

Korea Environmental Policy Bulletin

Natural Gas Vehicles Promotion Program in Urban Areas

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Summary

With the increase of motor vehicles on the road in Korea, transportation has become a significant source of air pollution. In particular, diesel vehicles emit large amounts of particulate matter (PM₁₀) and nitrogen oxide (NOx), which is the reason why diesel buses are being replaced by NGVs (natural gas vehicles). Pilot projects for NGVs started in 1998, and as of December 2007, 15,097 natural gas buses and 289 natural gas garbage trucks have been introduced. Ministry of Environment plans to replace 23,000 diesel vehicles with NGVs and install 400 natural gas stations by 2010. In order to increase the demand for natural gas buses, financial incentives and tax benefits are being offered for the purchase of the vehicles, or for the installation and operation of natural gas stations. The benefit of this program is estimated to reach 1.57 trillion Korean won in environmental improvement effect and 1.22 trillion Korean won in net economic benefit. Ministry of Environment is making an effort to share the experiences of its natural gas vehicles promotion program and

cooperate with other countries in introducing NGVs and relevant equipments. A General Assembly and Exhibitions for the 3rd ANGVA and IANGV will be held in the city of Donghae in 2009 and the city of Chuncheon in 2012, respectively. The Green Highway Project II is

underway in commemoration of the 2009 ANGVA General Assembly and Exhibitions. Ministry of Environment will organize a demonstration project and prepare a mid- and long-term plan for introducing LNG vehicles in 2009.

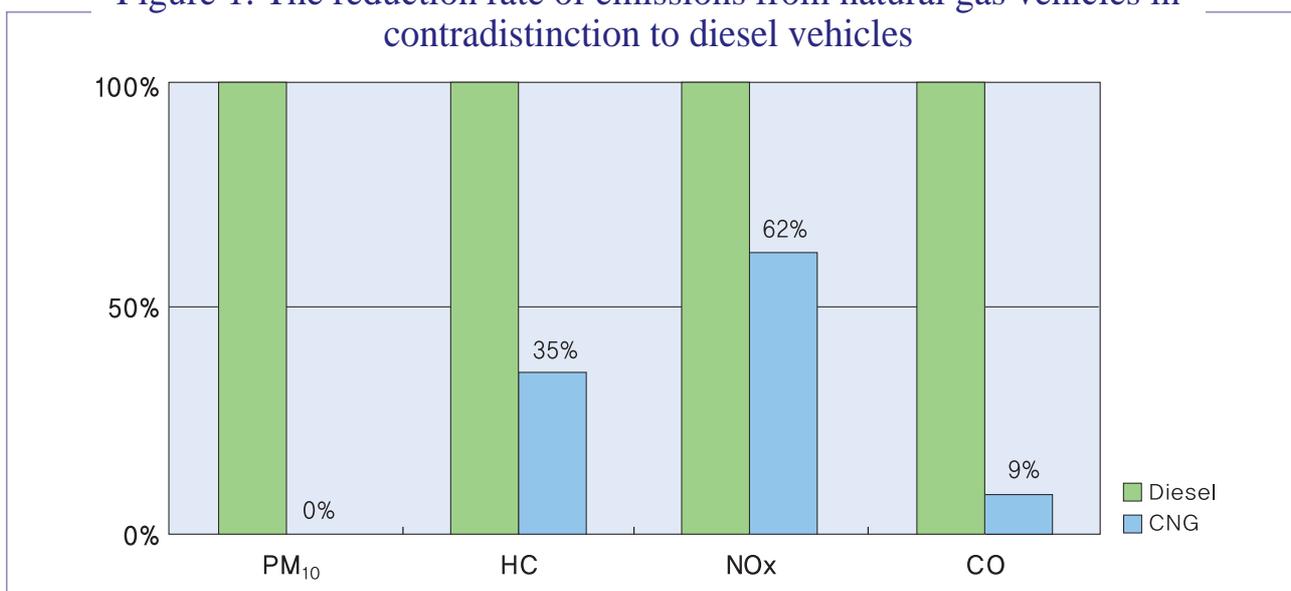
I. Background of the Natural Gas Vehicles Promotion Program

