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Low Carbon Transport in Asia

Strategies for Optimizing Co-Benefits

EDITED BY
Eric Zusman Ancha Srinivasan Shobhakar Dhakal

Low Carbon Transport in Asia

"This hugely important book arrives just in time. It is essential reading for those concerned about the future of our cities and vehicles. The authors tell us why strategies to reduce carbon emissions are the same strategies needed to create more livable, vibrant cities, and what to do about it."

Daniel Sperling, Director,
Institute of Transportation Studies, University of California, Davis, USA

Developing Asia is at a crossroads. Over the next few decades, the region's policymakers could formulate transport strategies that promote fuel-efficient vehicles, modern public transport, and sustainable land-use planning or become locked into inefficient vehicles, energy-intensive infrastructure, and suburban sprawl. The path taken will have implications inside and outside Asia, and it will depend upon the extent to which co-benefits are incorporated into a range of decision-making processes.

Integrating co-benefits into transport decisions can help determine which policy options mitigate greenhouse gases (GHGs) while improving local air quality, commuting times, and energy security. Factoring in both climate change and development co-benefits can allay concerns over GHG mitigation costs or bring carbon finance to development needs. But it can also present decision-makers unaccustomed to optimizing multiple benefits with unique technical, financial, and institutional challenges. This book represents a pioneering effort to identify and remove these barriers, thereby making it easier for Asia to take the low carbon path.

The book's first section presents analytical frameworks to classify transport strategies with co-benefits, offering new findings on black carbon and dieselization. The second section grounds the analytic work in case studies on fuel switching in Pakistan, urban planning in Bandung, congestion charges in Beijing, vehicle restraints in Hanoi, and bus rapid transit in Jakarta. A final section examines how the future climate regime can enable low carbon transport in Asia.

This book is essential reading for policymakers, planners, and researchers concerned with transport, climate change, and development in Asia and the wider world.

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Foreword

Few images better illustrate the limits to growth than the traffic routinely lining the streets of Bangkok, Beijing, and other rapidly motorizing cities in Asia. But long lines of idle vehicles are not the only signs that Asia's cities are fast approaching a metaphorical dead end. Other indications include an expanding public health threat from mobile source air pollution, rising safety concerns from traffic accidents, and deepening dependencies on foreign oil. Meanwhile, a predicted five-fold increase in Asia's transportation-related carbon dioxide emissions (CO_2) between 2000 and 2050 suggests that the costs of rapid motorization may extend to future generations outside the region. Though policymakers have become cognizant of each of these problems, they have tended to miss the co-benefits from managing them in an integrated manner.

The oversight stems in part from a gap in research on co-benefits. Energy experts conceived of "co-benefits" in the early 1990s when their models suggested pricing carbon could yield collateral air quality and public health benefits. During the next two decades, a literature emerged evaluating the co-benefits from interventions ranging from energy efficiency reforms to Clean Development Mechanism (CDM) projects. More recently, studies have looked at the co-benefits from low carbon policies and measures in key sectors. These studies made it clear that co-benefits needed to be explicitly acknowledged and incorporated in policymaking processes. But they did not make it clear how to bring research on co-benefits to bear on policy. Hence this book picks up where others studies leave off—and it does so in developing Asia's transportation sector.

The book shows that bridging co-benefits research and policy will be challenging in developing Asia's transportation sector. Not only are policymakers often skeptical that climate change can be compatible with development, but also national institutions and the international climate change regime have offered few incentives to reason otherwise. The book then recognizes it is important to move from 1) an analysis of co-benefits; to 2) their consideration in national policies; to 3) potential support from the international climate change regime. The book's three sections—analytical frameworks, case studies, and international initiatives—offer insights from

these three unique perspectives. More importantly, they collectively help produce a set of complementary operational, policy, and enabling reforms needed to leverage co-benefits for low carbon transport in developing Asia. In so doing, it is also hoped that the book will generate images of an Asia fast approaching a more sustainable, low carbon future.

