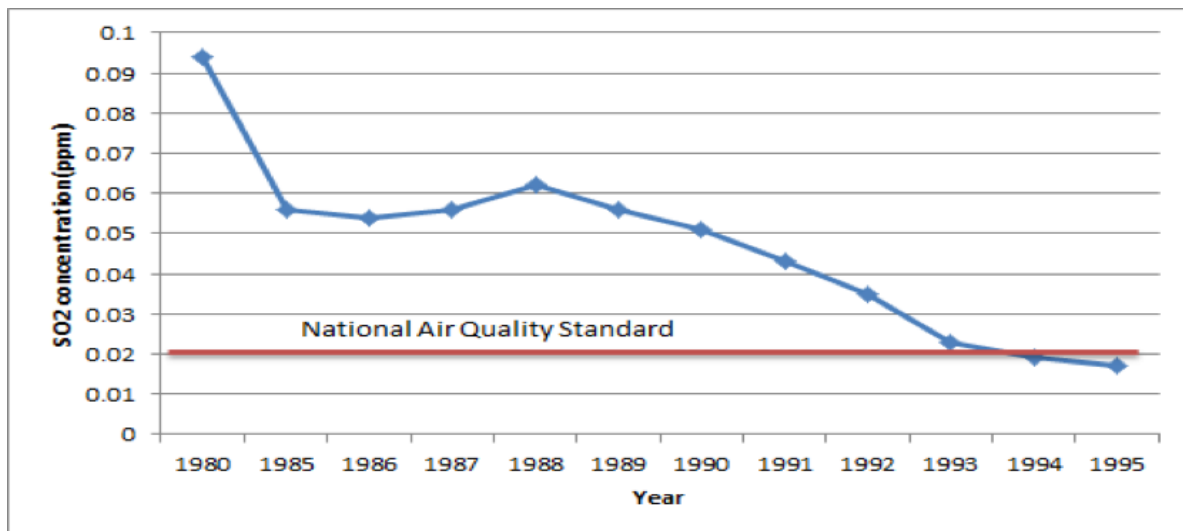
Background

Due to industrial development, growth in population and the consequential increased use of fossil fuels, the air pollution in Seoul was serious in the 1970s and 1980s. Sulfur dioxide (SO₂), particularly, in Seoul reached the highest level, more than four times the national environment standards in 1980, and more than twice the standards in 1990.

The main energy source in the 1960s was cheap coal, which made up around 40% of total energy consumption at that time. In the 1970s, oil replaced coal and became the main energy source, increasing dramatically as the heavy chemical industry developed, and the standard of living greatly improved.

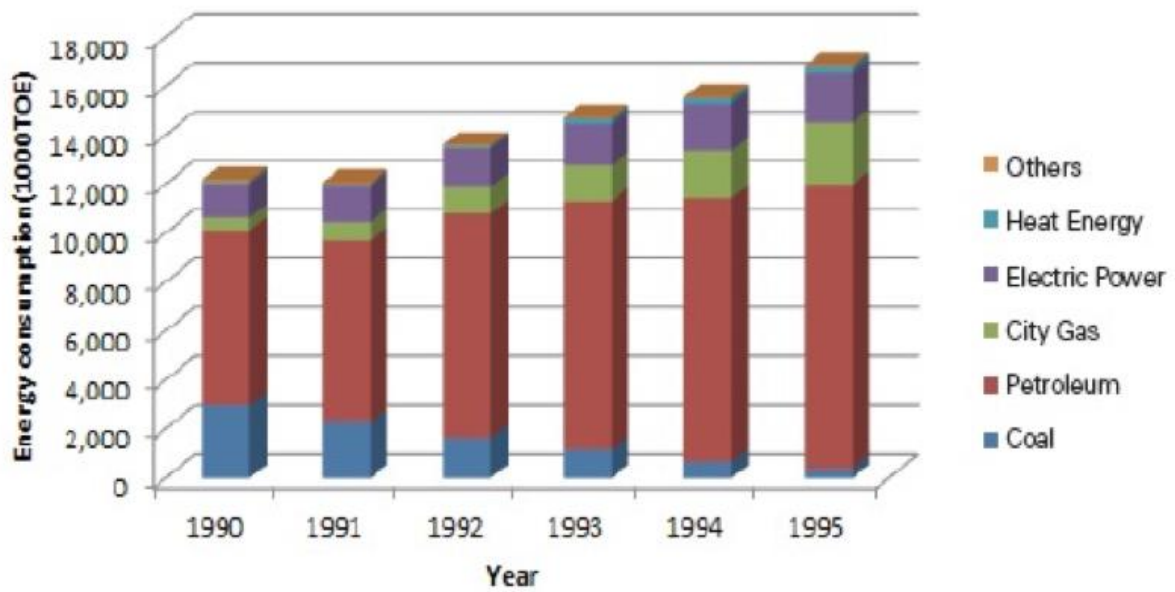
The major sources of SO₂ emissions are fossil fuels such as coal and oil. The sulfur content of fossil fuels is relatively higher than city gas and LPG. In the 1990s, the SO₂ concentration was still very high, as around 70% of the households in Seoul used coal briquettes for heating. Accordingly, the Seoul Metropolitan and central governments planned to expand the supply of clean fuels and introduce a variety of projects to reduce SO₂ emissions.