The world is suffering from serious air pollution because of the increase of automobiles and the exhaust emissions they emit. Mobile sources on the road are becoming increasingly responsible for air pollution and cause more than 65% of particulate matter (PM₁₀), and 51% of nitrogen oxide (NO_x) in the Seoul metropolitan area. Diesel motor vehicles are considered to be the primary cause of air pollution. Although they represent only 26% of total motor vehicles on the road, they account for 100% of particulate matter and 75% of NO_x in the

emissions from mobile sources on the road.

Therefore, to reduce the emissions from motor vehicles, Natural Gas Vehicles (NGVs) are being introduced to replace diesel vehicles. This will reduce air pollutants such as particulate matter (see Figure 1). Recently, compressed natural gas (CNG) vehicles, liquefied natural gas (LNG) vehicles, and hybrid electric vehicles that run on gasoline and electricity, or natural gas and electricity have been introduced in order to save energy and mitigate pollution in urban areas.

Figure 1. The reduction rate of emissions from natural gas vehicles in contradistinction to diesel vehicles



Source : Environmental Transportation Division, Ministry of Environment, The presentation material of “the supply policy of natural gas vehicles”, 2007.

Natural gas is an inflammable gas mixture of lower molecular weight hydrocarbons that is extracted from underground, and is mainly composed of methane (CH₄). Unlike oil reserves which are concentrated in the Middle East, natural gas resources are distributed throughout the world, and they are estimated to be sufficient in meeting demand for a long time in a stable way. Therefore natural gas is considered a good substitute for petroleum-based fuels.

Natural gas combustion emits very little pollutants due to the removal of impurities such as particulate matter and sulfur during the liquefying phase. In the case of leaks, natural gas diffuses in the air very quickly because its density (0.6) is lighter than air. The gas is considered to be relatively safe to use because the combustion limit¹⁾ is as high as 4.5% and ignition temperatures are high enough.

Depending on their fuel storage system, there are three types of natural gas vehicles. Compressed natural gas (CNG) vehicles use compressed (200 bar) gas in high-pressure containers, and liquefied natural gas (LNG) vehicles use low temperature (-162°C) liquefied gas in vacuum insulated containers. Adsorption natural gas (ANG) vehicles use adsorbed lower pressure (1/3-1/5 of CNG) gas to adsorbents such as activated carbon.

The CNG variant is currently the most popular, but LNG vehicles have recently been developed and commercialized. Though CNG vehicles have 1/4 lower MPG than gasoline vehicles due to the low energy density of CNG, LNG vehicles have three times more MPG than CNG.

In addition to fuel storage systems, there are also three types of natural gas combustion modes. Bi-fuel vehicles use both gasoline and natural gas. Dual fuel vehicles mainly use natural gas, and diesel is also used as auxiliary fuel for ignition. Dedicated natural gas vehicles use only natural gas and utilize the spark ignition method. The bi-fuel system is primarily applied to small gasoline vehicles, and the dual fuel system is mainly used for medium/large diesel vehicles. Since the late 1990s, a more efficient, less-polluting, and optimized dedicated system has been introduced and commercialized.

The development of advanced natural gas engines and other new technologies are crucial to meet strengthening emission standards across the world and also to limit CO₂ emissions to tackle climate change.

Domestic CNG vehicles were developed by modifying 6-cylinder diesel engines in order to spark ignition (Lean-burn engines). Natural gas fueled buses are the same as diesel buses in basic structure, but different in fuel supply system. High-pressure (20 Mpa) natural gas is stored in the vehicle's high-pressure gas container through a dispenser, and the amount of stored fuel can be monitored by a barometer at the dashboard. In the case of extremely high pressure, a safety system will work to release the pressure through a safety valve.

