

Urban Transportation and Environmental Management in Singapore:

Lessons for Other Cities

ABSTRACT: To combat the environmental problems and congestion which arise from urban transportation, both end-of-pipe interventions such as traffic management and tailpipe emission control and more upstream measures such as urban and land-use planning have been implemented in many cities around the world. Singapore, in particular, has achieved rare success in managing congestion and the environment amid high economic growth through integrated land use, transportation and environmental planning. This paper examines this success story in detail: the underlying situation; the major policy instruments designed to curb vehicle ownership and use, including quotas, fiscal control and road pricing; and policy impacts. The question “Why did it work in Singapore?” is addressed and the lessons of this success for other cities in the region and beyond are discussed.

A.1 Introduction

The use of fossil fuels is a major cause of emission from urban transportation. Cities around the world have implemented measures at different stages, ranging from end-of-pipe interventions to more upstream measures like containing travel demand, and in different forms, from command-and-

control to market-based. Since containing the growing demand for travel has negative implications for economic growth, cities often focus on how to organise travel demand into a better modal structure, a step requiring the integration of urban planning and land-use policies together with transportation and environmental planning. Many cities and regions in the world suffer from serious vehicle pollution and traffic congestion and their corresponding social, economic and human health costs. Policy makers are concerned about the share of private transportation in both meeting demand and contributing to pollutant concentrations. End-of-pipe approaches such as setting emission standards, improving fuel quality, and implementing vehicle technology interventions are limited neither the environment nor congestion will improve as long as the number of vehicles and their use increase. While such measures are necessary there are not sufficient. A long-term solution to the environmental and congestion problems urban transportation introduces in dense Asian cities requires additional steps.

Since the country gained independence in 1965, policy makers in Singapore have shown concern about integrated urban, land-use and transportation planning (see Table A1). The major motivation for Singapore was not environmental considerations but economic prospects; it saw itself becoming a prominent manufacturing, commercial and trading centre by utilising its unique geographical location. Singapore was successful in meeting an unprecedented demand for travel while keeping congestion and environmental pollution within acceptable limits (set by the WHO and EPA-USA) and achieving economic growth from SG\$ 7.5 billion in 1965 to SG\$ 138 billion in 2001 (at 1990 market prices) (SDS, 2002). Singapore employs a mixture of command-and-control and market-based instruments to manage travel demand and related environmental problems. This paper discusses and analyses several policies and instruments with special attention to two: congestion pricing and vehicle ownership restrictions. This analysis of the conditions underlying the workability of these instruments is important if other cities are to be able to replicate Singapore's success in their quest for congestion- and pollution-free urban systems. The following questions are explored: How successful was Singapore's action? What was the situation underlying the city-state's

opting for such aggressive policies? What kind of policies and policy instruments were implemented? What was the prevailing situation that led to the successful implementation of the policy instruments? Are there prospects for replicating one or more aspects of Singapore's experience elsewhere?

Table A.1 Key dates in transportation in Singapore

Year	Activity
1968	Ministry of Communications established, 30% import duty on cars imposed
1970	Bus service reform begins
1972	Import duty and ARF increases
1973	Singapore bus service is unified
1974	ARF raised to 55%
1975	ALS scheme initiated, ARF raised to 100%, preferential ARF started
1978	ARF raised to 125%
1980	ARF raised to 150%
1987	MRT begins
1989	ALS extended to other vehicles
1990	Vehicle quota system begins
1994	ALS implemented whole day
1995	Road pricing system on expressway
1998	ERP begins
1999	ERP extended to highways

A.2 Challenges and Strategies for Integrated Planning

The city-state of Singapore achieved independence in 1965, at which time housing shortages and unemployment were major problems. Singapore was a densely-packed settlement surrounded by shantytowns in the coastal area: the average density of the city's 400-hectare core exceeded 1,200 persons per hectare in 1959 (Willoughby, 2000). In 1965, nearly 70% of the population of 1.8 million was concentrated within a 5-km radius of the port of Singapore, the city centre (Humphery, 1985). In 1965, the newly elected People's Action Party made housing and employment a priority

and the landmark land-reform legislation the Land Acquisition Act of 1966 gave the government sweeping powers to acquire land. The result was an aggressive pursuit of urban planning, housing development and industrial estate development by the Urban Redevelopment Authority and Housing and Development Board (HDB) under the Ministry of National Development. Singapore's strategic location and policy of economic liberalisation attracted huge manufacturing investments after 1965, and Singapore maintained double-digit economic growth until the first global oil crisis in 1973. In the late 1960s Singapore also attracted the attention of the financial and commercial sectors. In the 1960s and 1970s, per capita car ownership in Singapore was high relative to its per capita income. In the 1960s alone, the numbers of cars doubled and that of motorcycles tripled. Income was rising steadily. The public transportation system was slow and unreliable. Traffic congestion in 1975 vehicular speeds during peak hours to an average of 19 km/hour (Phang and Toh, 1997).

Realising that land-scarce Singapore needed sound long-term city planning in order to accommodate the growing economy, the government initiated a four-year State and City Planning (SCP) Project. This 20-year conceptual plan was completed in 1971 with support from the UNDP. Unlike earlier plans, it focused on planning to accommodate four million rather than two million residents. In terms of the transportation sector, the project estimated that by 1992 it would be environmentally unacceptable and physically impossible to build road infrastructure to meet the prevailing rate of growth in numbers of private automobiles and that buses alone would not be able to meet public travel demand. It suggested easing traffic congestion within the business centre by developing a rapid transit system in addition to expressways (Fwa, 2002). Following the recommendations of SCP, the Singapore government implemented a number of measures from 1972 to 1992. They included restricting private vehicle ownership by imposing high import duties, charging additional registration fees (ARF), using a vehicle quota system VQS, restricting private vehicle use in city centres through an Area Licensing System (ALS), expanding expressway systems and constructing a 67-km mass rail transport (MRT) system. At the time, public transportation was provided by three principal groups: a large British-owned bus company, eleven smaller Chinese-owned companies

and unlicensed taxis; the result was a slow, inadequate and unreliable system. To organise the system, the government forced a merger in 1973; the major market share of this single company was initially in government hands but was floated on the Singapore Stock Exchange in 1978. With the quality of public transportation improved, switching away from private cars became a viable choice for travellers.

Since appropriate land use and urbanisation influence travel demand, interventions are often limited because the government has no rights over built private property. In Singapore, however, the government's control over land rights enabled the HDB to plan housing zones and to construct high-rise and affordable housing estates in them. The government scheme was successful in moving city dwellers to newly-constructed public housing well-equipped with supporting commercial and recreational establishments. Today, 86% of the population lives in such estates (MIA, 2001). These activities followed SCP's suggestions to adopt a ring concept, in which high-density residential areas, industries and urban centres were to be distributed in a ring formation around the central business districts. A revised plan introduced in 1991 replaced the ring concept with four decentralised areas in a constellation pattern (Lye, 2002).

Despite strong economic growth and a twenty-fold increase in office space and in employment, Singapore has maintained its environmental and transportation systems under acceptable limits. In 1995, the level of motorisation was slightly over 100 cars per 1000 people, the average level of cities with an income level one-third that of Singapore. Recent data suggests that the average speed during rush hour is 20-30 kph on city roads and 45-65 kph on expressways. In addition, the concentrations of major air pollutants in Singapore are well within the limits the WHO and the U.S. Environmental Protection Agency have laid out (see Table A.2).

Table A.2 Singapore ambient air quality

Pollutant type	Average time	1982	1988	1994	1999	Standard
Carbon monoxide	8 h (roadside), ppm	1-3	1-3	1-3	1-3	9
Lead: roadside	3 months, $\mu\text{g}/\text{m}^3$	1.5	0.4	0.2	0.1	1.5
Lead: ambient	3 months, $\mu\text{g}/\text{m}^3$	0.6	0.2	0.1	0.1	1.5
Sulphur dioxide	Annual mean, $\mu\text{g}/\text{m}^3$	29	20	19	22	80

Pollutant type	Average time	1982	1988	1994	1999	Standard
Nitrogen oxide	Annual mean, $\mu\text{g}/\text{m}^3$	18	16	29	36	100
Ozone	Max 1 h, $\mu\text{g}/\text{m}^3$	450	176	237	181	235
Ozone*	1 h concentration >235 $\mu\text{g}/\text{m}^3$, days	30	0	1	0	–
PM10	$\mu\text{g}/\text{m}^3$	–	–	48	34	50
TSP	$\mu\text{g}/\text{m}^3$	70	47	55	–	75

* In 1982 ozone measurements were conducted using the neutral-buffered potassium iodide method; this method was subsequently replaced by the ultra-violet photometric method.