<Figure 1> Changes in Annual Average SO₂ Pollution in Seoul



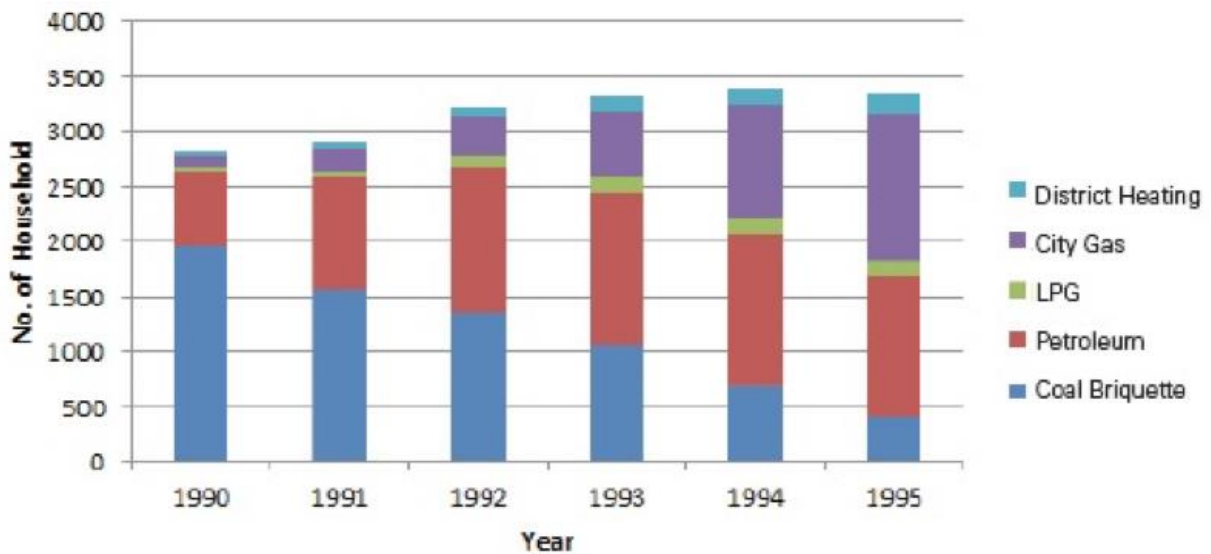
National Air Quality Standards / SO₂ concentration (ppm)

<Figure 2> Changes in Seoul's Fuel Consumption, by Fuel



Other/ Heat Energy/ Electric Power/ City Gas/ Oil/ Coal/ Energy consumption (1000 TOE)

<Figure 3> Change in Number of Households by Heating Fuel in Seoul



District Heating/ City Gas/ LPG/ Oil/ Coal Briquettes/ No. of Households

Expansion of the Supply of Low Sulfur Oil

To fundamentally reduce SO₂ emissions from fuel, Seoul introduced standards for sulfur content of diesel and heavy oil and applied them in Seoul (the first time in Korea) in 1981. These standards have been strengthened several times and the relevant areas continuously expanded. As a result of the strict standards, only heavy fuel oil with less than 0.3% sulfur content, and diesel with less than 0.1% are currently supplied.

<Table 1> Change in Sulfur Content of Heavy Oil & Diesel

	Heavy Oil	Diesel
1981	1.6%	0.4%
1993	1.0%	0.2%
1997	0.5%	0.1%
2001	0.3%	0.1%

Regulations to Prohibit the Use of Solid Fuels

To reduce the emission of air pollutants, Seoul and the metropolitan cities introduced an institution in 1985 to prohibit the use of solid fuels such as coal, coke, and combustible waste. Since then, the areas of application have been gradually expanded.

Mandatory Use of Clean Fuel

From 1988, it became mandatory to use LNG in business facilities (both private and public) in which boiler capacities were at least 2 tons in total, as it is a clean fuel. The compulsory use of clean fuel or diesel was then expanded to facilities with boiler capacities of at least 1 ton in 1990, 0.5 ton in 1991 and 0.2 ton in 1994. For apartment complexes using central heating, the use of clean fuel was mandated in 1990 for units with an average area of at least 35 pyeong (115.7 m²). The mandatory use of clean fuel or diesel has been expanded to apartment complexes with an average area of at least 30 pyeong (99.2 m²) in 1991, 25 pyeong (82.6 m²) in 1992 and 12.1 pyeong (40 m²) in 1997.