Achieving a sustainable, low carbon future in Asia is consistent with the mission of the Institute for Global Environmental Strategies (IGES). IGES is an international research institute based in Hayama, Japan that conducts strategic policy research on sustainable development in Asia and the Pacific. Many of the book's chapters were submitted for an IGES supported pre-event at the Clean Air Initiative for Asian Cities (CAI-Asia) 2008 Better Air Quality (BAQ) Conference in Bangkok, Thailand. Revisions were made based on blind peer reviews and feedback at the International Forum for a Sustainable Asia and the Pacific (ISAP) in Hayama, Japan in 2009. The book has benefited greatly from those exchanges and the collective wisdom of many others along the way.

Hironori Hamanaka
Hayama, September 2011

Preface

Michael P. Walsh

Introduction

On-road motor vehicles cause urban air pollution, congest our cities with traffic, and often add unwelcome noise and stress to our lives. While there has been significant progress in developing air pollution abatement for gasoline- and diesel-fueled cars and trucks, growth in vehicle population and vehicle kilometers traveled, especially in rapidly industrializing countries in Asia, will offset many of these gains (WBCSD 2004). And from a climate standpoint, the transport sector is the world's fastest growing source of greenhouse gases (GHGs) (Wright and Fulton 2005).

The fact that the above problems are interrelated offers hope for a resolution. That resolution involves co-benefits. A co-benefit approach treats urban air pollution, congestion, noise pollution, and climate change as an integrated set of problems needing an integrated solution. As this book demonstrates, a co-benefits approach requires a transformation in how policies are formulated and implemented similar to the technical advances that brought reductions to urban air pollutants emissions. This preface outlines why such a transformation is both challenging and necessary. It begins by reviewing trends in motor vehicles and emissions before outlining why a co-benefit approach holds the key to low carbon transport in Asia.

Trends in world motor vehicle fleets

The three primary drivers behind the growth in the world's vehicle fleet are: population, urbanization, and economic development. All three continue to increase, especially in Asia. According to the United Nations, the global population grew from approximately 2.5 billion people in 1950 to about 7 billion today; and the population is projected to increase to approximately 9 billion by 2050. Annual gross domestic product (GDP) growth rates over the next two decades are also forecast to be high, particularly in Asia. As a result, a steady and substantial growth in the global and regional vehicle population (WBCSD 2004) is forecast to follow the historical trends in Figure 0.1.

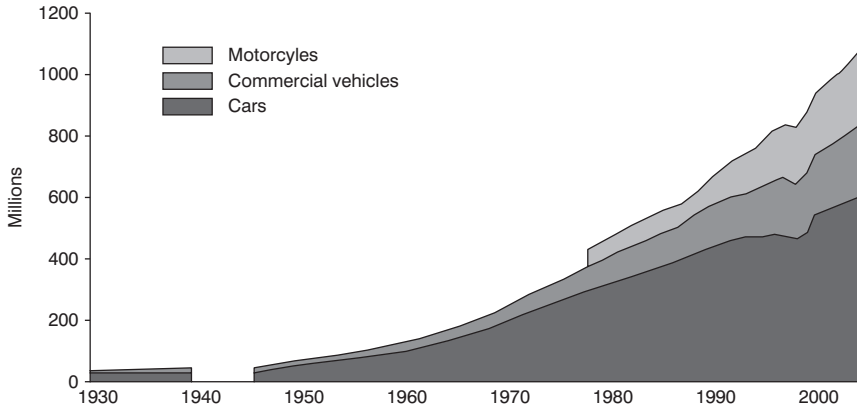

Figure 0.1 Trends in world motor vehicle production

Overall growth in the production of motor vehicles, especially since the end of World War II, has risen from about 5 million motor vehicles per year to over 70 million. In fact, between 1970 and 2005 approximately one million more vehicles have been produced each year than the year before (Wards 2006). Motor vehicle production has gradually moved from North America in the late 1950s to Europe by the late 1960s to Asia in the 1980s. In 2007, Asia became the largest producer of cars, trucks and buses in the world. While this surge started in Japan, recent growth has been centered in China. As illustrated in Figure 0.2, China is currently the world's first or second largest producer of motorcycles, cars, trucks and buses and is rapidly becoming a major market as well (Sperling and Gordon 2009).