Source: Ang and Tan (2001) citing Pollution Control Department; Ministry of Environment, Singapore

Initially, it was the Ministry of Communications and Information (MCI) of Singapore that had the mandate to oversee all land transportation policies through its departments and statutory bodies. Ministerial restructuring was carried out in 1990, 1999 and 2001, and in November 2001, the department's name was changed to the Ministry of Transport. The role of vehicle emission enforcement was transferred to the Ministry of Environment on 1 July, 1999. Today, the Ministry of Transport has a mandate to look after civil aviation and air transport, maritime transportation and ports, and land transport. The Land Transport Authority (LTA), a statutory body created under the Ministry of Transport in 1995, is directly responsible for all aspects of restricting car ownership and all policies and schemes curbing car use. It is also responsible for the planning, implementation and management of all public and private land transportation and infrastructure policies. The Urban Redevelopment Authority (URA) under the Ministry of National Development is responsible for land-use planning and land allocation, under which other development planning is pursued. The LTA and the URA jointly manage parking spaces and policies, while the LTA and the Ministry of Environment (especially the National Environmental Agency created 1 July, 2002) cooperate with the traffic police to control motor vehicle emissions. The HDB is responsible for the construction and sale of housing complexes. These agencies coordinate closely to achieve integrated land use, transportation and environmental planning.

The countermeasures in Singapore to reduce air pollution and thereby improve the environment include driving clean vehicles with emission

limits, using clean fuels and controlling traffic congestion. Interventions in fuels and vehicles have had much success in cities around the world, whereas interventions in traffic congestion have not. Singapore, with its system of travel demand management (TDM), is an exception. TDM was principally achieved through four major instruments to limit the number and use of private cars: (1) fiscal measures to curb car ownership (2) a VQS (3) an ALS, which has been recently upgraded to an electronic road-pricing (ERP) system, and (4) efficient and affordable public transportation systems.

A.3 Analyses of Major Policy Instruments

A.3.1 Fiscal measures to curb car ownership

Singapore has relied upon high taxes and fees to curb car ownership. Fiscal measures include an import duty levied through the Customs and Excise Department; a goods and services tax; registration fees, including an ARF imposed by the Land Transport Authority when imported vehicles are registered; and road and fuel taxes. These measures generated a large amount of revenue, which, in turn was invested in land transportation infrastructure. The import duty was 30% of the open market value (OMV) of in 1968; it increased to 45% after 1972 but was subsequently reduced to 31% of the OMV for cars, 12% for motorcycle, 7% for taxis and 31% for buses with eight or fewer seats. On 4 May, 2002, the import duty for cars was further reduced to 20% of the OMV. In 2002, the goods and services tax stood at 3% of the cost of CIF cost plus the customs duty. The ARF was originally introduced in the late 1950s and, after several revisions, stood at 140% of the OMV from 1980 to 4 May, 2002, when it was reduced to 130%. In 1968, registration fees were SG\$ 15; they had increased to SG\$ 1,000 in 1980, but after the introduction of ERP in April 1998, dropped to SG\$ 140. Total car registration fees, including ARE, increased 17.5 times from October 1972 to October 1983, from 10% to 175% of a car's price (Fwa, 2002). The Singapore government has also imposed high taxes on retail fuel prices. Taxes vary according to fuel grade. The best grade of gasoline is taxed at SG\$ 0.44 per litre (or 35% of the pump price before a 3% goods

and sales tax). The tax on diesel was lifted in late 1998. The annual road tax varies from SG\$ 70 cents per cubic centimetres for cars with 1000 cubic centimetres engines to SG\$ 175 cents for those with engines larger than 3000 cubic centimetres engines per year (Lye, 2002). Since ERP was introduced in September 2002, a rebate in road tax has been offered. The formula for calculating the rate of rebate for cars is given in the appendix. A preferential ARF for vehicle modernisation, in which the registration fees for new vehicles whose purchase results in the scrapping of older vehicles of the same class and size, was launched in 1975. The growing economy and rise in living standards, however, soon surpassed the economic disincentives to own a car. Despite the heavy financial burdens of owning a car, Singapore saw a 73% rise (an average of 13,000 cars a year) in the number of cars from 1977 to 1984, followed by a brief recession and again a steep rise of an average 15,000 car a year from 1987 to 1990 (Fwa, 2002). Although this increase was much less than in other similar nations, it was unacceptable for the Singapore government, which imposed a new fiscal measure to control the number of vehicles: the VQS maintains a 3% annual growth rate. In part, the preferential ARF contributed to the increase in the number of vehicles due to the continued increase in the ARF and the appreciation of the Japanese yen. Dealers marketed cars by arguing that assets would increase. Indeed, in the case of some classes of cars, older cars did increase in value over time (Willoughby, 2000).

A.3.2 Vehicle Quota System

Announced in February 1990, VQS was intended to cap the number of newly registered vehicles. VQS was an easier instrument than the ARF, a pricing instrument whose changing level was politically sensitive. With VQS, the government fixed the number of allowable vehicles but not their price, which remained determined by the market. Under this system, prospective vehicle owners obtain a certificate of entitlement (COE) making ownership of a vehicle valid for 10 years through open bidding. Bidding is opened twice a month and a list of bidders in descending order is arrayed. The bid quoted by the last bidder of the designated quota is called a "quota premium," and is the price levied on all successful bidders for COE. So far, the demand of COE has exceeded the designated quota by

two times or more and quota premiums for passenger cars have been in a range of 30-80% of the selling prices of cars (Fwa, 2002; Willoughby, 2000). Table 3 lists an illustration of COE prices.

Table A.3 Certificate of entitlement (COE) bidding on 20 November 2002

Category	Quota	Quota premium	Total bids received	No. of successful bids	Unused quota carried forward
Category A (Cars 1600cc and below and taxis)	1,334	\$29,008	1,942	1,328	6
Category B (Cars 1601cc and above)	663	\$28,001	879	597	66
Category D (Motorcycles)	835	\$1	676	676	159
Category C (Goods vehicles and buses)	576	\$13,789	736	567	9
Category E (Open)	1,095	\$28,005	1,445	1,094	1

1) A, B and D are non-transferable categories 2) C and E are transferable category

Source: <http://www.onemotoring.com.sg/main/default.asp> (Accessed on 25 November, 2002)

To allow less wealthy consumers to own cars, different sub-categories, including weekend cars, small cars, medium cars and taxis, big cars, and luxury cars were established at the outset. Since this system resulted in too many complexities, it was simplified in 1999. Now, only two categories exist for cars: below 1600 cc and equal to or above 1600 cc. Public and school buses, diplomatic vehicles, ambulances and emergency vehicles are all excluded from the scheme. When his ten-year COE expires, an owner has to de-register or acquire a new COE at the price of the three-month moving average quota premium in that category. Since 1999, many efforts have been made to discourage speculation and other distortions but the basic rule has remained the same (Phang, Wong and Chia, 1996; Toh and Phang, 1997; Chu and Goh, 1997). For example, when it was introduced, COEs were transferable and a speculative market soon developed. Indeed, in the first two months, 20% of COEs changed ownership. In response, the government in October 1991 made COEs, with the exception of open and goods categories, non-transferable. To soften such strict measures, which controlled demand rather than need, the government implemented relief measures such as the week-end car (WEC) scheme, which provided rebates

in ARF, import duties, quota premiums and road taxes but allowed WEC use only during off-peak hours. For urgent cases, five-day-use licenses were granted when annual road taxes were paid at the cost of SG\$ 20 a day. In essence, WEC was a manual road pricing scheme, although in a very primitive form.