<Table 2> Expansion of Facilities Obligated to Use Clean Fuel or Diesel

	Boiler Capacity	Area of Apartment	Power Plant
1988	At least 2 tons	-	
1990	At least 1 ton	At least 35 pyeong	
1991	At least 0.5 ton	At least 30 pyeong	All power plants
1992	-	At least 25 pyeong	Cogeneration plants for business use
1994	At least 0.2 ton	-	
1995	-	At least 21 pyeong	
1996	-	At least 18 pyeong	
1997	-	At least 12.1 pyeong	

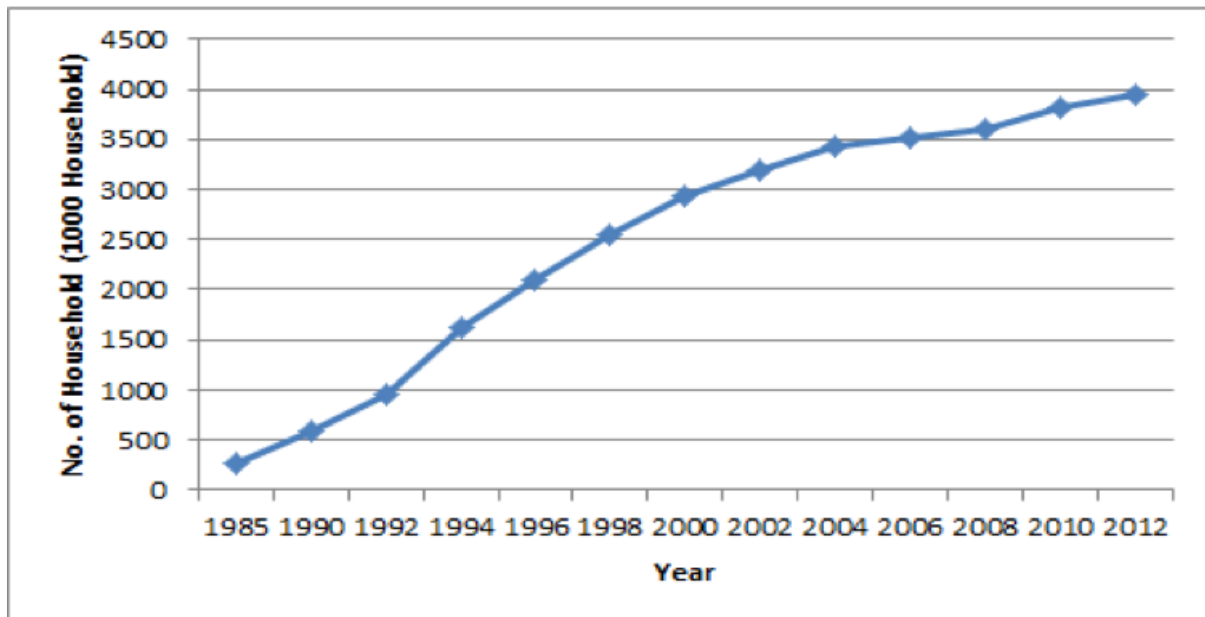
Expansion of City Gas (LNG) Supply to General Housing

- Overview

Thanks to the policy to mandate the use of LNG and clean energy introduced in the late 1980s, the pipeline network of city gas was able to accommodate 260,000 households in 1985, and has expanded year by year since then. The households that had used coal briquettes and oil in the past began using city gas with relatively lower emissions as heating fuel, and main fuels were switched to cleaner fuels. Thanks to such efforts, around 95% of households in Seoul are using city gas for heating.

Seoul implemented a variety of policies to expand the supply of city gas by introducing a system that imposes a part of the cost on consumers through their city gas bills to secure the funds needed for city gas suppliers, financing for replacement of old pipelines to increase stability of supply and adopting a financing system for city gas users.

<Figure 4> Change in the Number of Households Using City Gas in Seoul



- Raising a Fund for & Operation of the City Gas Project

- Ordinance: Enactment of an ordinance on a fund for installation of the city gas project in Seoul in 1992
- Purpose for Raising the Fund: To provide low interest loans to city gas suppliers to cover a certain amount of the installation cost for natural gas infrastructure necessary for the quick expansion of supply
- Use of the Fund
 - Loans for installation of pipes and monostat facilities to provide city gas to residential, public and social welfare facilities
 - Loans for installation of pipes to provide city gas to public bath facilities planning fuel conversion
 - Loans for installation of compressed natural gas stations for city buses and the related