Trends and motor vehicle emissions

The motorization of Asia has already had an impact on local air quality. Motor vehicles emit large quantities of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), sulfur oxides (SO_x), and toxic substances such as benzene, formaldehyde, acetylaldehyde, 1,3-butadiene, fine particles, and lead. Each of these pollutants, along with secondary by-products such as ozone (O_3) and particulate matter, can have adverse effects on health and the environment. Because of growing vehicle populations and resulting emissions, the fraction of health damaging pollution due to motor vehicles is rising in many cities in Asia.

The GHGs most closely identified with the transportation sector are three of the six main Kyoto gases, CO_2, nitrous oxide (N_2O), and methane (CH_4). The global warming potentials (GWPs) of N_2O and CH_4, relative to CO_2, are presented in Table 0.1. It is also important to point out that other vehicle-related pollutants contribute to global warming, although their quantification has been difficult; these include CO, non-methane hydrocarbons (NMHC),

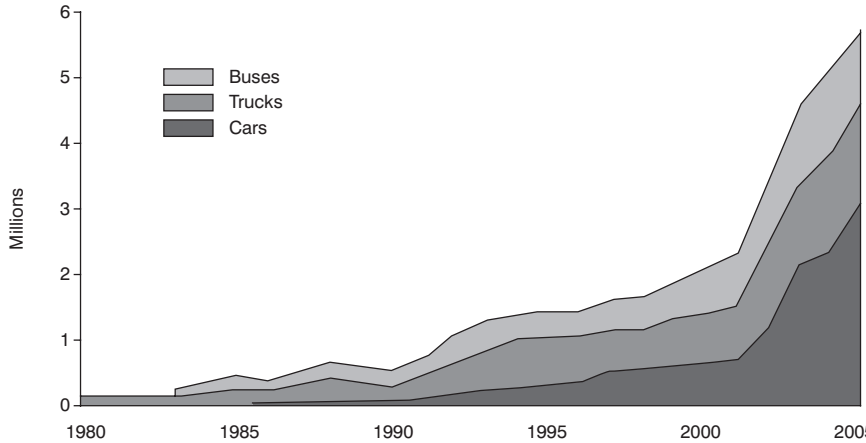

Figure 0.2 Production of cars, buses, and trucks in China

and nitrogen dioxide (NO_2). It is generally agreed, for example, that CO emitted from vehicles is eventually converted to CO_2 in the atmosphere and in the process consumes hydroxyl radicals which might otherwise reduce CH_4 concentrations. Similarly NMHCs and NO_x contribute to global background tropospheric ozone, a potent GHG. The GWPs listed in Table 0.1, including those attributed to CO, NMHCs and NO_2, are from the assessment report of the (1990) Intergovernmental Panel on Climate Change (IPCC) report.[1]

There is also growing concern that black carbon (BC) or soot emitted from diesel vehicles and other sources is a potent GHG, in part due to the snow albedo (reflectivity) effect for solar radiation. According to the IPCC, BC is at least the third largest contributor to the positive radiative forcing that causes climate change. This is based on its estimated direct radiative forcing value of 0.34 W m^{-2} and the value of its snow albedo effect of 0.1 W m^{-2}. The combined effect, 0.44 W m^{-2}, is undoubtedly positive. In fact, Ramanathan and Carmichael have recently concluded that, "emissions of black carbon are the second strongest contribution to current global warming, after carbon dioxide emissions"(Ramanathan and Carmichael 2008).