A.3.3 Area Licensing System

ALS is a road-pricing mechanism in which each car is charged for its contribution to congestion in central business districts (CBD). Import duties, ARF and other measures such as road or fuel taxes cannot influence the use of cars once they are on the street, but ALS can. Introduced in 1975, the scheme was based on a cordon-pricing system, in which a cordoned CBD area of 5.59 km² (600 hectares) referred to as a restricted zone (RZ) was isolated from the rest of the city by constructing a 22-entry point (Toh, 1977). In the scheme, a license to enter a restricted zone during morning peak hours (7.30 to 9.30 A.M.) had to be purchased in advance at the cost of SG\$ 3 (later SG\$ 4) a day (or SG\$ 60 per month; later SG\$ 80). The system was paper-based and verified by observers at the entry posts. Non-complying vehicle owners had to pay a fine, about which they were notified at home through a letter. Restricted zones, times and prices of ALS licenses were changed several times to accommodate CBD expansion, traffic and economic conditions. Initially, taxis and cars with more than three passengers, excluding the driver, and buses were exempted from buying entry licenses; after 1989, they were not exempted. Also in 1989, the charge for public parking in restricted zones was raised and additional surcharges were levied on private parking operators to discourage car use.

ALS was highly successful in curbing traffic congestion during morning peak hours. By the fourth week of ALS, traffic flow during peak hours had fallen by 45.3%, the number of cars had dropped by 76.2%, and the percentage of commuters travelling by public had risen from 35.9% to 43.9% (Toh, 1977, Yap 1986). The average speed of vehicular traffic increased from 18 to 35 kph (Willoughby, 2000). Traffic was reduced by 45.3%, substantially more than the targeted 25-30%. However, ALS also increased traffic pressure just before and after restricted hours as well as on areas contiguous to the restricted zone that served as an escape corridor.

Supplemental traffic management measures were then implemented in those areas to relieve pressure. The anticipated mirror effect of less traffic during evening peak hours, did not occur. In order to make optimal use of road space and to ensure a smooth flow, several adjustments in the times and places restricted were made in later years through careful monitoring. After 27 years of ALS implementation, the inbound traffic volume in CBDs during morning peak hours was still less than it used to be before ALS implementation (Fwa, 2002). Apart from congestion, the major advantages of ALS were energy saving and air pollution reduction. Fwa and Ang's conservative estimate of energy savings with and without ALS, which was based on 1990 data on the flow and speed of traffic, suggested that savings amounted to 1.043 GJ per day in 1996. The shift from clean vehicles to a clean transportation system relieved Singapore's over-dependence on end-of-pipe measures for air pollution in CBDs.

One of the major questions regarding ALS is whether the pricing was correctly fixed with respect to the given externalities to society due to congestion and environment. In 1990, a study by the Public Works Department in Singapore revealed that in RZs the average speed during morning peak hours was higher than it was during non-peak periods (McCarthy and Tay, 1993). The existing price of the access license was calculated at about 50% more than the optimal price. However, in the absence of pricing mechanisms varying over time and space, no price, in fact, could be optimal. Electronic road pricing (ERP), the new measure that has replaced manual ALS, may, however, with its improved technology, pave the way for a fair pricing mechanism.

A.3.4 Electronic Road Pricing

ERP replaced ALS in September 1998. Its basic idea is similar to ALS, but since it is ERP technologically sound, it can vary charges over time and spaces and reflect the true cost of vehicle use in CBDs. In this system, all 33 ALS gantries were replaced with ERP gantries for every 720 ha of core area and vehicles allowed to enter RZs were fitted with in-vehicle units (IU)—in the lower right-hand corner of windscreens of four-wheeled vehicles and on the handlebars of motorcycles. IU units read stored-value cash cards from which charges are deducted automatically using a short-

wave radio frequency link as soon as a vehicle enters a RZ through an ERP gantry. Photographs of the license plate of non-complying vehicle are taken automatically for further action.

On the institutional side, four departments in the Land Transport Authority are involved in the operationalisation of ERP. The traffic management department is responsible for setting up rules and guidelines; the computer information department maintains the hardware and software, and the regulation department enforces rules and regulations and deals with violations. The vehicle engineering department also plays a role.

At the moment, pre-determined ERP charges vary each half hour throughout the day, from SG\$ 2.50 during peak hours to 50 cents during off-peak hours depending on the road section. Charges are different for motorcycles, cars, goods vehicles, taxis, buses, etc., and different IU units are installed in each category of vehicle. The fundamental question is how much an appropriate charge is. Theoretically speaking, real-time pricing reflecting the cost and level of congestion and the relative contribution of each vehicle category to that congestion is an ideal mechanism that can internalise the externality of congestion. In reality, it is not easy to enforce such pricing, although it is not impossible through ERP. At the moment, however, charges do not fluctuate depending on the traffic conditions in Singapore. Instead, ERP charges are subject to review every three months to suit changing traffic conditions. These charges are basically tied to prevailing speeds with the aim of maintaining traffic speeds of 45-65 kph on expressways and 20-30 kph on arterial roads (Willoughby, 2000). The successful implementation of ERP has facilitated the reduction of taxes and other charges and increased the allowable vehicle quota. The cost of IU units is less than SG\$ 300 and for new vehicles with IU units, rebates of as much as SG\$ 200 are offered on road taxes. Frequent adjustments, such as special reduced-ERP prices during school holidays when traffic is reduced, are possible and, in fact, are being carried out.

A.4 Why Did TDM Work in Singapore?

TMD has had only limited success in many parts of the world, most of which actively pursue supply side measures (such as building road

infrastructure, etc.). Supply side measures, however, are never sufficient and, in fact, place a greater burden on the environment because more infrastructure usually means more vehicles on the street. From a global sustainability perspective, TDM measures facilitate energy and resource conservation downstream as well as upstream. The fundamental question is why TDM worked in Singapore.

Integrated city planning is the key word in Singapore's success. All the measures it has introduced are a part of a comprehensive strategy and are coordinated very closely to produce a comprehensive solution. No single measure alone can work. The right to travel is a basic human right; however, government policies can offer options which encourage travellers to choose modes which are both sustainable in the long term and acceptable to residents. When ERP was implemented in Singapore, commuters had several choices: (1) pay the charges and drive smoothly, (2) change the time of travel and pay lower charges, (3) use alternative roads, (4) use public transport, and (5) use other schemes, such as park-and-ride (Menon, 2002). Singapore's success is also coupled with favourable economic, social and urban conditions. The smallness of both the land area and the population size allowed for flexible planning. As a city-state, Singapore has only a single tier of government; thus, all the complexities which arise from layers of authority and a mismatch between local and national priorities are eliminated. The economy of Singapore relies heavily on foreign investment and on transactions related to international trade, commerce and finance, for which efficient transport and communication is essential. The need to fulfil this condition for economic reasons has contributed to sustainable growth in transport and concern for the environment. Unlike in other countries, where economic growth is curbed by environmental countermeasures, economic growth in Singapore was actually fostered by improvements in environment and transport. A strong government, stable and strong regulations and institutional frameworks for enforcement are other reasons why TDM worked in Singapore. From the point of view of jurisdiction, the roles and responsibilities of authorities responsible for urban and land use planning, land transport and environment were clearly demarcated. The land reform process initiated in 1967 allowed the government to acquire

a most of the land and the subsequent development of housing estates on the city's periphery and facilitated the development of infrastructure suitable for sound land-use planning. The HDB, which was set up in 1960 by the British colonial government, provided housing to just 9% of the population in 1960. Because the sweeping powers of the Land Acquisition Act enabled the government to acquire private land for public housing or other development activities, today 85% of the population live in HDB housing complexes. Another reason for Singapore's success is the periodic adjustment of policies using feedback from the public and other stakeholders, which is made possible by transparency in policy formulation. Singapore has learned by doing. It recognises that policies are never perfect and provides for adjustments. For example, ERP charges are subject to review every three months, and charge structures and times change depending on traffic and economic conditions.

Another key to TDM's success has been infrastructure investment. Demand side management was supplemented by constructing additional road infrastructure, maintaining roads well, coordinating traffic light systems, and building expressways and MRT. The taxes and fees imposed on vehicles generated huge financial resources, which were invested in demand and supply side management but also applied to reducing less desirable taxes. Willoughby (2000) estimated that the annual revenue from road transportation was at least three to four times greater than road expenditure.

Some technology factors also played important roles in Singapore. ERP for example, depends on sophisticated technology that allows time-of-day pricing which reflects traffic conditions. Its prototype, ALS, was, in contrast, a non-technology measure. A computerised traffic controlling system was already in place by 1986 in CBDs (Lee, 1986). It was replaced with a more advanced automated traffic signalling system called GLIDE (green link determining system), a traffic-adaptive signal control system monitored centrally to adjust to changing traffic conditions (Lee, 1990). Efforts are now being made now to create a Global Positioning System (GPS)-based coordinated public taxi-calling system which dispatches taxis automatically from the nearest location. Individual taxi operators are already using GPS. These high-technology measures provided support to

non-technology restrictions on car ownership and use. Some researchers claim that the overall effectiveness of high-technology measures is questionable (Fwa, 2002).

