Challenges for Environmentally Sustainable Transport in Seoul

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<TABLE OF CONTENTS>

I. INTRODUCTION

Throughout the 1990s, Seoul faced demographic changes that created new transportation demands that the city could no longer respond to. These changes in transportation patterns increased private car use, unorganized bus transportation routes, and travel across longer distances. Buses were once the most widely used mode of transportation, but demographic changes devastated the service. The transportation system was in chaos and urgently needed reform. The traditional method of piecemeal approaches for the bus system reform no longer worked, as evident in the mid-1990s in Korea. Innovative and intensive reorganization strategies, rather than fragmented approaches, were necessary.

The Public Transportation Reform is a major step towards sustainable mobility. The key of its success lies in its integrated approach combining organizational measures, innovative technology, infrastructure development, and transport operation. Seoul is one of the rare cities to have implemented such comprehensive reform, in such a short period of time, and working simultaneously

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at different levels. Measures included, among others:

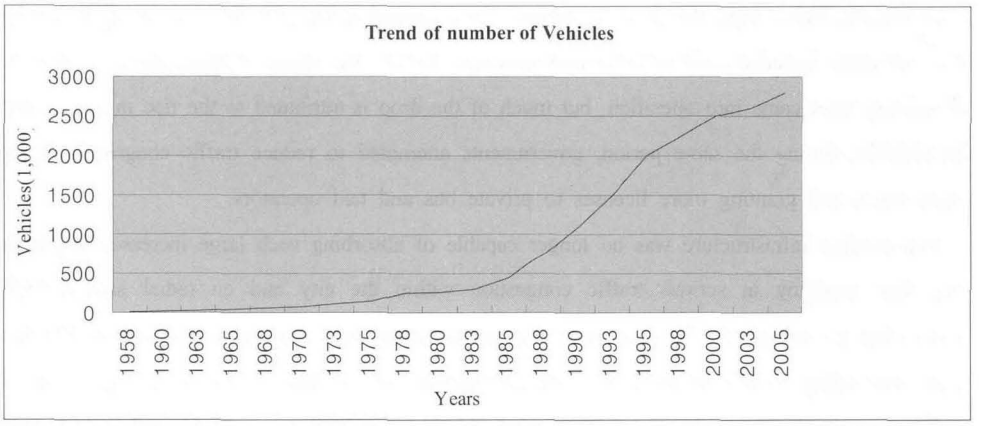
* construction of exclusive median bus lanes
* reorganisation of the bus network (categorization of bus lines into express, trunk, feeder, and local lines)
* reform of the institutional framework (contract provision of bus operators and a semi-public operation system)
* integrated multimodal electronic fare system (T-Money)
* integrated transport operation and information service (TOPIS)
* Compressed natural gas (CNG) buses
* car traffic management and enforcement of illegal parking

The reform has generated many benefits, including greater operational efficiency through better alignment of transport capacities and demand. In addition, the launch of the integrated fare system decreased overall public transport deficiencies and led to a growing number of passengers. This in turn led to increased revenue collection by transport operators; decreased need for government subsidies; improved traffic conditions for buses; improved decision-making processes; and greater transparency between operators and the Seoul Metropolitan Government.

This paper reviews how the bus transport reform in Seoul came together at many levels through the establishment of a new institutional and regulatory framework, the restructuring of bus service operations and management, and the alignment of investment programs to environmental concerns, while ensuring greater quality of services for consumers. Such integration and political leadership are the main highlights of this case study.