After the compressed gas passes through its supply pipeline from the container, the pressure of the gas is adjusted by a reduction valve, and the gas is fed into the engine after having been mixed with air.

II. Natural Gas Vehicles Promotion Program

1. Present status and goal

The government of Korea developed natural gas

vehicles between 1991 and 1997 as part of the "G-7 Project" and started test operations of four urban buses in two cities (Incheon and Ansan) in July

¹⁾ Combustion limit : the minimum fuel concentration to combust in the air

1998. Between June 2000 and 2002, 5,000 diesel buses in Seoul, six metropolitan cities, and the city of Suwon were replaced by NGVs.

The central government and local municipalities have been actively involved in replacing diesel

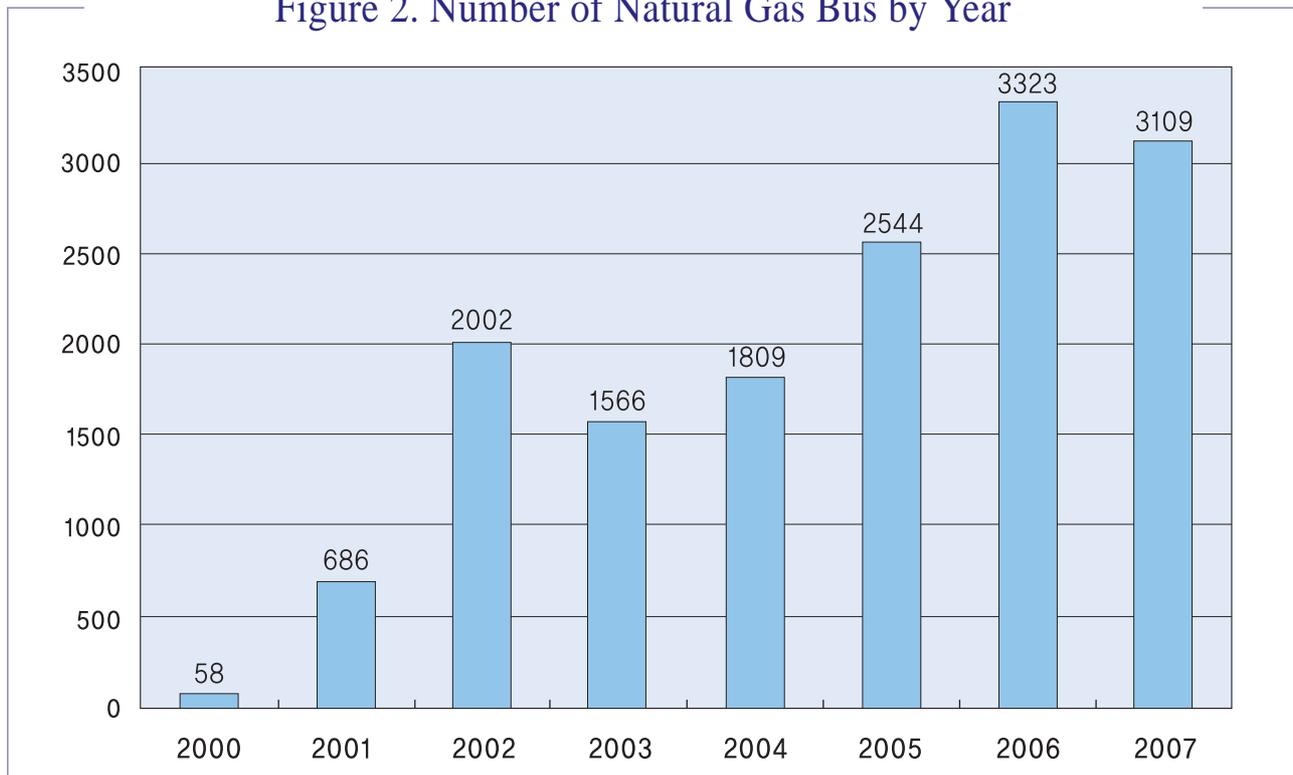
buses with natural gas buses in urban areas. As of December 2007, 15,097 natural gas buses and 289 natural gas garbage trucks were introduced and 87 natural gas stations were constructed.