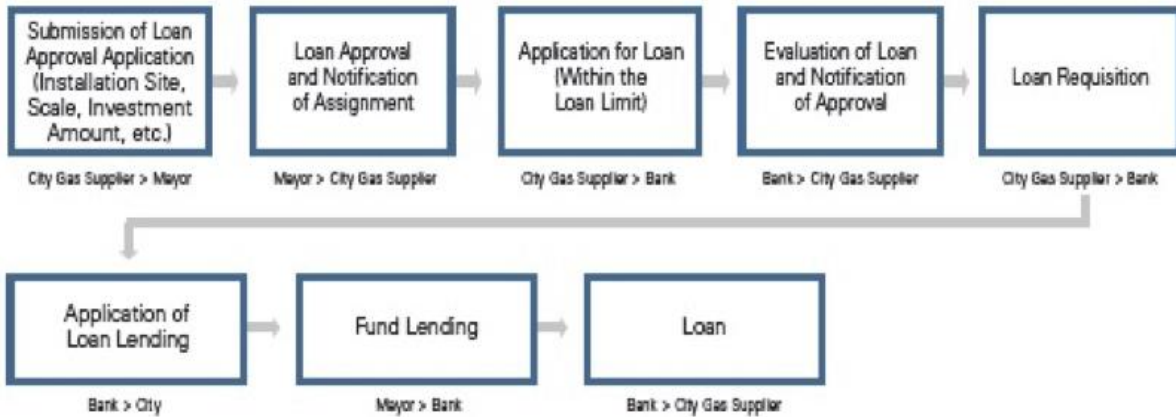
pipes

- Beneficiaries of the Fund: City gas providers whose business meeting funding criteria
- Fundraising Method: Contribution from Seoul's general account and earnings generated through operation of the Fund
- Fund Operation & Management
 - Fund Operator: Energy Management Team of the Seoul Metropolitan Government
 - Fund Management: Consignment management (Woori Bank, Kookmin Bank)
 - Loan Limit: Up to 80% of the costs for installing city gas supply facilities
 - Repayment Conditions: Level repayment in 5 years with a 3-year grace period
 - Loan Interest: Annual interest of 4.5% (annual lending interest rate of 3.8%)
- Loan Process
 - City Gas Supplier: Submission of loan application to the Mayor
 - Mayor: Review of construction results → Decision on loan amount → Notification of loan handling bank to the city gas supplier
 - Loan Handling Bank: Review of construction details, etc. → Funds lent (← Seoul City) → Loan (→City Gas Supplier)

<Figure 5> Amount of Fund & Loan Process

(Unit: KRW Million)

Year	Sum	94	95	96	97	98	99	2000	2001	2002	2003	2004	2005	2006	2007
Item															
Sum	114,766.5	22,679.4	14,101.9	15,0026.5	10,846.2	10,310.8	5,793.5	7,480.7	8,366.8	5,565.8	5,195.1	3,238.5	1,896.1	2,232.9	2,030.3
Contribution from General Account	48,000	10,000	10,000	10,000	5,000	3,000	-	-	-	-	-	-	-	-	-
Loans from the Treasury Investment and Loan Institutes	10,000	10,000	-	-	-	-	-	-	-	-	-	-	-	-	-
Earnings from Fund Operation	66,766.5	2,679.4	4,101.9	5,026.5	5,846.2	7,310.8	5,793.5	7,480.7	8,366.8	5,565.8	5,195.1	3,238.5	1,896.1	2,232.9	2,030.3



Contribution from General Account/ Loans from Treasury Investment & Loan Institutes/
Earnings from Fund Operation

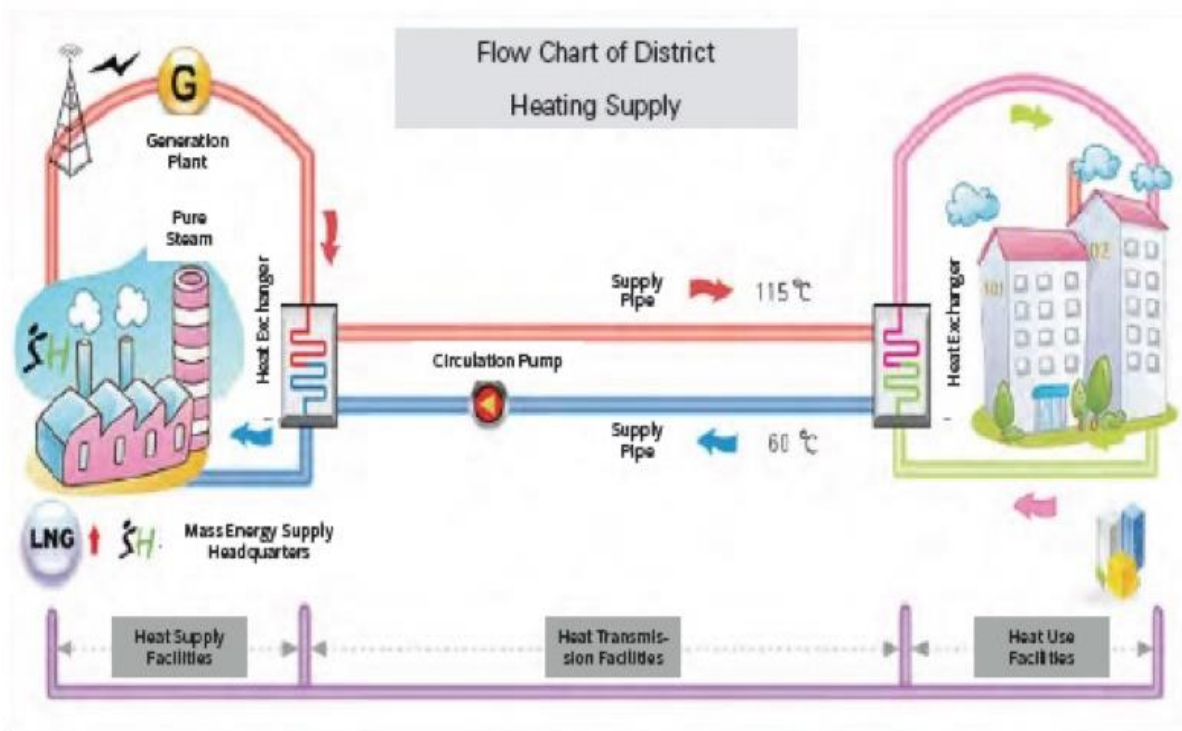
Submission of Loan Approval Application (Installation Site, Scale, Investment, Amount, etc.)	Loan Approval & Notification of Assignment	Application for Loan (Within the Loan Limit)	Evaluation of Loan & Notification of Approval	Loan Requisition
City Gas Supplier>Mayor	Mayor> City Gas Supplier	City Gas Supplier>Bank	Bank> City Gas Supplier	City Gas Supplier>Bank
Application of Loan Lending	Funds lent	Loan		
Bank > City	Mayor>Bank	Bank> City Gas Supplier		