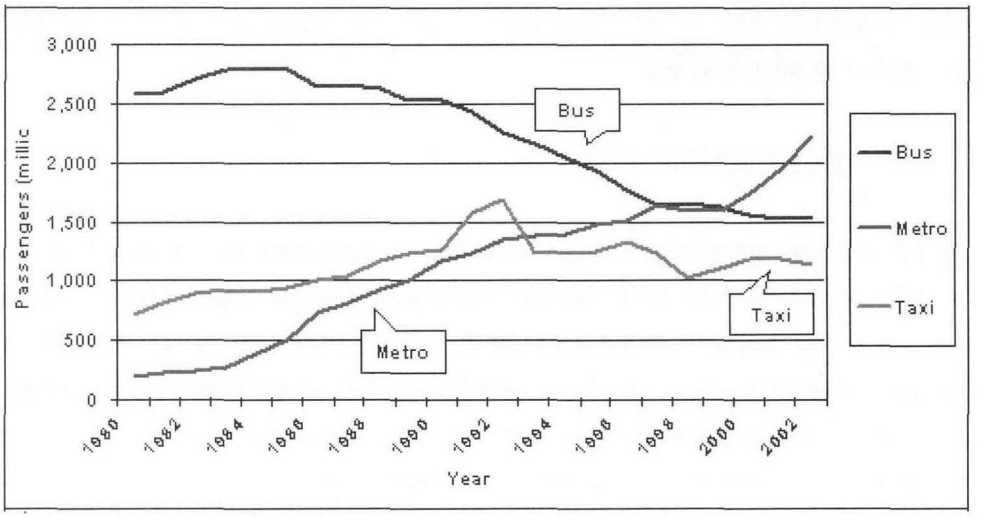
II .OVERVIEW OF TRANSPORTATION IN SEOUL

In the early 1950s, Seoul began to reform its urban transportation system in response to rapid demographic changes. Since then, Seoul has experienced population growth of at least four-fold within 50 years, and real income growth of at least 40-fold. Such dramatic changes led to land scarcity, rising housing prices, and traffic congestion in the capital. As a result, overcrowding forced migration into the surrounding suburbs where more than 12 million people now reside. The existing transportation infrastructure could no longer sustain the changes in transportation patterns, which have shown an increase in the average length of trips and the number of daily trips per person. The total



Source: Seoul Metropolitan Government and Seoul Development Institute

Figure 1. Number of Total Registered Vehicles



Sources: Ministry of Construction and Transportation and Korea Transportation Database

Figure 2. Change of Transportation Mode Share in Seoul (1980~2002)

number of daily trips for populations in the outer portions of suburban areas increased five times, from 5.7 million to 29.6 million between 1970 and 2002. A continuously growing economy ensures additional growth in the travel demands concentrated in these areas.

Private transportation quickly gained popularity as a means of traveling throughout the 1980s and 1990s, while the buses and taxis were largely disregarded. The rise in the number of passenger cars contributed the most to the increase in travel and total number of automobiles registered. By 2003, 21.5% of the population owned cars, jumping from only 0.2% in 1973.

Previously, buses were the primary means of transportation for over 80% of the daily commutes; the remainder included taxis (17.6%) and subways (1.1%). The share of buses began to fall sharply as subway lines came into operation, but much of the drop is attributed to the rise in private car use. In addition, during the same period, governments attempted to reduce traffic congestion by adding more buses and granting more licenses to private bus and taxi operators.

The existing infrastructure was no longer capable of absorbing such large increases in private car use, thus resulting in serious traffic congestion within the city and on radial arterial highways connecting the suburbs to the city center. Congestion costs were estimated to exceed US$8 billion a year, amounting to 4% of GDP by 2003. Increased car use has also caused high levels of air pollution, noise, traffic accidents, and excessive use of scarce land for roadways and parking facilities.

To deal with such problems, the Seoul Metropolitan Government centered its efforts on expanding Seoul's transportation network. This has been implemented in three stages: (i) development of a mass transit system from 1950 to 1980, (ii) restructuring of the bus system, and (iii) implementation of a new strategy in urban land use.

III. BUS SYSTEM REFORM

Prior to the bus system reform, buses were unable to compete with other modes of transportation. In 2000, bus reform plans came underway. The objectives of the reform were to redesign the provision of bus transport services within the Seoul Metropolitan area in light of environmental concerns, increasing passenger satisfaction, and achieving financial sustainability in the industry.

The determinants of change can be divided into external and internal drivers. The external factors are related to socio-economic and political aspects. The internal factors, on the other hand, are associated with the lack of standards and inefficient operators. Addressing these factors was crucial for the viability of the bus system.