Table 0.1 Global warming potentials of transport pollutants

GWP	*Carbon dioxide (CO_2)*	*Methane (CH_4)*	*Nitrous oxide (N_2O)*	*Carbon monoxide (CO)*	*Non-methane hydro-carbons (NMHC)*	*Nitrogen dioxide (NO_2)*
100-year time horizon	1	21	310	3	11	7

Source: IPCC 1990

Trends in emissions reductions programs

Reducing the pollution that comes from vehicles usually requires a comprehensive strategy. Generally, the goal of a motor vehicle pollution control program is to reduce emissions to the degree reasonably necessary to achieve healthy air quality as rapidly as possible or, failing that for reasons of impracticality, to the practical limits of effective technological, economic, and social feasibility. A comprehensive strategy to achieve this goal includes four key components: 1) increasingly stringent emissions standards for new vehicles; 2) specifications for clean fuels; 3) programs to assure proper maintenance of in-use vehicles; and 4) transportation planning and demand management. These emission reduction goals should be achieved in the most cost-effective manner possible.

In almost every region, for every type of road vehicle and fuel, there is a clear trend toward increasingly stringent emissions requirements. Over the next decade, this pattern is moving toward similar controls for off-road vehicles and fuels. Driving these trends are several factors:

- the aforementioned growth in the number of vehicles (especially in China) and their concentration in urban areas where pollution levels remain unacceptably high;
- the accumulation of health studies that show adverse impacts at lower and lower levels and in the case of PM at virtually any level; and
- advances in vehicle technology and clean fuels that are making it possible to achieve lower and lower emissions levels at reasonable costs.

As suggested in the last bullet point, often progress in reducing emissions comes from combining cleaner fuels and technologies. For instance, almost every country in Asia has completed the elimination of lead from gasoline and started to reduce the sulfur levels in both gasoline and diesel. The reduction of sulfur levels has been beneficial for two reasons. First, sulfur is emitted as sulfur dioxide (SO_2) or sulfate particulate matter – both pollutants with wide-ranging impacts on human health, acidification of ecosystems and visibility. Second, cleaner fuels allow the introduction of vehicle pollution control technologies with the result that virtually every new gasoline-fueled car being sold in Asia comes equipped with a catalytic converter. Sulfur reductions and regulations will enable the use of improved catalysts, filters, and other technologies that can remove most of the pollution from gasoline and diesel fueled vehicles (UNEP 2007).

Technologies and fuels are now in the marketplace or rapidly emerging which in combination with clean fuels can lower road vehicle emissions of CO, HC, NO_x, and PM and other toxins to a very small fraction of what they were per kilometer driven. The major challenge now is getting these technologies adopted around the world.

Trends in reducing GHGs

In contrast to urban air pollutants, the prognosis for mitigating GHGs is less promising. Even in developed countries CO_2-equivalent emissions from the transportation sector grew significantly between 1990 and 2010; in fact, the growth in the transportation sector was by far the largest of any major sector during the period.

A variety of measures to reduce GHGs in the transportation sector are under development. Examples include: 1) mandatory fuel economy requirements or GHG emissions standards for motor vehicles; 2) shifts to renewable, lower carbon fuels; 3) mandating advanced vehicle technologies including battery electric cars, hybrids, plug-in hybrids and fuel cells; and 4) approaches to reduce vehicle kilometers driven, including congestion pricing, bus rapid transit (BRT), and vehicle and fuel taxes. Many countries have proposed, established, or are in the process of tightening motor vehicle fuel economy or GHG emission standards. These include the United States, the European Union, Japan, Canada, Australia, China, and South Korea. China has already implemented the second stage of its fuel consumption control program and is in the process of developing its next generation of requirements. India has also started introducing new fuel economy requirements.

But with regard to the impacts of transportation on climate change, to date the overall growth in vehicles is overwhelming control efforts. A variety of approaches to reduce vehicle kilometers driven, such as congestion pricing, BRT, and vehicle and fuel taxes, are making inroads in many parts of the world and these have the potential to reduce both conventional air pollution and GHG emissions, but require significant administrative and financial resources.

The Bellagio Memorandum

In June of 2001, a group of 18 experts met in Bellagio, Italy to develop a set of principles for the next generation of government actions that will shape future motor vehicle technology. The group included top regulators and experts from China, India, Thailand, the European Commission, France, Germany, Japan, and the United States. The meeting focused on air pollution emissions from road transport, including conventional and toxic pollutants as well as GHGs. The meeting arrived at a set of 43 principles reflecting the consensus opinion of the experts in attendance (Energy Foundation 2002). One of the most important of the Bellagio principles was that clean vehicle strategies should promote air quality (including air toxics) and greenhouse goals in parallel. To significant extent, this book demonstrates this principle's importance to a rapidly motorizing Asia.