Table 1. Number of natural gas buses and construction of natural gas stations and machines by year

	2000	2001	2002	2003	2004	2005	2006	2007	Total
Natural gas bus	58	686	2,002	1,566	1,809	2,544	3,323	3,109	15,097
Gas station (machine)	4 (24)	24 (55)	8 (27)	7 (27)	20 (54)	14 (42)	1 (14)	9 (21)	87 (247)

Note : Only fixed gas stations are calculated.

Figure 2. Number of Natural Gas Bus by Year



Source : Ministry of Environment, The updated data based on “the study on the effect evaluation of NGVs promotion program and its promotion alternatives”, April, 2007.

In areas where it is difficult to install natural gas supply pipelines, 85 gas-charging vehicles are running to supply natural gas (in December 2007), and gas stations in Dae-jon, Gim-hae, Pyeong-taek, and Go-yang are in operation as the mother stations

to supply natural gas to gas-charging vehicles.

Ministry of Environment plans to replace 23,000 diesel motor vehicles in areas where city gas is being supplied and to construct 440 gas stations by 2010.

2. Institutional Arrangement of NGVs Promotion Program

Over the past 7 years, the central government has been promoting financial aid policies such as tax cuts to stimulate the supply of natural gas vehicles, and revised related laws in order to ease regulations

on gas station construction.

The government provides various benefits, such as grants for the purchase of vehicles, loans, and financial support for the construction and operation of natural gas stations, and tax cuts to promote the introduction of natural gas buses.

Table 2. Promotion Policies for the Purchase and Operation of NGVs

Date	Legal Arrangement
April 1999	Establishment of legal basis for natural gas supply (Amendment of the Clean Air Conservation Act)
August 1999	VAT and acquisition tax exemptions for natural gas buses (Amendment of the Restriction of Special Taxation Act)
January 2000	Grant-in-aid for the natural gas vehicle promotion program (Establishment of the guideline on grant-in-aid for the natural gas vehicles promotion program)
2001-2006	Exemption of custom duties for major imported parts of buses (Amendment of the enforcement regulations of the Customs Act)
December 2002	Permission for gas station construction, excluding residential areas (Enactment of the National Land Planning and Utilization Act)
December 2002	Mandatory non-/low-emission vehicle purchasing (Amendment of the Clean Air Conservation Act)
March 2003	Expansion of grants for garbage trucks and town buses in limited local areas, etc. (Amendment of the grant-in-aid service processing guideline)
December 2003	Mandatory low emission vehicle purchasing (Enactment of the Special Act on Metropolitan Air Quality Improvement)
2004-2006	Provision of grants for airport limousines, commuter buses, school buses, and intercity buses

Source : Ministry of Environment, The study on the effect evaluation of natural gas vehicle promotion program and its promotion alternatives, April, 2007.

First, the price differential between natural gas and diesel vehicles is covered by the grant. In the beginning, only inner city buses were eligible for the grant. However, the grant became available for

garbage trucks, airport limousines, intercity buses, and school buses. Prime rate loans are also applied for the construction of natural gas stations.

Table 3. Grant-in-Aid and Loans for the Purchase of NGVs

	Grant & Loan Amount
Purchase of CNG Bus	22.5 million Korean won/bus
Purchase of CNG Garbage Truck	· 5 ton: 30 million Korean won/truck · 11 ton: 60 million Korean won/truck
CNG Station Construction	700 million Korean won/gas filling machine (loan)

Second, the government partly supports the fuel expenses and operation costs for natural gas buses and gas stations.