1. Main Targets of Bus System Reform

Seoul's bus renovation project was planned in response to consumers' needs and expectations in terms of urban mobility, rapid urbanization of the metropolitan area, and environmental concerns. The key to solving traffic congestion and maintaining a sustainable transportation system is simultaneously improving public transportation while restricting use of private passenger cars. The aim of Seoul's bus renovation project was to revitalize the bus system through improving the regulation and operation of bus services. Reform introduced new forms of governance in the bus transport industry. Additionally,

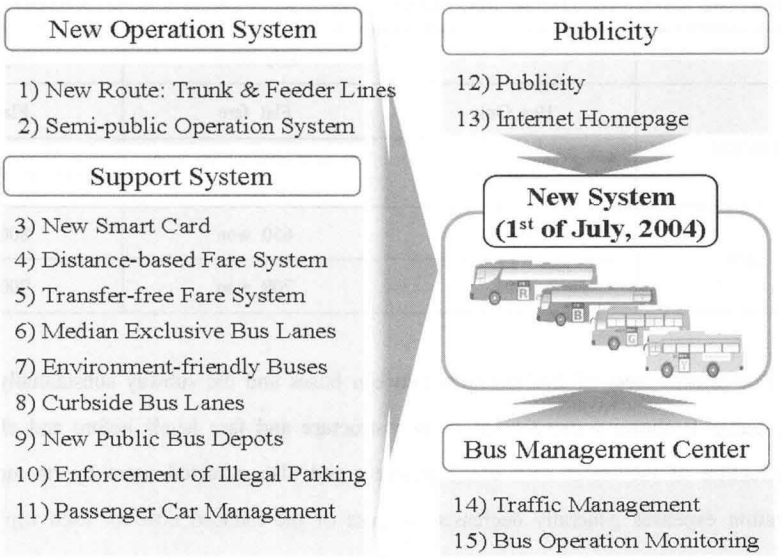


Figure 3. Public Transport Reform in Seoul

the reform also introduced new monitoring methods, reorganized route networks, created median lanes, improved the quality of business, and introduced a new incentives framework for bus drivers and operators. To achieve this aim, several projects were prepared and implemented. All of these projects, discussed in following sections, were integrated and implemented as packages in order to effectively address the complex issues faced by the bus transport industry in Seoul.

2. New Fare System

The new system unified and coordinated the fare structure to integrate both bus and rail services. The previous fare system resulted in bus riders traveling shorter distances to pay more because buses charged a single fare. The new fare system varies by mode of transportation and total distance traveled. For passengers transferring out of Seoul, the fare is charged based only on the total distance traveled and not on the transportation mode used. Within Seoul, the single fare for bus service starts at 800 Korean won (approximately 0.8USD) for the first 10 kilometers (km), and increases by 100 won for each additional five km. The base fare also includes up to four free transfers to both other bus lines and the subway. Users have the option of paying with a smart card or with cash, but users paying by cash do not have free transfer privileges and must also pay a surcharge of 100 won regardless of transportation mode.

The distance-based fare system replaced the flat-fare system, including free transfers within 30

Table 1. Bus Fare Structure Before and After Reform

		July 2003	July 2004
Structure	Bus Only	Flat fare	Flat fare
	Transfer	50 won discounted from fare charged	Free (distance-based)
Fare	Card	650 won	800 won
	Cash	700 won	900 won

minutes. The effectiveness of free transfers between buses and the subway substantially increased bus ridership. Table 1. shows a comparison of fare structure and fare levels before and after the reform. The introduction of the smart card eased payment and also attracted users by its multiple benefits. Transportation expenses generally decreased because of the reduced cost for each trip (average costs decreased from US$0.674 to $0.632) and popularization of the"subway monthly commuting ticket". The new fare system made large a large contribution toward increasing services and ridership.

3. Infrastructure

Two major types of bus-related infrastructure were created and improved: the bus route network and exclusive median bus lanes.

Bus Route Network

The bus route network was entirely re-designed to integrate all bus routes in the metropolitan area. All bus services are now grouped into four types and color-coded to make them easily distinguishable. The red long-distance intercity buses connect outlying suburbs with each other and the city center. The blue trunk buses operate between sub-cores and along major arterial corridors in Seoul. The green feeder buses, including community buses, provide local services to feed subway stations and express bus stops. Finally, the yellow circular buses provide local services within the city's center. Route numbers were also reconstructed, enabling passengers to easily identify the zones where buses start and end.