The book's main argument is that treating greenhouse goals and other development priorities "in parallel" or through what is termed a co-benefit approach, holds the key to a low carbon future in Asia. A co-benefit approach's

appeal is simple: it can reduce concerns that benefits from low carbon policies will only be global, long-term and uncertain by identifying policies which also have local, near-term, and certain benefits (Krupnick et al. 2000). Yet, as the book also demonstrates, realizing the potential of a co-benefits approach is not simple. It requires 1) frameworks for analyzing which policies and measures can maximize synergies between climate and development goals; 2) experiences with the barriers encountered in developing and implementing those policies and measures; and 3) an appreciation of how the international climate change regime, development agencies, and foreign governments can address remaining challenges at the international level. The book will make a valuable contribution to each of these areas. To a significant extent, it demonstrates that the next great challenge to mobility requires a different approach to policymaking. It also demonstrates that efforts to overcome this challenge will be based in Asia.

Note

Because of difficulty reaching agreement on the appropriate quantification, specific GWPs for these gases were not contained in the most recent Intergovernmental Panel on Climate Change (IPCC) report.

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Eric Zusman, Ancha Srinivasan, and Shobhakar Dhakal

Abbreviations

ADB	Asian Development Bank
APPCB	Andhra Pradesh State Pollution Control Board
AWG-KP	Ad Hoc Working Group on Further Commitments for Annex-1 Parties under the Kyoto Protocol
AWG-LCA	Ad Hoc Working Group on Long-term Cooperative Action under the Convention
BAQ	better air quality
BAU	business as usual
BC	black carbon
BCA	benefit-cost analysis
BJTRC	Beijing Transportation Research Center
BMA	Bangkok Metropolitan Administration
BMBLR	Beijing Municipal Bureau of Land and Resources
BMCHURD	Beijing Municipal Commission of Housing and Urban–Rural Development
BMCT	Beijing Municipal Commission of Transport
BMDRC	Beijing Municipal Development and Reform Commission
BMEPB	Beijing Municipal Environmental Protection Bureau
BRT	Bus Rapid Transit
C_5H_5	cyclopentadienyl
CAFE	Corporate Average Fleet Efficiency
CAI-Asia	Clean Air Initiative for Asian Cities
CDM	Clean Development Mechanism
CEC	Central Environment Council
CERs	certified emission reductions
CH_4	methane
CIE	Chief Inspector of Explosives
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
COP	Conference of the Parties
CPCB	Central Pollution Control Board
DALY	disability-adjusted life year
DIESEL	Developing Integrated Emissions Strategies for Existing Land-transport
DOC	diesel oxidation catalysts

DPF	diesel particulate filters
EC	European Community
EIA	environmental impact assessment
EMR	Extended Metropolitan Regions
ENERCON	Energy Conservation Centres
EPA	Environmental Protection Agency
ERP	Electronic Road Pricing
EU	European Union
Euro-I	Europe I emissions standard
Euro-II	Europe II emissions standard
Euro-III	Europe III emissions standard
FAS	free acceleration smoke
FDI	foreign direct investment
G8	Group of Eight
GAPF	Global Atmospheric Pollution Forum
GCP	global cooling potentials
GDP	gross domestic product
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (formerly Deutsche Gesellschaft für Technische Zusmmanarbeit or GTZ)
GPS	global positioning systems
GT	gigatonnes
GVW	gross vehicle weight
GWP	global warming potential
HAIDEP	Hanoi Integrated Development and Environment Program
HAPAP	Hyderabad Air Pollution Action Plan
HC	hydrocarbons
HDDV	heavy-duty diesel vehicles
HDIP	Hydrocarbon Institute of Pakistan
HEI	Health Effects Institute
HUDA	Hyderabad Urban Development Area
I/M	inspection and maintenance
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
IES	Integrated Environmental Strategies
IGES	Institute for Global Environmental Strategies
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
ISAP	International Forum for a Sustainable Asia and the Pacific
ITDP	Institute for Transportation and Development Policy
ITF	International Transport Forum
JICA	Japan International Cooperation Agency
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KBA	German Federal Motor Transport Authority
LEM	Law on Environmental Management
LPG	liquefied petroleum gas
LSPM	Law on Spatial Plan and Management
LTOT	Law on Traffic and Overland Transports