A final reason for the success of TDM is that Singapore is a migrant society with citizens who originated from many countries. Since most were economic migrants, their opposition to government policies was minimal. Thus, there were no barriers in the form of an organised force of resistance.

A.5 Concluding Remarks: Significance of Singapore's Experience for Other Cities

The big question is what lessons Singapore's experience can offer to other cities once localised favourable conditions are discounted.

Because Singapore is both a city and a nation, policies can be implemented with ease. It is possible to control the flow of goods and services in and out of the city as it is effectively an island. As mentioned earlier, the root of integrated land use and transportation planning goes back to the Land Acquisition Act of the 1960s, which allowed the government to acquire land and reserved land for city planning. With the exception of cities in a few centrally-administered countries, the governments of most dense cities in Asia do not exercise similar control over land. Calls for land reform have set limits and placed constraints on the public, but the policy makers of many countries do not address land reform because it is such a sensitive issue. In densely built-up cities, some changes in land use may be possible by providing incentives to de-populate central areas; however, their effectiveness may well be nominal.

Implementing VQS in other countries would need serious planning and would not be as simple as it was in Singapore. The collaboration of national government and local authorities is essential. Controlling quotas only at the national level might produce "hot spots" due to the over-concentration of vehicles in a few cities. The national government could, however, exercise control over total vehicle import quotas and allocate registration quotas to local governments based on their traffic conditions. Some form of restriction on transit vehicles in the form of local

road-use charging systems could compliment such policies. Hong Kong, in particular, has long used strong vehicle ownership control measures through fiscal measures.

In general, a strong legislative and institutional framework is a prerequisite. ERP may seem a little bit too ambitious at the moment for cities in developing countries but other measures such as ALS and VQS do not need high technology and are not complicated to operate. ALS, for example, is a simple, easily enforceable measure suitable for dense city core areas in mega- and medium-scale cities which curtails emissions and congestion during peak hours. Local governments, under the self-governance acts in force in many cities, can carry out such provisions. Like parking regulations, ALS does not interfere with the national government, and the revenue generated can be used by city authorities to improve roads and signal systems and to relieve pressure on escape routes around the cordoned area. The financial burden of maintaining road infrastructure can also be relieved. ALS, in particular, has generated much interest around the world and many cities have already initiated such schemes. The Norwegian cities of Bergen, Trondheim and Oslo, for example, adopted a scheme whose area is wider than that in Singapore in 1980. High- technology options, especially ERP and Intelligent Transport Systems (ITS) have attracted attention in developed countries: Canada, Norway, and the U.S. have initiated applications, while Chile, the Netherlands and the U.K. are expected to do so (Willoughby, 2000) in the near future. London started a system similar to ALS in late 2002; entering the core area costs five pounds. In Bangkok and Kuala Lumpur, restrictions on vehicle ownership and use have been proposed several times since the late 1970s but have as yet had little success. In Manila, restrictions were proposed in 1977 (Freeman and Fox, 1977), but were dropped ostensibly because of the lack of enforcement mechanisms (Kirby *et al.*, 1986).

Most cities in Asia do not have clear functional boundaries; the fact that there are often many interactions outside of the cities poses difficulties in making effective policies. In many cities, too, the transportation sector provides employment to low-income groups through cheap travel modes such as manual tricycles (Bangladesh and India), three-wheelers (many cities in South and Southeast Asia), and the jeepney (the Philippines).

Policies need to provide viable alternatives to such groups. The root causes of policy failure in cities of developing countries are inappropriate and inadequate policies, the lack of integration of policies, the lack of the institutional capacity to enforce existing policies, problems related to the jurisdiction and coordination of authorities, and the political interests of governing parties. These are all examples of poor governance and are often associated with the lack of financial resources. Selling to the public is not easy because it directly affects the travel of each city dweller. Such measures will not be acceptable or popular unless they are part of a city's overall strategy. Regardless of the economic and social conditions of a city, a good public campaign and acceptable alternatives are essential. In particular, the development of a sound public transportation system is key to replicating Singapore's other successful measures.

Acknowledgements: The author is solely responsible for the analyses and opinions offered above as well as for any inaccuracies in data and information. The author is grateful to the following persons, all of whom spared time for discussions and provided information to the author during from 14-20 November, 2002: Ho Siew Thong, Hui Kok Choy, and Basir Ahmad (National Environment Agency); Collin Sng and Hazri Hassan (Ministry of Environment); Dr. Chin Kian Keong (Land Transport Authority); Gopinath Menon (MSI Global Pvt Ltd); Professor Ang Beng Wah (National University of Singapore); Professor Fwa Tien Fang (Centre for Transport Research, National University of Singapore); Dr. Paul Barter (Public Policy Program, National University of Singapore); and Dr. Lye Lin Heng (Asia Pacific Centre for Environmental Law, National University of Singapore).

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**The Role of the Government,
the Private Sector and Civil Society in**

Promoting Battery-Operated Electric Three-Wheelers in Kathmandu, Nepal

B.1 Introduction and Background

Kathmandu Valley, which also includes the capital city of Nepal, is situated 1,320 m above sea level and is surrounded by mountains. The topography of the city exacerbates the rising levels of air pollution and photochemical smog because wind flow is blocked. Air pollution in the Valley is increasing at an alarming rate; the concentration of pollutants, especially PM, is well above the health guidelines set by the WHO. The result has been a decrease in atmospheric visibility and an increase in asthma and respiratory-related health problems in the last decade. The implication of air pollution is not limited to health issues: it also threatens the tourism industry, which is one of the major economic activities in the Valley. Motor vehicles are the major source of air pollution in the Valley, mostly because vehicles are old and poorly maintained, fuel is low quality and adulterated, two-wheelers and two-stroke engine vehicles prevail, congestion is increasing, and the road infrastructure is inadequate and poorly maintained.

Box

B.1 Vital statistics of Kathmandu Valley

<i>Area:</i>	<i>550 km² (valley floor)</i>
<i>Altitude:</i>	<i>1350 m above sea level</i>
<i>Road Length:</i>	<i>535 km (2002)</i>
<i>Registered number of vehicles</i>	<i>171,678</i>
<i>Vehicle composition:</i>	<i>Car/jeep, 23.7%; bus/truck 5.2%,; 3-wheelers, 2.9%; 2-wheelers 65.3%, rest/others (2001)</i>
<i>Pollutant concentrations:</i>	<i>24-h average: PM₁₀ concentrations are 225,135 and 126 µg/m³ in the core, sub-core and remote parts of the valley, respectively; the highest value is 495 µg/m³. TSP concentrations are 376, 214 and 137 µg/m³ in the core, sub-core and remote parts of the city.</i>
<i>Size of electric vehicle market</i>	<i>Rs. 500 million</i>

Sources:

- Department of Transport Management
- Ambient air quality monitoring of Kathmandu Valley. Final Report of ADB-TA-2847-NEP Project prepared by Nepal Environmental Services for Asian Development Bank, 1999, Kathmandu.
- Electric Vehicle Association of Nepal

Diesel three-wheelers imported from India in the late 1980s once produced a visible cloud of black smoke and other air pollutants over the Valley, even after new registrations were banned in 1992. In 1995, an outright ban on usage was imposed. In order to fill the vacuum, the government, the private sector and civil society (mainly NGOs and advocacy groups) worked together to promote and expand the use of battery-operated electric three-wheelers on a commercial basis. This successful introduction of zero-emission (by tail-pipe considerations) electric three-wheelers is noted as a successful practice of sustainability in many international forums, including USAID⁴⁷ and UN Sustainable Development;⁴⁸ the IPCC Special Report on Technology Transfer features a Kathmandu Valley safe

47 <http://www.info.usaid.gov/countries/np/success/success2.htm>

48 Success Stories Vol. 4/2000, <http://www.un.org/esa/sustdev/success/PCBCP-5.htm>

(clean) tempo on its cover page. Although, a single end-of-pipe solution for reducing pollutant emissions from a sectoral niche is not a solution to overall air quality problems, it does provide useful information. As a case of the successful interaction of the government, the private sector and civil society in improving urban air quality by controlling vehicular emissions and promoting clean vehicles, however, the experience is of interest to other cities in the region which rely on gasoline and diesel three-wheelers for a major proportion of their public transportation systems. Facilitation is essential if clean vehicles are to move into any market; this paper examines how it was done in the Kathmandu Valley. The introduction of *safa tempos* has established a new industry, invited private sector investment, created employment opportunities, and promoted the first experimentation in employing women drivers in Nepal's public transport sector.