Exclusive Median Bus Lanes

Previously, exclusive bus lanes were installed along the curb side. This provided only insignificant

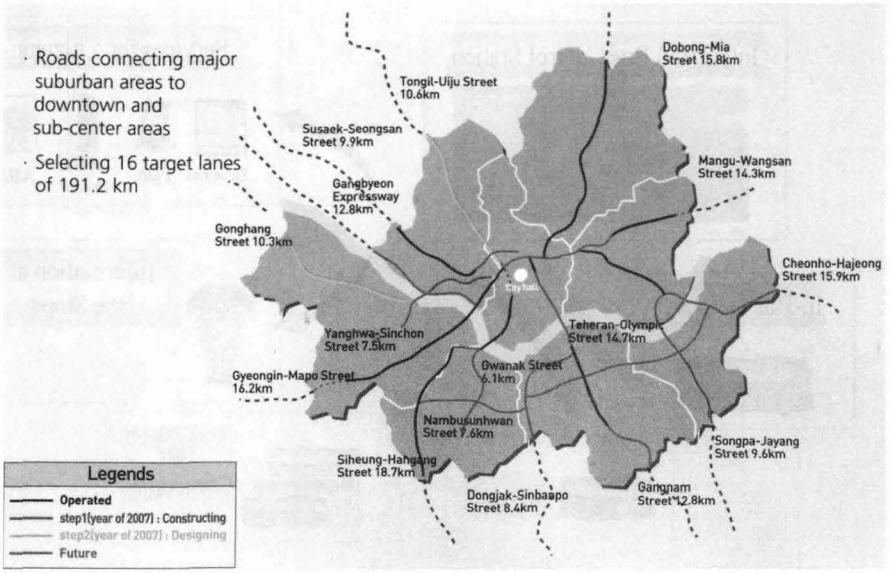


Figure 4. Existing and Planned Exclusive Bus Lanes in Seoul (16 routes, 191.2 km)

improvements in traffic congestion, especially at intersections where turning cars continued to interfere with traffic. During the reform, median bus lanes replaced former curbside lanes. Much effort was invested to expand and upgrade these lanes from 219 km to 294 km. Exclusive median bus lanes run throughout three major corridors (27 km), and expanded to six corridors (58 km) by 2005. The development of a Bus Rapid Transit (BRT) network, high-quality median bus stops, priority traffic signals at intersections, real-time information for passengers and system operators, and new, state-of-the-art buses all contributed to the success of exclusive median bus lanes. Substantial improvements were seen in the overall average bus speed, with increases of up to 20%. By 2006, there were already 86 km of such exclusive median bus lanes over six different corridors, which continue to expand rapidly.

4. Technological Innovation

New Smart Card System

A new smart card was introduced to facilitate inter-modal ridership. The new smart card system is a stored-value, multipurpose smart card (called T-Money). Smart cards have had advantages for both passengers and bus companies. Passengers can use their smart cards for bus and rail travel, transfer fare discounts, and to choose between pre-paid and credit card-linked options. For bus companies, fare

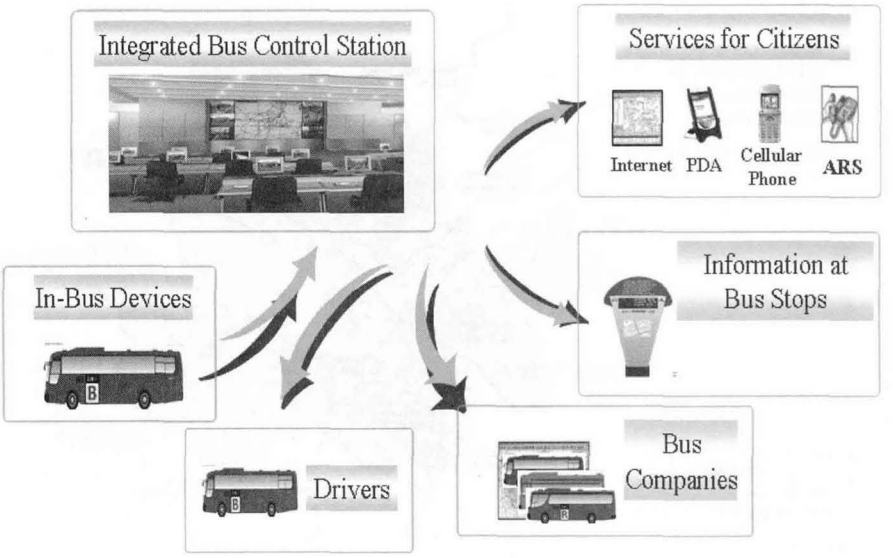


Figure 5. Bus Management System (BMS)