Expansion of Supply of Mass Energy (District Heating)

- Overview

The Mass Energy project aims to supply the energy (heat or heat & electricity) produced by one or more concentrated energy plants (cogeneration plants, heating-only boilers, resource recovery facilities, etc.) collectively to numerous users in residential areas, commercial areas and industrial complexes.

<Figure 6> Flow Chart of District Heating Supply

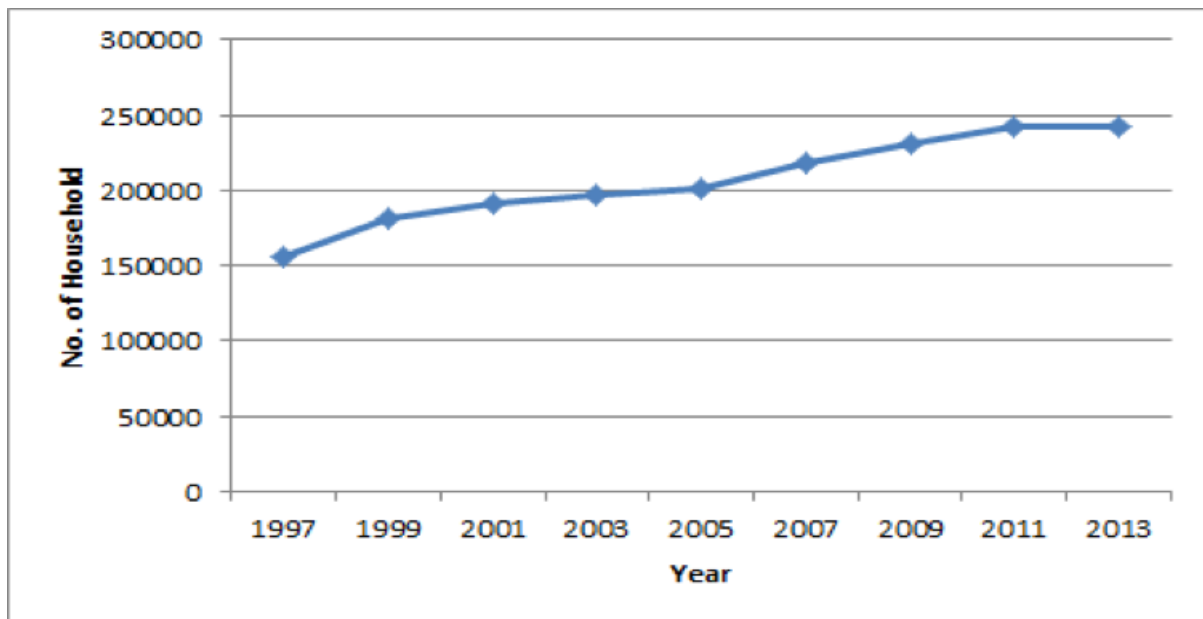


History

When confirming development plans for the Mok-dong new town in 1983, the Seoul Metropolitan Government (SMG) became the first in Korea to adopt district heating, in which a portion of electric energy is provided from the residual heat of cogeneration plants, which is used to provide heat. In order to implement this heating method, Seoul set up a “Mok-dong District Development Office” exclusively for the development of the new town and entered into a business consignment agreement for the entire construction project and its operation with the Korean Energy Management Corporation, as it was able to provide professional and specialized technicians. Seoul also consigned the design, construction, supervision and operation for the Mass Energy supply project to SH Corporation. Under the scheme, the cogeneration plants in Gangseo and Nowon *gu*-districts were constructed.

In 1984, Seoul provided around 26,000 households with heat in this way. This number exceeded 240,000 in 2013.