Table 4. Grant-in-Aid Policies for NGVs and Gas Station

	Detailed Measures
Fuel Cost	Financial assistance to offset price differentials between natural gas and diesel at a maximum of 115 Korea won/liter
Empty Running Cost	In the case of more than 4 km distance from the nearest gas station, grants for empty running cost of up to 22 km
Gas Station Operation Expense	Grants for the loss of the services of less than 31 vehicles in a station with the service capacity of 100 vehicles per day
Mobile Filling Cost	Financial support for fuel filling cost difference between mobile gas stations and fixed gas stations

Third, VAT, acquisition tax, and customs duty reductions are provided for purchasing NGVs. They are also exempted from charge for Environmental Improvement on diesel motor vehicles. The corporate tax cuts and lower industrial electricity fees are also applied for natural gas stations.

Environmental damage charges on building parking lots and gas stations in limited development districts can be reduced by 10-20% by amending the enforcement decrees of the "Act on special Measures for Designation and Management of Areas of Restricted Development".

Table 5. Tax & Charge Reduction & Exemption Policies

	Amount of Tax Reduction
VAT & Acquisition tax	VAT: 9,000,000 Korean won/vehicle Acquisition tax: 3,000,000 Korean won/vehicle
Charge for Environmental Improvement	1,660,000 Korean won/year/vehicle
Corporate Tax	15,000,000 Korean won/gas station
Customs	Application of Reduced rates for the import of major parts of NGVs such as cylinders

In addition, to encourage the construction of natural gas stations, related regulations such as

facility standards on safety distance and guards have been amended.

Table 6. Regulation Amendment on Standards of Natural Gas Station Construction

Date	Regulation Amendment
April 1999	Permission of gas station construction in inner city bus garages (Downtown areas) (Amendment of the enforcement decrees of the Building Act)
January 2000	Relaxation of safety distance from gas station border; from 10m to 5m (Amendment of the related notifications of Ministry of Commerce, Industry and Energy)
March 2000	Permission of gas station construction in public parking lots under a local government's ordinance (Amendment of the Seoul city's municipal ordinance)
July 2000	Permission of gas station construction in green belt zones (Amendment of the enforcement decrees of the Act on Special Measures for Designation and Management of Areas of Restricted Development)
June 2001	Safety guard employment obligation eased from 4 persons to 3 persons (Amendment of the enforcement decrees of the High-Pressure Gas Safety Control Act)

April 2001	Relaxation of safety distance of protection wall from residential zones: from 50m to 25m (Amendment of the Regulations on Standards, etc. of Housing Construction)
September 2001	Reduction of environment damage charges on building parking lots and gas stations in development restricted zones to 10-20% (Amendment of the enforcement decrees of the Act on Designation and Management of Areas of Restricted Development)
September 2002	Permission of gas station construction in areas with distribution facilities (Amendment of the municipal rule on standards of facilities for urban planning)

Source: Ministry of Environment, The study on the effect evaluation of natural gas vehicles promotion program and its promotion alternatives, April, 2007.

Standards have been set on the manufacture and inspection of natural gas containers used for NGVs. There are two major gas container inspection standards at the domestic level: one developed by the Korea Gas Safety Corporation, and the other by the Korean Standards Association. These two standards on steel containers without joints are in force.

3. Environmental and Economic Effectiveness

Comparisons of air pollutant emissions from natural gas buses and diesel buses showed that emissions per horsepower (g/kWh) of CO, NMHC, NO_x, and PM₁₀ from natural gas buses are 8.89~10%, 27.7~43.1%, 49.2~74.8%, and 0% respectively of those of diesel buses.

Table 7. Comparison of Emission Standards and Emission Test Results per Power Output

		Emission Test Results (g/kwh)				Year
		CO	NMHC	NO _x	PM ₁₀	
CNG bus	Emission standard	0.400	0.200	3.500	–	2002
	Company A	0.105	0.121	3.190	–	2006
	Company B	0.007	0.109	2.277	–	
Diesel bus	Emission standard	2.100	0.660	5.000	0.100	2002
	Company A	1.181	0.437	4.267	0.098	2006
	Company B	0.070	0.253	4.626	0.068	

Source : Ministry of Environment, The study on the effect evaluation of natural gas vehicles promotion program and its promotion alternatives, April, 2007.