We analyse why the introduction of electric vehicles succeeded in Kathmandu although in other cities techno-economic limitations have resulted in their failure. We also analysed the prevailing situation and the roles played by the government, the private sector and advocacy groups. The role of various command-and-control and market-based economic instruments are also illustrated. Last, the factors determining the potential for replication elsewhere are discussed and the relevance of this experience for other cities in the region is explored.



Figure B.1 A typical battery-operated three-wheeler in Kathmandu Valley

B.2 The Success Story

B.2.1. Serious air pollution and smoke-belching three-wheelers

Gasoline-operated three-wheelers were introduced into the Kathmandu Valley as a cheap alternative to taxis in the late 1980's. Many cities in the Indian sub-continent had embraced this vehicle since foreign-

built cars were expensive and three-wheelers serviced short commuting routes cheaply. Three-wheelers carry three or four persons, including the driver in front, and are powered by two-stroke engines. Kathmandu then saw a sudden surge in the number of larger diesel-operated three-wheelers from 1989-92; each ferried ten passengers on its narrow chassis.⁴⁹

The vehicles plied the streets emitting thick black smoke and creating a lot of noise. At that time, there were no environmental standards for emissions from motor vehicles in the Valley. In 1992, due to the public outcry over these polluting three-wheelers, the government banned further registrations of new three-wheelers. Despite growing public awareness about air quality and pressure from NGOs and other civil groups, however, it failed to remove the vehicles from the streets altogether due to a number of local economic and political difficulties. For three years, policy makers failed to create any incentives for restricting the use of three-wheelers.

In a series of programmes designed to improve the environment, the government set emission standards for in-use vehicles in 1994 (65 HSU for diesel vehicles and 3% CO by volume for gasoline vehicles⁵⁰), formed the Ministry of Environment in 1995, and passed the Environmental Protection Act in 1997. Although it was announced that non-complying vehicles would be phased out within two years, by late 1998 (Budget Speech 2055/56), and a phasing-out programme was prepared by the Ministry of Environment, the Department of Transport Management, and local municipal governments in consultation with the private sector and NGO groups in early 1999, phasing out was a failure. An anti-diesel three-wheeler movement peaked in early 1999. NGOs, the tourism sector, cine-artists associations, local clubs and the public participated in street protests and road blockades of three-wheelers. Finally, in its 1999 budget (2056/57), the government provided an alternative to owners of diesel three-wheelers in the form of a 75% customs duty holiday on the import of twelve- to fourteen- passenger vans. In consequence, diesel three-wheelers were banned in the Valley from July 1999.

49 Built by Scooters India Ltd. with a payload of 1000 kg powered by a 10 HP, four-stroke, one-cylinder diesel engine.

50 This standard was later relaxed. For two-wheelers, a rate of 4.5% CO was set in early 1998.

**Box
B.2****Key dates**

- *November 1991* Ban on new registrations of three-wheelers
- *1993* Techno-economic feasibility demonstration of electric three-wheelers by Global Resources Institute
- *August 1994* Announcement of in-use vehicle emission standards
- *July 1996* Reduced import customs tariff and sales tax on electric vehicle parts
- *July 1999* Ban on in-use diesel three-wheelers
- *September 2001* Number of electric three-wheelers exceeded 600

B.2.2 Demonstration of techno-economic feasibility

Interest in converting from diesel to electric three-wheelers existed in the Valley as early as 1992. In 1993, at the request of the Kathmandu Metropolitan Corporation, a U.S.-based NGO called Global Resources Institute, with support from the United States Agency for International Development (USAID) and the U.S.-Asia Environmental Partnership Program, started a pilot project to design and convert diesel three-wheelers into electric three-wheelers. By 1995, a total of eight electric three-wheelers had been designed and tested on one of the major routes in the Valley for six months; they had carried over 200,000 passengers and travelled more than 175,000 km.⁵¹ This pilot project demonstrated that battery-operated three-wheelers are economically feasible in the local context. Apart from designing vehicles, the initiative also created awareness among and acceptance by the government, the private sector and the public.

B.2.3 Favourable government policy 1991-2000

Since 1995, the government has consistently adopted policies which directly and indirectly facilitate the electric vehicle (EV) industry. The

51 Peter Moulton and Marilyn Cohen (1998), Promoting Electric Vehicles in the Developing World, Paper presented at International Electric Vehicles Conference, Cosata Rica, November 1998.

National Transport Policy of 2001⁵² further consolidates the policy of promoting electric transportation system in the country. Indirect facilitation mainly consisted of banning diesel three-wheelers and thereby creating a market vacuum which electric three-wheelers could exploit. Direct facilitation included fiscal benefits in the form of reduced import customs tariffs and waivers on annual vehicle registration fees (annual registration fees were about 4,500 Rs/year in 2001). The 1996 budget⁵³ reduced customs duties on parts and accessories for electric three-wheelers to 1% and completely waived sales taxes.⁵⁴ A similar policy has continued to be implemented, thus greatly reducing the price of EVs and encouraging many private groups to invest in the EV industry. From the transportation management side, the government initially ensured EVs would have favourable routes by eliminating competition from other three-wheelers. Though this policy was later scrapped, it encouraged private sector investment. As for the fuel side, the state-owned Nepal Electricity Authority provided the electricity needed for charging batteries at low tariff rates. The EV industry began using surplus and unutilised energy during off-peak periods (at night) at low rates and the electric utility got a new market. There is currently no price difference between the rates for peak and off-peak charging although the possibility for introducing a graded system exists. Since most of Nepal's electricity is generated by run-off-river hydropower plants, battery charging is emission-free.

The EV sector also enjoys benefits that are offered to manufacturing industries. These deal with energy efficiency, energy conservation and pollution abatement as announced by the Industrial Enterprises Act of 2049 (Article 15e). Under this act, industries are entitled to discounts of up to 50% of taxable income for a period of seven years.

52 National Transport Policy 2058. Available from the Ministry of Labour and Transport, Kathmandu, Nepal.

53 Fiscal year 2053/54 budget presented to the Parliament.

54 Import duty (and sales tax) was 60% for diesel three-wheelers and 160% for four-wheelers. For batteries and electronic components, it was 20-40%. The same budget set a 5% duty (and sales tax) on components for EVs other than three-wheelers; and a 10% duty on all complete EVs.

Table B.1 Comparison of electricity tariff rates in 2002 December

	Fixed power cost	Running energy cost
Electric three-wheelers	Rs 200/kw (Rs 8000 for 40 kw)	Rs 4.30/kwh
Industry	Not available	Rs 5.10/kwh
Household	Not available	Rs 6.8/kwh

1 US\$ was about Rs 78 in 2002.

In the promotion of electric vehicles, four government bodies have played important roles: the Ministry of Environment, the Department of Transportation Management, the Ministry of Finance and Valley Traffic Police. Since it did not have jurisdiction over this area, the role of the Kathmandu Metropolitan Corporation was limited to pressuring the government and bringing stakeholders together.

B.2.4 Emergence of a new industry

The demonstration project demonstrated that battery-operated three-wheelers are technologically feasible in the Valley and inspired the private sector to invest. Since then, the private sector has fostered the expansion of EVs. The seven converted electric three-wheelers of the demonstration project were bought by a private company, which then expanded its fleet size to 15 vehicles and opened more routes. A total of about 500 million rupees⁵⁵ has been invested in the Valley's EV industry.⁵⁶ By 2002, over 600 electric three-wheelers had been manufactured and sold. Operated by the private sector, these vehicles ply 16 routes in the Valley and employ over 70 women drivers.

Box B.3 Performance of batteries

Type: *Trojan, US125 and Excite USA*

Cost: *Rs 60,000 per pack (12 6-V)*

Average driving distance per charge: *65 km*

Energy per charge: *15-18 Kwh*

Average cycle life: *450*

Average life: *18 months (a considerable improvement over the 9-10-month average earlier reported)*

⁵⁵ On average, an electric three-wheeler costs Rs. 540,000. Investment in a charging station investment amounts to about Rs. 1.5 Mn.

⁵⁶ Personal communication with the Electric Vehicle Association of Nepal.