<Figure 7> Change in the No. of Households Using District Heating in Seoul



The Gangseo Region Project - Process

- May 1983: Confirmation of New Town Development Plan in Mok-dong (Adoption of district heating method)
- Oct. 1983: Submission of Mass Energy Supply Project Plan (Draft) for Mok-dong Area
- Dec. 1983: Public announcement of the Ordinance on Implementation and Consignment of Mass Energy Supply Project
- Dec. 1983: Consignment agreement for the Mass Energy Supply Project for Mok-dong (Consignee: Korea Energy Management Corporation)
- Mar. 1984: Commencement of design service contract
- Aug. 1984: Permission acquired for heat supply project
- Supply Target: 26,629 households in the new towns of Mok-dong and Sinjeong-dong
- Facility Scale: Heat transmission pipes (20 km), cogeneration boiler (1 unit of 100 tons/h and turbine/generator 21 MW), heating-only boilers (2 units of 140 tons/h, 2 units of 80 tons/h and 3 units of 10 tons/h)
- Project Period: Dec. 1983 - Dec. 1987
- Project Budget: KRW 36.199 billion
- Nov. 1984: Construction begins on waste incinerator (Completed on Dec. 31st, 1986)
- Jan. 1985: Construction begins on cogeneration plant (Completed on Dec. 31st, 1987)
- Oct. 1985: Construction begins on heat transmission facilities (Completed Nov. 30th, 1987)
- Nov. 1985: Start of the 1st phase heat supply (Mok-dong Apt. 1 District, 1,882 households)
- Aug. 1990: Confirmation of Mass Energy Supply Project for Gayang and Banghwa Apt. 1 District
- Supply Target: 24,314 households in Gayang and Banghwa Apt. 1 District

- Facility Scale (Linked to the existing Mok-dong Cogeneration Plant): heating-only boilers (2 units of 110 tons/h), heat transmission pipes (31.6 km), 1 booster pump site
- Project Period: Aug. 1990 - Nov. 30th, 1993
- Project Budget: KRW 30.603 billion
- Apr. 1993: Confirmation of Mass Energy Supply Project for Deungchon and Banghwa Apt. 2 District
- Supply Target: 14,365 households in Deungchong and Banghwa Apt. 2 District
- Facility Scale (Linked to the existing Mok-dong Cogeneration Plant): heating-only boiler (1 unit of 110 tons/h, heat transmission pipes (11.4 km)
- Project Period: Apr. 1993 - Jan. 10th, 1995
- Project Budget: KRW 8.961 billion

The Nowon Region Project - Process

- Oct. 1991: Service agreement for the Basic Plan for Mass Energy Supply Project in Nowon Region
- Use of incinerator heat from the Sanggye Resource Recovery Facility
- Jun. 1992: Confirmation of Mass Energy Supply Project for Nowon Region
- Supply Target: 104,968 households in Nowon-gu, Dobong-gu and Jungnang-gu
- Facility Scale: Cogeneration boiler (1 unit of 150 tons/h and turbine generator 37,000 kW), heating-only boilers (4 units of 150 tons/h), heat transmission pipes (80 km)
- Project Budget: KRW 80.760 billion
- Project Period: Jun. 1992 - Dec. 1996
- Jul. 1993: Permission for Mass Energy Project
- Dec. 1993: Construction begins on Nowon Cogeneration Plant
- Dec. 1993: Construction begins on installation of heat transmission pipes
- Dec. 1994: Heat supply begins (3,420 households in Gongneung 1 Land Development District)
- Dec. 1996: Completion of Nowon Cogeneration Plant
- Oct. 2009: Completion of the Fuel Cell (2.8 MW) Generation Plant in the Nowon Cogeneration Plant

<Figure 8> Status of Consignment for the Mass Energy Supply Project

- Dec. 20th, 1983 ~ Dec. 31st, 1998 (Consignor: Seoul Mayor / Consignee: Korea Energy Management Corporation)
- Jan. 1st, 1999 ~ Dec. 31st, 2001 (Consignor: Seoul Mayor / Consignee: Seoul Energy)
- Jan. 1st, 2002 ~ Present (Consignor: Seoul Mayor / Consignee: SH Corporation)

Dec. 31st, 2013

Classification	Gangseo Region (Mok-dong Cogeneration Plant)	Nowon Region (Nowon Cogeneration Plant)
Location (Site Area)	Mok-dong Seo-ro 20 (Mok-dong 900), Yangcheon-gu, Seoul (53,302.4 m ²)	99 Deongneung-ro 70 gil (Sanggye- dong), Nowon-gu, Seoul (24,356.7 m ²)
Service Area	9 <i>dong</i> in 3 <i>gu</i> -districts (Gangseo-gu, Yangcheon-gu, Guro-gu)	11 <i>dong</i> in 4 <i>gu</i> -districts (Nowon-gu, Dobong-gu, Jungnang-gu, Uijeongbu)
No. of Target Households	114,659 households (211 buildings)	127,545 households (47 buildings)
Facility Capacity	<ul style="list-style-type: none"> • Turbine Generator: 30.2MW • Cogeneration Boiler: 100 tons (1 Unit) • Cogeneration (low pressure) Boiler: 150 tons (1 Unit) • Heating-only Boilers: 770 tons (7 Units) • Heat Transmission Pipes: 88.4 km x 2 lines 	<ul style="list-style-type: none"> • Turbine Generator: 37MW • Cogeneration Boiler: 150 tons (1 Unit) • Heating-only Boilers: 600 tons (4 Units) • Heat Transmission Pipes: 85.2 km x 2 lines
Start of Heat	Nov. 20 th , 1985	Dec. 8 th , 1994