revenues can be calculated more accurately with the new smart card system. In 1997, Seoul became one of the first cities to use a radio frequency identification card system (the Mifare card from Philips) for fare collection. However, after six years of implementation, the limited capacity of memory, slow transaction speed, and security problems weakened the system. Thus, a new card system using an integrated circuit (IC) chip was developed.

The new smart card satisfies international standards and has increased capacity after adopting the Europay, Mastercard, and Visa global standard (EMV), which helps ensure that smart cards, terminals, and other systems are interoperable. This allows it to provide multiple functions, supports more accurate management of bus scheduling, and increases the transparent management of bus fare revenues. Future plans will extend smart card services for taxi use and high street shopping. In addition, the Seoul Metropolitan Government developed a bus management system (BMS) to increase the efficiency of bus operations.

The BMS integrated the Transport Operation and Information Service (TOPIS), which provides data on traffic information that can be uploaded to various transportation agencies in the metropolitan areas. This combined the Intelligent Transport System (ITS) and Global Positioning System (GPS) technologies to assess buses' positions, control scheduling, and provide bus information to passengers via internet, mobile phone, and PDA. Such information also supports research and assists in decision-making processes.

Figure 6. Articulated Bus Introduced in Seoul

5. Quality and Passenger Safety

The previous bus system failed to provide quality to riders and was not environmentally friendly. New features designed to enhance passengers' comfort included: improved design of bus stops, increased number of seats on buses, and ensuring the cleanliness of vehicles' interiors. To improve quality, Diesel Particulate Filters (DPFs) were installed in most buses, and new types of vehicles were introduced, such as low-floor buses, articulated buses, and CNG buses. The Seoul Metropolitan Government also installed a bus information system (BIS) to provide information on arrival times for passengers waiting at bus stops.

The 300 low-floor buses have run on CNG by early 2006. Eventually, all blue and red express buses will be low-floor buses running on CNG. In addition, loading platforms will be installed at bus stops so that getting on and off express buses will be easier, faster, and safer. The government now views the BRT expansion as a more cost-effective and faster method to provide express public transport service as compared to expanding the metro system, which requires much more time and capital investment.

6. Environmental Concerns and Passenger Car Reduction Policy

The Opening of Seoul City Hall Plaza

Seoul City Hall Plaza was opened on 1 May 2004. The area, previously jammed by traffic, exhaust, and noise, was returned to the citizens, transformed into an open town square park with a large grass lawn. It has succeeded in restraining traffic flow in this area and securing space for pedestrians.

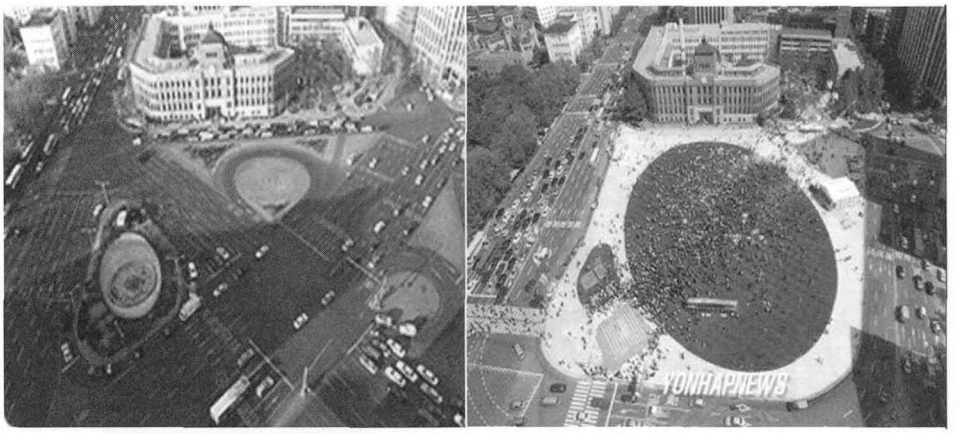


Figure 7. Reform of Seoul City Hall Plaza (Before and After)