The EV industry consists of three major groups: vehicle manufacturers, vehicle owners and charging station operators. Currently, there are about five major manufacturers,⁵⁷ 38 battery-charging centres, and many owners.⁵⁸ Each charging centre owns between five and 10 vehicles; individuals own the remainder.

Some success has been made in adapting local technology instead of relying on expensive imported technology, especially in chargers; this trend has reduced costs to some extent. The energy source for EVs, batteries, are a key determinant of whether or not EVs succeed. The cost and performance of batteries are often barriers to a full-scale diffusion of EVs in a transportation system. In the Valley, electric three-wheelers commute along short, fixed routes averaging about 10-13 km; total daily travel runs to 120 km and batteries are changed once a day. Three types of batteries are used: Trojan, US125 and Excite USA. Since their expense is a serious concern, a mechanism of battery leasing has been devised; today, 99% of all batteries are acquired from this system. A 50% down payment is made in the beginning and the remaining payments are made over several months on an instalment basis with 7% interest. This mechanism fostered the expansion of the industry.

The Electric Vehicle Association of Nepal is an umbrella organisation of the EV industry. It integrates the charging station operators' association, the manufacturers' association and the owners' association and lobbies for the EV industry with the government, the media and the public at large.

B.2.5 Efforts of NGOs and of civil society

The role of advocacy and civil groups was significant in opposing diesel three-wheelers and in facilitating the introduction of electric three-wheelers in the Valley. These groups organised a number of activities that created public awareness about air pollution, the role of polluting vehicles and the need for clean vehicles. They also created a forum to stimulate discussions among the private sector, the public and the government, highlighted technical and policy debates, and lobbied for EVs. The

57 The major EV manufacturers are the Nepal Electric Vehicle Industry (NEVI) and the Electric Vehicle Company (EVCO); each has a share of about 40% in the local EV market.

58 There are about 450 owners.

major NGOs and civic groups involved in these issues included Martin Chautari, Winrock International-Nepal Office, Leaders Nepal, Abhiyan Group (a group of cinema artists), Pro-public and Explore Nepal (a group in the tourism sector). A number of other organisations, groups and local clubs also took part in protests against diesel three-wheelers. At the peak of protests, groups such as Abhiyan and local clubs boycotted and physically blocked the operation of diesel three-wheelers on the streets, demonstration and mass rallies were organised, FM radio talk programs were held, and lawsuits were filed in court against diesel three-wheelers. The role of the media was favourable: it disseminated information air pollution from diesel three-wheelers and other motor vehicles to the public. All these activities put tremendous pressure on the government to act.

B.3 The Potential replication and Significance to Other Cities

B.3.1 Local conditions

In order to assess whether Kathmandu Valley's experience can be replicated elsewhere and what significance it has for other cities, it is important to identify the local conditions under which these electric three-wheelers were successful. The phasing-out of diesel three-wheelers and the introduction of electric three-wheelers were accomplished during a period of intense objection to visible air pollution; thus, public support was easily garnered. Geography, traffic patterns, travel demand, and energy availability affect the feasibility of EVs in any urban transportation system. In Kathmandu Valley all were favourable; the main barrier was limitations in battery technology. The area of Kathmandu Valley is about 550 km² and the majority of the vehicles ply inside a circle about 15-20 kilometres in diameter. The top speed of traffic in the city does not exceed 30-35 km/hour, while the average speed is as low as 10-12 km/hour. Under such conditions, neither top speed nor driving distance was a serious constraint for electric three-wheelers. Since these vehicles were to run on fixed routes, battery changing would be easy to carry out once or twice a

day. Nepal also has great potential for hydroelectric power. Most plants are run-of-river types, where electricity is “spilled away” if it not utilised during surplus or off-peak times. This made it possible to offer a low tariff rate for the off-peak charging of batteries. In addition, the country could save a huge amount of foreign currency (an important consideration for a trade-deficit country like Nepal) and financial resources ordinarily spent on foreign fossil fuels if a significant number of electric vehicles ply the streets. Although off-peak charging mechanisms and time-of-day tariffs were not created in the period from 1995 to 2000, the possibility of introducing them helped to create a favourable response among the public and policy makers. The interest of foreign donors was another important local factor. The roles of two donor communities, USAID (US ODA agency) and DANIDA (Danish ODA agency), was instrumental; USAID/US-AEP supported demonstration programmes and DANIDA provided support at later stages. Their interest helped to create a favourable response from policy makers.

B.3.2 Significance for other cities

Three-wheelers make up a significant part of the urban transportation systems in many cities in South Asia,⁵⁹ particularly those in India, Pakistan, Sri Lanka and Bangladesh. Three-wheelers are also popular in Chinese cities. In Bangkok, tuk-tuks are widely used for short-distance commuting. Despite their prevalence, governments in South Asia are fighting to phase out three-wheeler, which, because they run on two-stroke gasoline engines, have significantly exacerbated air pollution. Resistance, however, is high. Cheap modes of transportation like three-wheelers are closely linked to low-income groups and intertwined with urban poverty issues. Without providing an alternative to the owners, it is difficult to ban or replace polluting three-wheelers. In most cases, vehicles are being pushed out of cities rather than being phased out. Bangladesh announced a ban on three-wheelers with two-stroke engines in Dhaka City from 1 September, 2002; nearly 12,500 vehicles were affected.⁶⁰ The government of Bangladesh has permitted 5,000 four-stroke CNG three-

59 South Asia refers to Nepal, India, Sri Lanka, Pakistan, Bhutan, the Maldives, and Bangladesh (the Indian sub-continent).

60 Bangladesh Centre for Advanced Studies web-page <http://www.bcas.net/>. Accessed on 25 December 2002.

wheelers to ply the street to fill the gaps in travel supply which the ban created.⁶¹ Possibilities for replicating Kathmandu's experience in Dhaka are being examined by the South-South-North Project of the Bangladesh Centre for Advanced Studies (BCAS).⁶²

Table B.2 Number of three-wheelers in South Asia

Country	Number of three-wheeled vehicles	
	Two-stroke	Four-stroke
Nepal 1999	NA*	5,900 (including two stroke)
Bangladesh 1999	68,000	7,600
India 1997	1,180,000	210,000
Pakistan 1999	91,000	NA
Sri Lanka 1997	59,000	NA

*NA = data not available

Source: Masami Kojima, Carter Brandon, Jitendra Shah, *Improving Urban Air Quality in South Asia by Reducing Emissions from Two-Stroke Engine Vehicles*, The World Bank, December 2000, Washington DC.

Drawing upon what it learned from its successful demonstration in Kathmandu of converting diesel three-wheelers to electric ones, USAID went on to provide assistance to India in a programme called "India Zero Emission Transportation Program (IZET) in 1999-2003. The objective of this programme was to reduce the adverse health impacts from vehicular emissions. This demonstration program designed, tested, and assembled 1,000 electric three-wheelers in Delhi, Agra and Pune. Under this programme, seven three-wheelers were successfully field tested in the city of Agra for one year. In view of this success, two private companies (Bajaj Auto Limited of India and New Generation Motors of the U.S.) are entering into a joint venture to produce 1,000 electric three-wheelers in India. USAID will provide US\$ 3.9 million of the US\$ 9.3 million programme; the remainder of the cost of investment will be borne by the private sector.⁶³

61 Bangladesh has large natural gas reserves and an extensive network of gas pipelines in Dhaka.

62 Recent BCAS News <http://www.bcas.net/>. Accessed on 3 January 2003.

63 For the complete project, see the web -page of the U.S. Department of Energy, Office of Policy and International Affairs, <http://www.pi.energy.gov/library/EWSLIndia-izet.pdf>

Kathmandu's experience is a good case for exploring the role of electric three-wheelers in cities where a significant number of gasoline or diesel three-wheelers exist and where three-wheelers are responsible for a significant volume of air pollution. However, introducing EVs is limited to designing and testing vehicles; this step should be supplemented by increasing public awareness and acceptance, creating laws and regulations, government policies and incentive mechanisms which remove initial market barriers, and inviting private investment on a commercial basis. The cooperation of the government, the private sector and advocacy groups facilitates the successful introduction of EVs. It should be mentioned that three-wheelers are a low-occupancy public transport mode and that a large-scale penetration of these vehicles may slow down other forms of transport through congestion and other externalities. Three-wheelers are best suited for short commutes and full integration with high-occupancy public vehicles through well-designed transportation planning is essential.