The environmental impacts of NGVs were evaluated by estimating the amount of air pollutant emissions reduced by the introduction of natural gas buses. Air pollutant reduction was estimated through the quantitative analysis of emissions by applying an emission coefficient per kilometer traveled (g/km).

Applying the pollutant-specific marginal social costs of the EC to the air pollutant reduction benefits of natural gas buses showed that the environmental improvement benefits of the natural gas buses introduced until 2006 would equal 1,560,811 million Korean won.

Table 8. Estimated Environmental Benefits from Natural Gas Bus Promotion by Pollutants

(Unit: million Korean won)

Pollutant	PM ₁₀	NO _x	HC	CO	Total
Environmental Benefit	1,280,782	327,155	-83,604	36,478	1,560,811

Note : All Natural Gas buses are regarded to have 10-year durability

Source : Ministry of Environment, The study on the effect evaluation of natural gas vehicles promotion program and its promotion alternatives, April, 2007.

The net economic benefit of natural gas buses promotion program was evaluated by the cost-benefit analysis on the expenses paid by the central governments and local municipalities for the introduction of those vehicles and their environmental improvement benefits applying the

EC marginal social costs of air pollutants, which is suitable to the situation in Korea. The results showed that the net economic benefits of natural gas buses introduced until 2006 were about 1,221,000 million Korean won, which was adjusted for the price levels in 2000.

Table 9. Net Economic Benefits from the Natural Gas Bus Promotion

(Unit: million Korean won)

	2000	2001	2002	2003	2004	2005	2006	total	
Environment improvement benefit (A)	6,086	86,999	247,502	199,730	267,968	328,930	423,596	1,560,811	
Cost (B)	Grant-in-aid for vehicles	1,305	15,435	45,045	35,235	40,703	57,240	74,768	269,730
	Loans for gas stations	583	1,176	6,320	2,861	2,965	2,194	2,113	18,212
	Sales and registration tax reductions and exemptions	53	631	1,807	1,441	1,664	2,340	3,057	11,029
	Exemption from environmental improvement charges	197	2,332	6,807	5,324	6,151	8,650	11,298	40,759
	Subtotal	2,139	19,575	60,014	44,861	51,482	70,424	91,236	339,730
Net Economic Benefits (A-B)	3,947	67,424	187,488	154,869	216,486	258,506	332,360	1,221,080	

Note : 1) Acquisition and registration tax benefits : 920,000 Korean won/vehicle

2) Exemption from environmental improvement charges : 3.4million Korean won/10 years/ vehicle

Source : Ministry of Environment, The study on the effect evaluation of natural gas vehicles promotion program and its promotion alternatives, April, 2007.