MAQML	mobile air quality monitoring laboratory
MMTS	multi-modal transport system
MoE	Ministry of Environment
MoEJ	Ministry of the Environment, Japan
MRV	measurable, reportable, and verifiable
N_2O	nitrous oxide
NDRC	National Development and Reform Commission
NGOs	non-governmental organizations
NGVs	natural gas vehicles
NMHC	non-methane hydrocarbons
NMT	non-motorized transport
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
O_3	ozone
ODA	Official Development Assistance
OECC	Overseas Environmental Cooperation Center, Japan
OECD	Organisation for Economic Co-operation and Development
OGRA	Oil and Gas Regulatory Authority
OMCs	oil marketing companies
PAPA	Public Health and Air Pollution in Asia
Pb	lead
PCU	passenger car unit
PM	particulate matter
PPP	public-private-partnership
PUC	pollution under control
RNSP	Regulation on National Spatial Plan
SD-PAMs	sustainable development policies and measures
SEA	strategic environmental impact assessment
SO	sulfur monoxide
SO_2	sulfur dioxide
SO_x	sulfur oxides
SPM	suspended particulate matter
SUTP	Sustainable Urban Transport Project
TDM	transport demand management
TSP	total suspended particulates
UITP	International Union of Public Transport
ULSD	ultra-low sulfur diesel
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
VQS	vehicle quota system
WBCSD	World Business Council on Sustainable Development
WHO	World Health Organization
WRI	World Resources Institute

Part I
Introduction

1 Low carbon transport and co-benefits in Asia

An overview

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Introduction

Developing Asia[1] is rapidly motorizing. Though the majority of the region's population relies upon non-motorized transport, a fast-growing proportion is turning to motorized vehicles. The negative externalities from this shift are mounting quickly. From Beijing to Bandung, policymakers are struggling to control urban air pollution, curb on-road congestion, and cut petroleum imports. The consequences of developing Asia's motorization do not end in the region, however. Carbon dioxide (CO_2) emissions from developing Asia's transport sector are predicted to grow from nearly 1 billion tons to more than 2 billion tons per year between 2005 and 2030 (WBCSD 2004, ADB 2009).[2] Without a significant deviation from these predictions, growth in the region's transport-related greenhouse gas (GHG) emissions could undermine progress in other sectors and heighten the risks of a climate crisis (IEA 2009). Low carbon alternatives are therefore urgently needed from developing Asia's transport sector.

Crafting low carbon alternatives requires reconciling several tensions. Accessibility and connectivity are essential to economic development, but much of Asia lacks access to dependable vehicles and infrastructure. The region's policymakers can still construct low carbon transport systems, but short-sighted investments may close windows of opportunity soon. Increased awareness of climate change can prevent carbon-intensive lock-ins, but incentives for early climate actions are currently limited. Viewed from this perspective, developing Asia's prospects for a low carbon future appear slim. This book is nevertheless cautiously optimistic that developing Asia can craft the low carbon transport strategies needed to deviate from business-as-usual (BAU) predictions. The key to designing and implementing these strategies are their co-benefits.

The term "co-benefits" originated from studies on climate policies in industrialized countries. The first such studies estimated the local air quality and public health *developmental co-benefits* of a carbon tax (Ayres and Walters 1991, Pearce 2000, Markandya and Rubbelke 2003). Since this early work, some have reinterpreted the concept to argue that *climate co-benefits* from sector-specific development policies merit more attention in developing