Figure 8. Restoration of Cheong Gye Cheon (Before and After)

The Restoration of Cheon Gye Cheon

Cheong Gye Cheon, an historical stream running through Seoul last 550 years since capitalized. It was covered by roads and highways in 1937, with a daily traffic volume of 190,000 vehicles. The restoration of this six km stream has made a great contribution to the realization of people-oriented, environment-friendly policies and sustainable transport. Public transportation was encouraged to relieve the huge traffic flows, and the bus reform has played a great role in decreasing car traffic volume by two-thirds, or 125,000 vehicles per day.

IV. ACHIEVEMENTS OF THE BUS SYSTEM REFORM

The bus system reform enhanced operation and regulation capabilities of public transportation services in Korea. The Seoul Metropolitan Government forcefully targeted critical concerns during the 1980s when transportation patterns were shifting and bus services failed to provide an alternative option. The leadership of the Seoul Metropolitan Government in taking the necessary steps to reform the institutional framework of public transport operations was a major step towards sustaining success over the long term.

The reform fosters integration and coordination that enhances improvements in operation and regulation. All of these achievements confirm the willingness of the Seoul Metropolitan Government to improve mobility and the urban environment in Seoul. This solely came about as a result of participatory initiatives and a consensus-building forum involving the Seoul Metropolitan Government, bus operators, transport and city professionals, and citizens.

Targets that were implemented to improve the transport system achieved increasing mobility, efficiency, ridership, road safety, and information dissemination; at the same time, they mitigated negative impacts such as poor traffic conditions, pollutant emissions, and energy consumption.

The reform emphasized passenger-friendly and environmentally conscious services and buses that would mitigate negative impacts. Quality was achieved through three main initiatives: improving road safety; decreasing pollutants and energy consumption; and reaching consumer standards. Road safety profoundly increased when a mandatory bus driver quality certification was implemented. A

Table 2. Seoul's Bus System Before and After Reform

	2003	2004
Daily bus passengers (thousands)	4,869	5,350
Daily transit passengers (thousands)	9,307	9,888
Frequency (minutes)	5-15	5-15
Bus speed (km/h)	13 km/h	17.3km/h
Comfort (low-floor buses)	-	78 buses
Convenience (red zone pavement)	-	142 spots
Punctuality[1)]	0.537	0.493

1) Difference ratio of the permitted headway and actual operational headwa

Table 3. Increased Number of Passengers for Subway and Bus (thousands/day)

	2003		2004		Percentage Increase
	July	August	July	August	
Bus	3,793	3,744	4,142	4,140	9.9% ↑
Subway	2,699	2,557	3,055	2,867	12.6% ↑
Total	6,492	6,301	7,197	7,007	11.0% ↑

Table 4. Change in Number of Passengers After Reform (thousands/day)[2)]

Category	Public transport (a+b)	(a) Subway	(b) Bus (b=c+d)	(c) Trunk lines	(d) Feeder lines
July 2004-May 2005 Average	9,765	4,545	5,220	4,068	1,152
July 2003-May 2004 Average	9,282	4,497	4,785	3,863	922
Changes	483	48	435	205	230
Rate (%)	5.2% ↑	1.1% ↑	9.1% ↑	5.3% ↑	24.9% ↑

Table 5. Bus Related Traffic Accidents and Causalities

Year	Number of accidents	Number of the injured			
		Lightly injured	Heavily injured	Deaths	Total
2003	654	916	49	6	971
2004	478	704	36	0	740
Change (%)	26.9% ↓	23.1% ↓	26.5% ↓	100% ↓	23.8% ↓

competitive education program stressed driving-safety behaviors and understanding the use of smart cards, BMS, and GPS technologies. The significant decrease in bus-related traffic accidents is only partly attributed to driver education; the reorganization of bus routes that improved scheduling and timeliness of bus travel also reduced reckless driving.