Acknowledgements: The author is grateful to many individuals for sparing time for interactive discussions.

The author is solely responsible for all opinions as well as all omissions or mistakes, if any, in this paper.

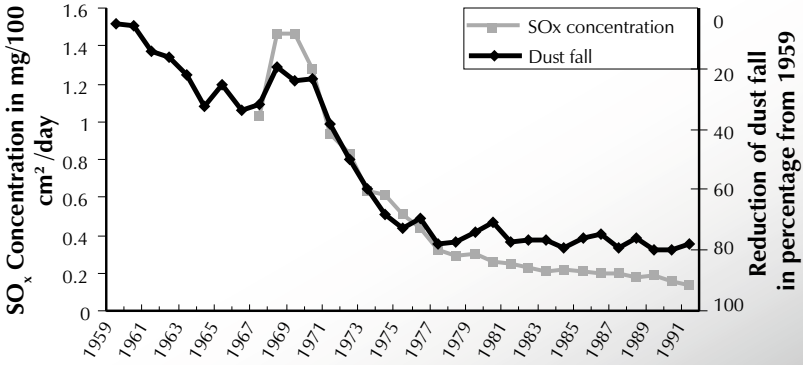
The author is grateful to the following people in particular for their time: Sushil Agarwal (Department of Transport Management); Bhusan Tuladhar (Clean Energy Nepal); Bikas Pandey, Ratna Sansar Shrestha and Ranjan Shrestha (Winrock International-Nepal); and the Electric Vehicle Association of Nepal.

Success in Controlling SO_x Emissions in Kitakyushu, Japan

C.1 Introduction

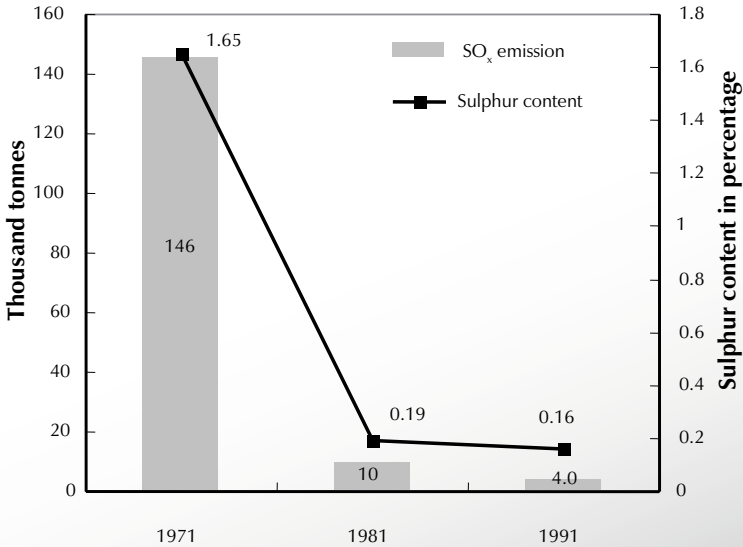
Kitakyushu was one of the most polluted cities in Japan during the 1960s and early 1970s due to industry-related pollution, such as high sulphur oxide concentrations and dust fallout. Since then, the city has taken drastic measures to improve reduce air pollution. As a result, it enjoyed both high economic growth as well as better air quality in later years. In fact, in recognition of its achievement, Kitakyushu was awarded the Global 500 Award by UNEP in 1990.

In the 1960s, Kitakyushu was one of the most industrialised cities in Japan; it was dominated by heavy industries, including paper and pulp, steel and petro-chemicals. A large quantity of energy, generated primarily by coal, was consumed. The high sulphur content of coal, the inefficient use of energy, inefficient industrial production processes, and non-utilisation of end-of-pipe technologies to reduce the emission sulphur oxides were major problems. Under pressure from residents, the government of Kitakyushu forged a partnership with industries to improve air quality through various means. The process involved strengthening local regulations, encouraging voluntary measures by industries, promoting technology, improving the quality of fuel, providing incentives to small- and medium-scale industries, strengthening monitoring systems and enhancing the institutional capacity of the local government.



Source: Modified from Masaharu Inoue, Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.

Figure C.1 SO_x concentration and dust fallout



Source: Masaharu Inoue, Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.

Figure C.2 SO_x emission and average sulphur content of fuels

C.2 Processes and Policies

The motivation for the local government to act to reduce concentrations of SO_x and dust, in particular, dates to the mid-1960's, when women's protest movements introduced the slogan "We want our blue sky back." This campaign increased awareness among people about the negative aspects of environmental pollution. Despite pressure from polluting enterprises, these women's groups petitioned and challenged the local government with their own studies on air quality. In other Japanese cities such as Kawasaki and Osaka, too, resident groups confronted polluting enterprises and the local government. The anti-pollution movement had a lot of political repercussions in those cities: local political leaders carried out anti-pollution measures partly because of the leftist party's active environmental agenda and ongoing campaigns for public awareness and environmental improvement. Polluting enterprises were urged to cut emissions significantly. Ultimately, voluntary agreements to implement pollution control measures were signed by residents, polluting enterprises (48 companies and 57 factories) and the local government in March 1972; they were renewed in January 1977.

The air pollution countermeasures implemented by the city government can be classified as follows:

- Strengthening local regulations and enhancing institutional capacity
- Improving fuel quality and encouraging fuel substitution
- Providing technical guidance and enhancement in the manufacturing process
- Changing the industrial structure
- Relocating factories away from residential areas
- Implementing financial mechanisms such as subsidies

C.2.1 Strengthening local regulations

In addition to the anti-pollution laws enforced by the national government (regulating environmental quality standards, emission standards, area-wide total pollution load control, and automobile exhaust emissions), Kitakyushu itself formulated strict laws, regulations and inspection systems, including (1) a new plant modification order,

improvement order, and strict inspection of smoke and soot treatment facilities, (2) continuous pollution monitoring, and (3) emergency measures (1969-74). The emergency measures demanded that industries systematically reduce SO_x emissions by 20%, 30% and 50% during the implementation period. Local regulations also included time and quantity reductions. For time regulations, a weather information system was developed in order to issue smog warnings and special weather events that would aggravate pollution concentration. Once a warning was issued, individual industries were required to implement the designated reduction in quantity during the time period specified. The K-value⁶⁴ regulation, in which the quantity of emissions was regulated by the height of the exhaust port, was set at 1.75; this was the second strictest value in Japan.

C.2.2 Enhancing institutional capacity

In order to support these countermeasures, the institutional capacity of the environmental section was enhanced by increasing the number of qualified staff members, introducing a monitoring system and improving equipment. The table below shows the number of administrative and research staff members employed since the early 1960s.

Table c.1 number of administrative and research staff

Year	Status	Administrative	Research
1963	Subsection	4	-
1965	Section	8	9
1870	Division	22	17
1971	Bureau	25	21
1977	Bureau	75	45

Source: Masaharu Inoue, *Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.*

The authority for making decisions about regulations and standards and smog warnings was shifted from Fukuoka Prefecture to Kitakyushu in

⁶⁴ In K-value regulation, allowable emissions are given as $n \text{ Nm}^3/\text{hr} = K * 10^{-3} * \text{He}^2$, where, He = effective stack height in meters, K=1.75meters., K = 1.75 m for Kitakyushu.

1970. This transfer of authority to the local body enabled the city to act quickly and created a sense of ownership among the city council, administration, enterprises and residents. Following this step, the Kitakyushu Air Pollution Prevention Joint Council, consisting of representatives from the national government, Fukuoka Prefecture and key polluting enterprises, was established. This council played a key role in implementing a wide range of countermeasures. The decentralisation of responsibilities within Kitakyushu itself was also a key institutional measure.

Apart from the local government's actions, enterprises which met certain criteria were mandated to have pollution control managers whose job was to manage technical and managerial matters related to pollutants. Such managers had to pass a national qualifying examination.

C.2.3 Fuel substitution and fuel quality improvement

Yet another key component of the countermeasures was the type and quality of fuel used. The city government encouraged enterprises to shift from coal-based energy systems to liquid fuel and then, gradually, to natural gas. The figure below shows the consumption of fuels in Kitakyushu. As these changes were accomplished, the sulphur content per unit of energy consumption was drastically reduced. The first stage of the process involved switching from coal to crude oil (sulphur 1%) in the 1960s. This was followed by a switch to low-sulphur crude oil (0.15%) and light oil, then to LPG, LDG and finally to LNG.