<Mok-dong Cogeneration Plant>



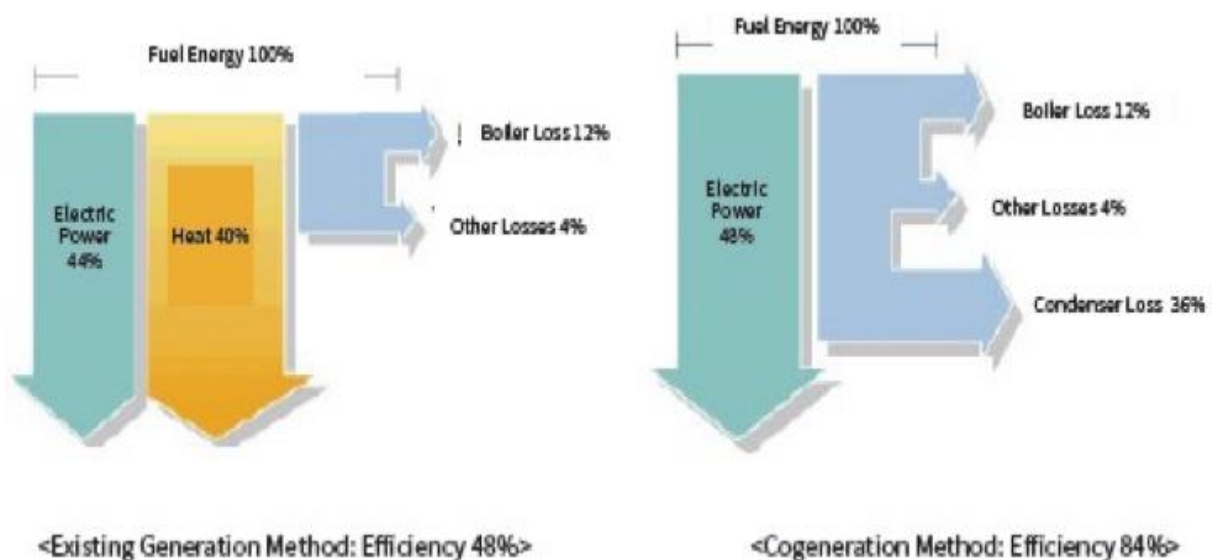
<Nowon Cogeneration Plant>



Project Effects

- Large reduction of energy consumption due to enhanced energy efficiency (20-30%)
- Reduction of sulfur oxide (SOx), nitrogen oxide (Nox) and fine dust emissions thanks to the improvement of the air from reduced fuel use and intensive environmental management
- Contribution to resolving power plant site problems and reducing the loss of transmitted power
 - Relaxation of peak load power in the summer through district heating
- Decreased oil dependency through fuel diversification and increased use of unused energy such as waste heat from resource recovery facilities and landfill gas

<Figure 9> Comparison of Efficiency between the Existing Generation Method & Cogeneration Method