Environmentally friendly buses were also in the center of the reform planning process. The number of CNG buses increased from 1,504 to 2,100, and simultaneously diesel particulate filters (DPFs) were adopted. The use of CNG and DPF energy products significantly reduced air pollutants, such as carbon dioxide (CO), nitro-oxygen (NOX), hydrocarbon (HC), and particulate materials (PM). Only CNG buses and those with DPFs installed may drive in the exclusive median bus lanes, which is required through legislation by the Seoul Metropolitan Government.

2) Data from 1 July 2004 and 11 January 2005 were eliminated due to the card terminal errors.

Table 6. Energy Pollutants and Consumption

	2003	2004
Safety (traffic accidents)	3,949	3,094
Accidents per day	21.9	17.2
Air pollution (CO: tons)	1,798.8	1,526.4
Air pollution (NOx: tons)	6,889.8	5,846.2
Air pollution (HC: tons)	390.5	331.4
Air pollution (PM: tons)	302.2	245.6
Energy consumption (CNG: 1,000m^3)	34,413	41,731
Energy consumption (Diesel: 1,000m^3)	147,064	126,485

Table 7. Number of Public Complaints After the Reform

Type of Complaint	April 2004	December 2004	May 2005
Transport card and fare	59,871	4,820	640
Service routes	1,216	44	15
Service schedules	1,638	141	29
Bus stops, route maps	561	24	4
Service of bus driver	392	40	30
Publicity of route and fare	331	19	1
Etc (suggestions, transfer)	981	48	34
Total	64,990	5,136	753

Quality standards for buses, such as clean interiors, comfort, and accessibility for users, have been greatly improved. Such standards extend to service providers, such as engineers who are regularly educated about maintenance of buses, smart card systems, BMS, and GPS technologies. Effectiveness of service providers can be tracked through the complaint resolution system.

V. LESSONS LEARNED AND CONCLUSION

Over the last 40 years, the Seoul Metropolitan Government has attempted to reform the bus operating system several times but had continuously failed. The failures were caused by the strong opposition of the bus industry and bus users, as well as the government's top-down, vertical approaches with its weak decision-making leadership. These factors were prominent in the failures of

the Seoul bus reforms of 1996 and 1997. However, the 2004 bus system reform had the support of citizens and organizations that urged the government to establish the bus reform citizen committee (BRCC).

Planning and implementing such a huge project could have not been possible without the leadership of decision makers. The entire transport reform was implemented successfully under the mayor of Seoul. Pushing his main projects forward, he made every effort to manage and minimize the various conflicts through consultation and discussions with citizens and stakeholders. It is meaningful that the concept of "New Governance" was substantially introduced as a new direction of the administration through the public transportation reform. The previous top-down approaches by the central government and the Seoul Metropolitan Government have been changed into a process led by a committee and supported by citizen groups and collaborative organizations.

The reform is the result of a participatory approach based on a consensus-building process involving the Seoul Metropolitan Government, bus operators, transport and city professionals, and citizens. The leadership of the Seoul Metropolitan Government took the necessary steps of reforming the institutional framework of public transport operations in order to increase efficiency and rationalize costs. In this respect, public transport operators benefited from the support of the Seoul Metropolitan Government, which helped them to modernize their fleet and adopt innovative technologies. After a phase of stabilization, this framework is expected to increase the responsibility and entrepreneurship of public transport operators by encouraging them to adopt a service-oriented approach.

Identifying alternative financing sources is a concern of all public transport organizations worldwide. In Seoul, the subsidy ratio of public transport operations is far lower than in the majority of networks in the world, and it is improving. However, due to the scarcity of public funds, it is important to consider other sources, such as value capture from property development, road use pricing, congestion charging, parking revenues, and other measures, in order to progressively reduce subsidies from the Seoul Metropolitan Government.

In conclusion, the bus system reform has been successful in addressing the needs of Seoul's population. The reform outcomes and methods have received attention both at home and abroad, leading to awards for Seoul's efforts to improve the city's public transportation. Seoul was named the winner of the 2005 World Technology Network (WTN) for Environment Award and received the Sustainable Transport Award from Environmental Defense and transportation research board (TRB) in USA in January 2006. The success from this experience not only speaks for the reform of the bus system but for reforms in other areas as well.

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