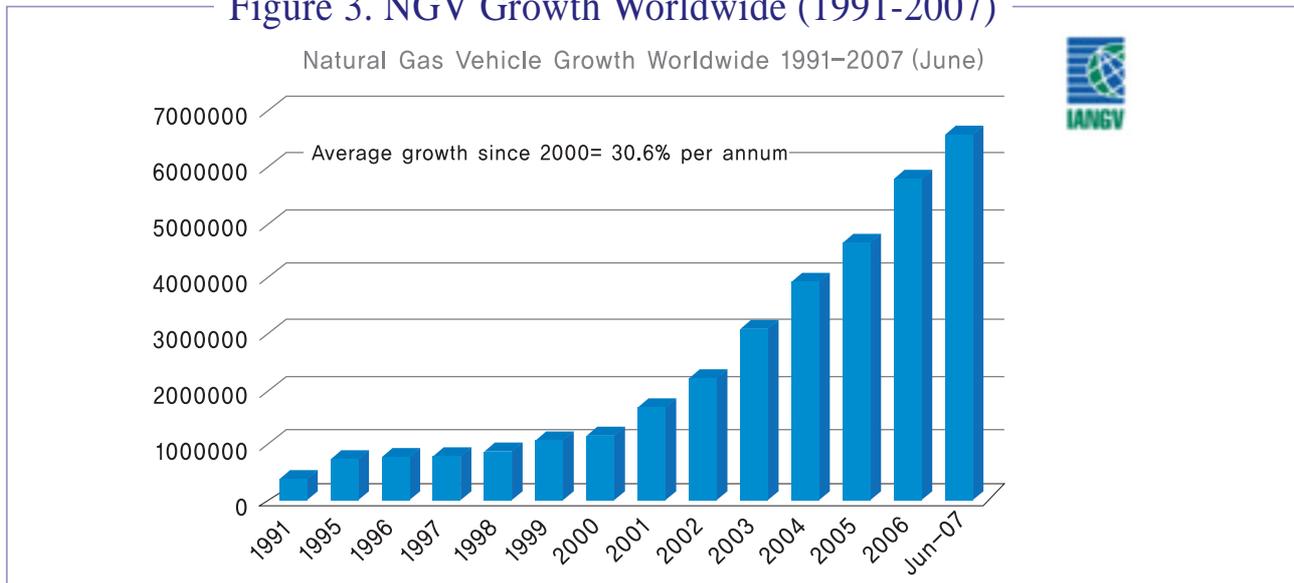
III. International Cooperation for NGVs Promotion

Until the 1980s, medium and small sized natural gas vehicles were introduced mostly in natural gas producing countries. However, in an effort to reduce air pollution in big cities, many countries around the world have recently developed NGV technologies and increased the use of large NGVs such as buses. As of June 2007, 6,945,595 natural gas vehicles

were introduced and 10,695 fixed gas stations were in operation throughout the world.

As emission standards for vehicles are being strengthened worldwide, diesel vehicles are being replaced by eco-friendly cars which emit far less pollution.

Figure 3. NGV Growth Worldwide (1991-2007)



Source : <http://www.iangv.org/tools-resources/statistics.html>(June, 2008)

Moreover, more countries focus on developing technologies to reduce automobile emissions. Since 2000, the Ministry of Environment has introduced NGVs in order to reduce air pollution and has made a lot of efforts to share its policies and promote technology cooperation with Southeast Asian countries and countries in other regions.

The Korean government and relevant industry organizations launched road shows in Southeast Asian countries including Indonesia, Malaysia, and Vietnam in June 2006. During the road show events, Korean NGV promotion policies, economic and environmental advantages of NGVs, and the technology of NGVs and natural gas stations were introduced to government officials, and the potentials for cooperation on NGVs were discussed between Korea and other countries as well. As the result of activities, a project to share NGV promotion policy and promote technological cooperation was adopted as a Korea-ASEANFTA economic cooperation project in November 2006. An NGV

forum was held in Korea for ASEAN government officials and representatives of relevant industries as a follow-up to the Korean-ASEAN FTA economic cooperation in 2008.

NGV policy and potential cooperation were discussed during a meeting between Korean and Egyptian Environment Ministers as well. In addition, Ministry of Environment introduced its policies on natural gas vehicles promotion during the ANGVA²⁾ general assembly and exhibition held in May 2005, and the IANGV³⁾ general assembly and exhibition held in Cairo in 2006. It also gave a presentation on the Korean NGVs promotion policies and advanced technologies of NGVs and natural gas stations at the ANGVA School, Kasetsart University in Thailand in March 2007. The general assemblies and exhibitions of the 3rd ANGVA and IANGV will be held in the city of Donghae and the city of Chuncheon in Korea in 2009 and 2012, respectively, by extension of those cooperation efforts.

²⁾ ANGVA (Asia-Pacific Natural Gas Vehicle Association) was established in 2003. It is composed of 50 member companies in 22 countries.