C.2.4 Technology during the manufacturing process and at the end of the pipe

Efficient manufacturing processes results in large energy savings. The following technology enhancements were carried out:

- Conversion to efficient processes such as cement kilns.
- Switching raw materials. Ferric sulphide replaced sulphur in sulphuric acid plants, for example.
- Desulphurisation of furnaces.
- Phasing out of small and medium-size boilers and introducing large-scale boilers.

- Introduction of better equipment.
- Recycling of waste energy.
- Increasing the height of chimney stacks
- Introducing end-of-pipe technology, in particular, FGD (fluidised gas desulphurisation) installations

The introduction of clean production (CP) measures was successful in considerably reducing energy consumption and emissions. The figure below shows the contribution of CP to SO_x reduction.

The local government’s provision of know-how and technical support to polluting enterprises by the local government was important. Local government employees, experts and other relevant persons on many occasions carried out pollution diagnoses and provided needed technical guidance to manufacturing establishments. They helped identify appropriate improvement measures and, at the same time, enhanced the degree of understanding and trust between the government and the enterprises.

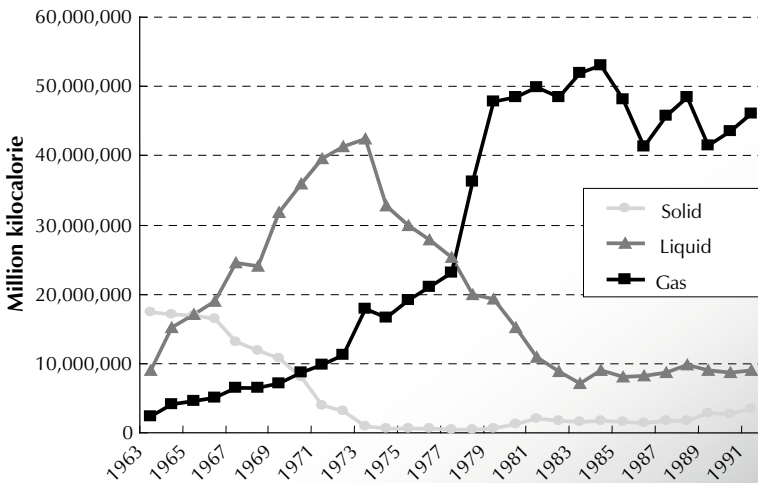
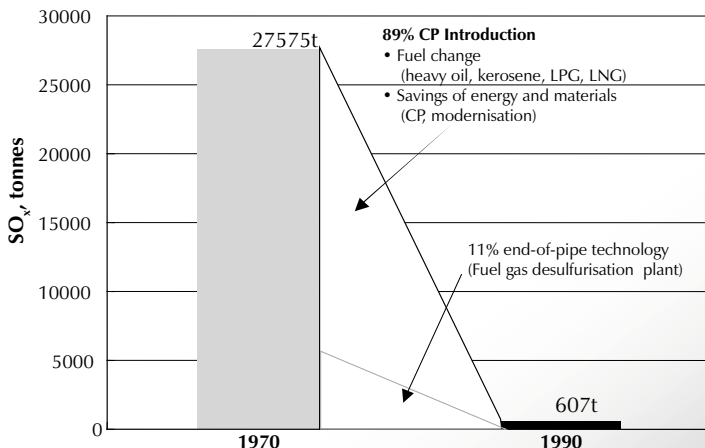


Figure C.3 Energy consumption in Kitakyushu City



Imai, S. Undated, Features of Pollution Control in Japan, Tokyo:

Source: Masaharu Inoue, Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.

Figure C.4 Reduction of SO_x emissions by various means

C.2.5 Factory relocation away from residential areas

In order to make controls effective and to reduce residents exposure to high SO_x concentration of SO_x, several factories were relocated from residential areas to industrial areas near the coastal zones. In the Okidai area, for example, approximately 100 factories were relocated to three industrial zones. Many relocated industries were steel and chemical. At the same time, residents of densely industrialised areas were persuaded to be relocated to less polluted area such as the Shiroyama area, where more than 650 households were resettled.

C.2.6 Financial mechanisms and subsidies

No activity described above would have been possible without the local government's financial facilitation of enterprises, particularly small- and medium-scale ones. Financial mechanisms consisted of (1) a public capital financing system and (2) tax incentives. The core of control measures was technological enhancements and fuel switching. The capital needed to implement technical countermeasures so that the terms

of voluntary agreements and regulations could be met was provided at low interest rates. The payback period (7-20 years) depended on the type of company.

Tax system benefits at both the national and the local level were introduced to reduce the financial burden of maintaining and managing pollution control equipment and activities. This included tax exemptions and reductions on fixed assets related to pollution control facilities and equipment and the extension of the terms for repayment applied.

The table below shows local governmental financing for air pollution countermeasures introduced by small- and medium-scale companies.

Table C.2 Local government support to small- and medium-scale companies

1968-95	Number of cases	Million US\$
Air pollution	57	4.8
Odour	19	1.0
Noise	161	15.0
Water pollution	45	3.0
Others	11	0.6

Source: *Communication with Kitakyushu officials*

C.2.7 Future considerations for the planning process

The local government included considerations for future development in subsequent years of planning. They included planning based on the number of anticipated industrial facilities, the scientific analysis of the relationship between source and pollution distribution, support from wind tunnel tests and computer simulations, and prediction models.

C.2.8 Enforcement

Without enforcement of regulations and standards, success cannot be achieved. The inspection systems developed by the local government included spot inspections, tele-metering and routine inspections. Violators were first given warnings and allowed to make needed modifications in two stages and, if this proved unsuccessful, were fined and imprisoned.

C.3 Lessons Learned

- Promoting public awareness and ensuring political will are important for tackling environmental problems.
- Comprehensive planning based on scientific approaches can produce good results.
- Anti-pollution measures should be implemented after taking stakeholders into confidence.

C.4 Replication

SO_x emission control in an urban industrial city is Kitakyushu's distinctive feature. Most of its achievements were made by implementing technical measures, mainly, modifying manufacturing processes and improving fuel quality, coupled with effective enforcement and monitoring. The case is of interest to rapidly industrialising cities, such as those in China and others Asian countries. Some conditions in Chinese cities are similar to those in Kitakyushu, such as a rapidly growing economy, the availability of plenty of city revenue, and a coal-based economy in transition to liquid and gaseous fuels. The experience of the local government of Kitakyushu in making a significant achievement in CP techniques by taking industry into its confidence might be useful for cities in Southeast and North Asia. Since technology, time and approaches have changed in recent years and since only a few aspects of the successful experience in one city can be transferred to another due to local conditions, caution must be taken in any attempt at replication.

Asian Mega-Cities

Cities in rapidly industrialising regions of Asia are confronted with multiple tasks for economic development and environmental protection. They tend to give priorities to immediate and local issues, and consider global warming as a far-away issue. The nature of energy use and greenhouse gas emissions from cities is not well understood in Asia. In fact, municipal policies to reduce energy consumption brings multiple benefits to the community. It helps to solve air pollution and traffic congestion, and also facilitates the reduction of CO₂ emissions.

Energy management at city level was neither a priority nor an important issue until recently because energy related decisions are made at the national level. These days, city policy makers are under growing pressure to incorporate greenhouse gases, especially CO₂ emissions into consideration while planning. But any policy measure solely for CO₂ reduction is a distant possibility for cities in Asia, with the exception of selected and relatively developed cities. Integrating energy consideration into policies, either by integrating energy concerns to overall urban development or by synergising measures to reduce air pollution and CO₂ emissions, is important. Therefore, efforts should be directed towards providing support to cities in generating knowledge and in building their capacity to understand the problem and to find possible measures for implementing policies. The prerequisite for systematic action is the analysis of CO₂ emission budgets of cities, their drivers and associated policy analyses.

In this context, ***Urban Energy Use and Greenhouse Gas Emissions in Asian Mega-Cities: Policies for a Sustainable Future*** aims to quantify CO₂ emissions from energy use and analyse their driving factors for selected Asian Mega-Cities—Tokyo, Seoul, Beijing and Shanghai. It presents discussions on the nature of future challenges. Further, it highlights the needs for taking into account the overall energy and CO₂ “footprint” of cities. Finally, it presents policy directions, policy challenges and identifies major opportunities and barriers for integrating CO₂ considerations into local environmental policies.



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