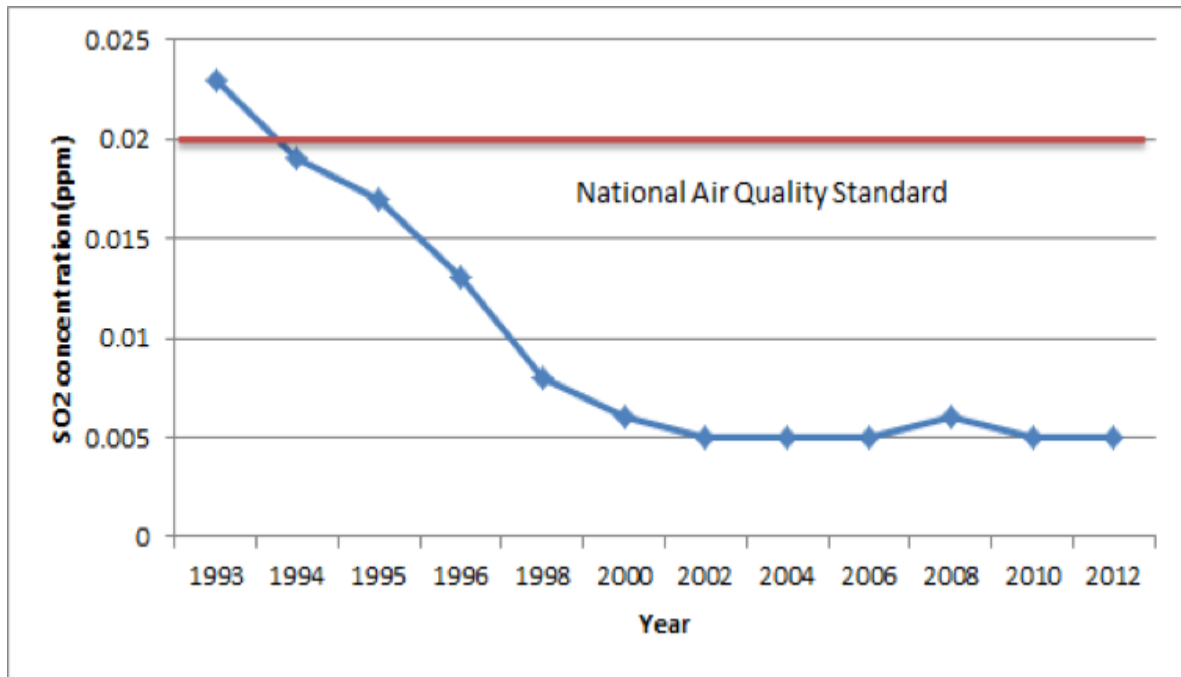


Conclusion & Implications

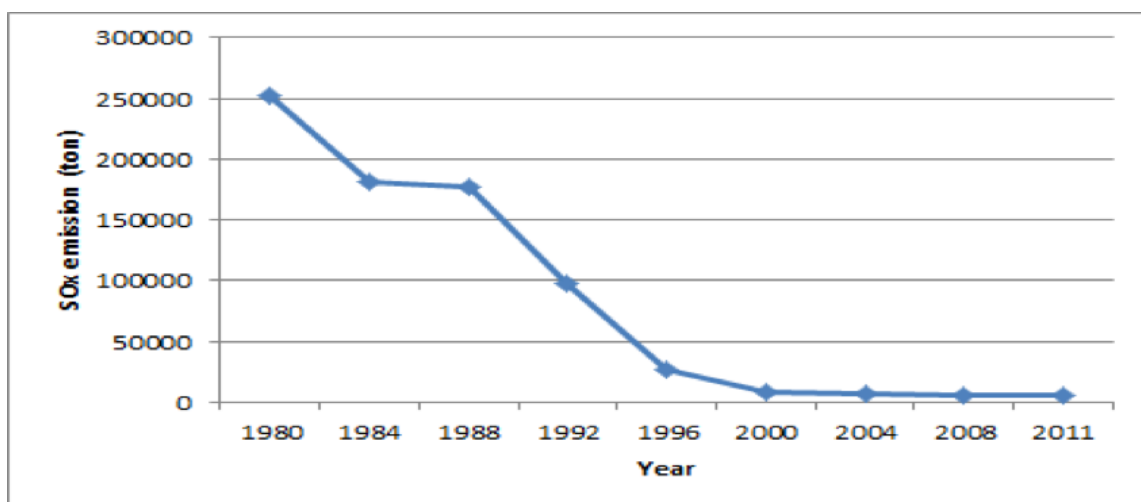
Project Outcomes

Thanks to the various policies and projects facilitated by the SMG and the central government to provide fuel with low emissions, the SO₂ concentration in Seoul has remarkably decreased, and has been lower than the national environmental standards since 1994, remaining at a very low level of around 0.005ppm since 2000.

<Figure 10> Change in SO₂ Concentrations in Seoul



<Figure 11> Change in SO_x Emissions in Seoul



SO_x emissions (tons)

Future Tasks

SO₂, one of the main causes of air contamination in Seoul until the early 1990s, has dramatically decreased, and in fact is no longer a cause for concern, thanks to Seoul's policy to supply a variety of clean fuels to a growing region. However, NO₂, fine dust, etc. generated from burning of fossil fuels like gasoline and diesel remain major air pollutants in Seoul. In addition, LNG, previously regarded as a clean fuel, is not free from climate change issues in terms of air quality, as it emits greenhouse gases such as carbon dioxide.

To address these issues, Seoul has planned and implemented ways to expand the use of new and renewable energy, including geothermal heat, sunlight, solar heat and fuel cells. Specifically, Seoul has focused on expansion of facilities related to solar power, fuel cells and geothermal heat and on heat generation from waste. As a result, the total production of new and renewable energy in Seoul has increased nearly three times from 78,000 TOE in 2003 to 233,000 TOE in 2012. Nonetheless, the amount of new and renewable energy produced in Seoul is just 2.6% of nationwide production and makes up only 1.5% of total energy consumption in Seoul. As the capital facilitates introduction of solar power facilities as a part of its policy of "One Less Nuclear Plant," the importance of solar generation is expected to increase significantly.

References

- The Seoul Metropolitan Government, White Paper on Energy, 2013 and 2014
- The Seoul Metropolitan Government, White Paper on Energy, 2011 and 2012
- The Seoul Metropolitan Government, White Paper on Energy, 2007 and 2008
- The Seoul Metropolitan Government, White Paper on Energy, 2002 and 2003
- The Seoul Metropolitan Government, Analysis of Air Pollution, 1995 and 1996
- The Seoul Metropolitan Government, Environment of Seoul in 2000, White Paper on Environment, 2000
- The Seoul Metropolitan Government, Evaluation Report on Seoul Air Quality, 2012 and 2013
- Ministry of Environment, 2004, 2005 Annual Report on Air Environment