³⁾ IANGV (International Association for National Gas Vehicles) which was established in 1986 to provide an international forum, foster NGV industry, and contribute to policy-making. It has more than 600 corporate members worldwide.

Table 10. Participation and hosting of general assemblies

Classification	Date	Place
2005 ANGVA general assembly and exhibition (participate)	Jul.26 to Jul.29,2005	Malaysia (Kuala Lumpur)
2006 IANGV general assembly and exhibition (participate)	Nov.09 to Nov.07,2006	Egypt (Cairo)
2007 ANGVA general assembly and exhibition (participate)	Nov.26 to Dec.01,2007	Thailand (Bangkok)
2008 IANGV general assembly and exhibition (participate)	Jun.03 to Jun.05,2008	Brazil (Rio de Janeiro)
2009 ANGVA general assembly and exhibition (host)	Oct.26 to Oct.30,2009	Korea (Donghae)
2012 IANGV general assembly and exhibition (host)	Oct.14 to Oct.19,2012	Korea (Chuncheon)

Source : Korea Association for Natural Gas Vehicles (KANCV)

In November 2007, Korean representatives also participated in the Green Highways Project which was organized on the occasion of the 2nd ANGVA general assembly and exhibition in Bangkok, Thailand. Natural gas vehicles were driven about 10,000 km through five countries for drawing public attention to the necessity of natural gas vehicles promotion and gas station construction. It also highlighted the various

advantages of NGVs and the need to coordinate different domestic regulations of each participating country on natural gas vehicles. A second Green Highway Project, under which NGVs will travel more than 10,000 km through five Asia-Pacific countries and finish their journey in the city of Donghae, Korea, will be organized in commemoration of the 2009 ANGVA general assembly and exhibition.

Figure 4. Green Highway Route



Source: ANGVA, Green Highways Project

Trade activities are one important part of international cooperation. Trade volume of NGVs between Korea and other countries, mainly Malaysia, Indonesia, Thailand, Pakistan, and

Bangladesh, is increasing rapidly, reaching 30 million dollars in 2006 and 146 million dollars in 2007. Main trade items are gas containers, compressors, natural gas buses, and mobile recharging vehicles.

IV. Comprehensive Evaluation and Future Plans

Many countries around the world are introducing NGVs as a major measure to reduce air pollution in big cities. To promote the introduction of NGVs, countries including USA, Canada, Japan, and European countries are affording grant-in-aid and tax benefits for NGVs and gas stations through related laws and programs.

In Korea, 15,097 natural gas buses and 289 natural gas garbage trucks were in use as of December 2007 through the policy of replacing diesel motor vehicles with NGVs since 2000, and this has resulted in economic and environmental benefits through the emission reduction of air pollutants.

The recent rise of oil prices has affected the world, especially distribution industry. As a result, more natural gas vehicles are expected to be used as they reduce harmful emissions and contribute to diversifying energy sources.

The Korean Ministry of Environment plans to phase in Liquefied Natural Gas (LNG) vehicles following Compressed Natural Gas (CNG) vehicles. LNG vehicles have a better fuel economy, longer mileage, and lower maintenance costs than CNG vehicles.

In the beginning, some airport limousine buses, which mostly run long distances, are going to be replaced with LNG vehicles. LNG vehicles will be phased in while maintaining the complementary relationship with CNG vehicles.

During the first stage of the project (from 2008 to 2009), the Ministry will consult with relevant agencies on various issues such as basic research on the introduction of LNG vehicles and the construction of gas stations, and find ways to secure financial resources. The funds will be used, for example, as grant-in-aid for the purchase of LNG vehicles because they are more expensive than diesel vehicles due to the low-temperature fuel container installed.

Based on the first stage of the project, Ministry of Environment will organize a demonstration project and prepare a mid- and long-term plan for LNG vehicles in 2009. The third stage of the project will be carried out by expanding NGVs in a full-fledged manner. However, there are some issues to be resolved such as building infrastructure for LNG stations and providing nation-wide financial support.

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