Getting on Track: Finding a Path for Transportation in the CDM

Final Report

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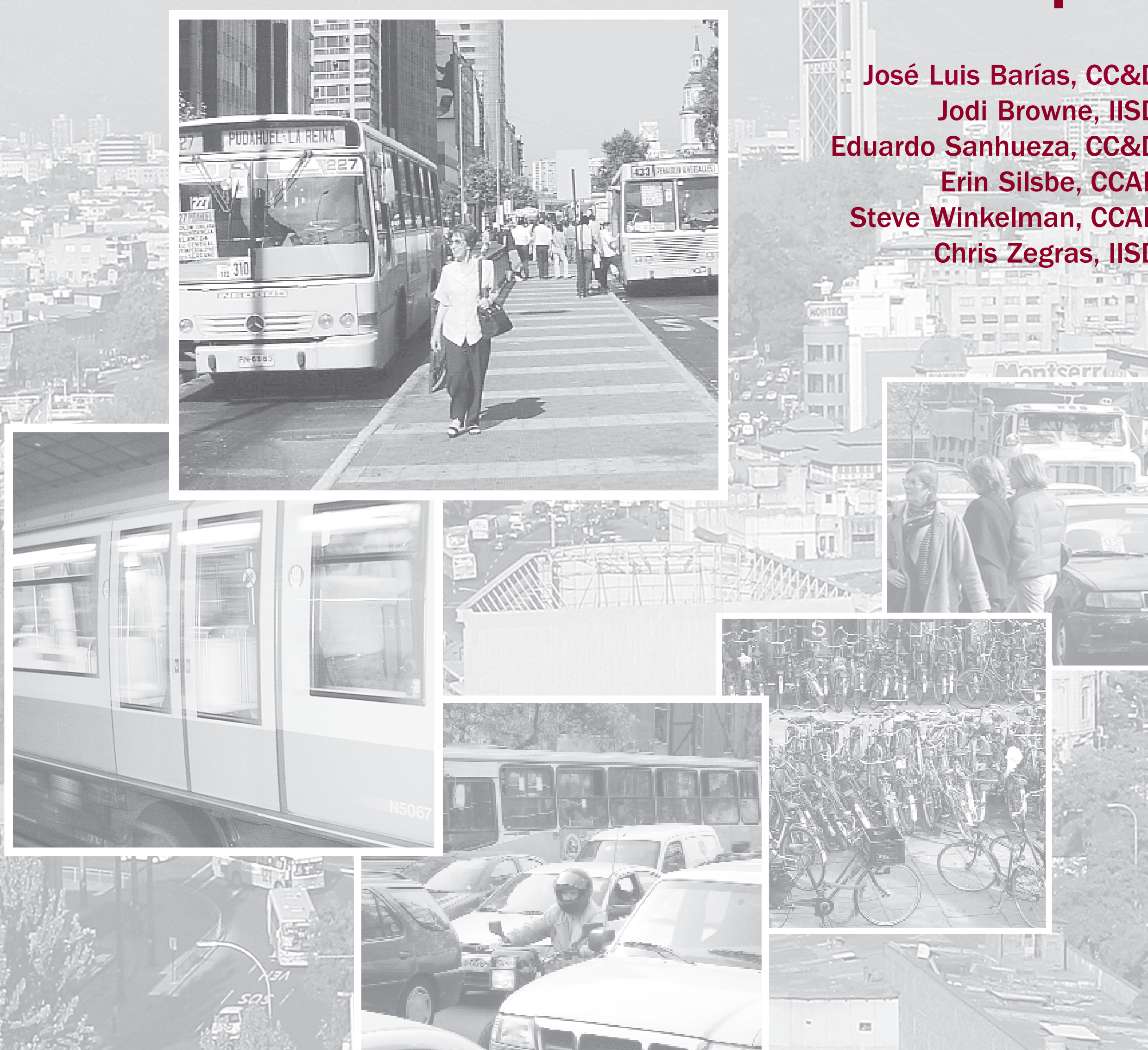

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Transportation and the Clean Development Mechanism

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Finding a Path for Transportation in the CDM

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Canada
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IISD

The International Institute for Sustainable Development contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change, measurement and assessment, and natural resources management. Through the Internet, we report on international negotiations and share knowledge gained through collaborative projects with global partners, resulting in more rigorous research, capacity building in developing countries and better dialogue between North and South.

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The Center for Clean Air Policy was established in 1985 by a group of state governors to develop and promote innovative policy solutions to energy and environmental problems. From our initial work as a key player in the development of a SO_2 trading system to help control acid rain to ongoing projects that focus on market-oriented approaches to ozone, climate change, and air toxics, we have promoted the idea that sound energy and environmental policy solutions serve both environmental and economic interests. The Center has over 15 years of experience addressing climate change, air emissions, and energy policy in ways that are both efficient and effective. The Center has been actively engaged in analyzing and advancing policies in all sectors of the economy—electricity, transportation and land-use, buildings, commercial, industrial, agriculture and forestry—as well as cross-cutting experience in emissions trading and emissions registries. For more information about CCAP please visit our Web site: www.ccap.org

CC&D

Cambio Climatico y Desarollo (Climate Change & Development) is a Chilean-based firm specializing in the evolution of the Kyoto Protocol, including the positions of the parties and particular negotiation stances and strategies. Eduardo Sanhueza, Principle of CC&D, has participated as part of the Chilean National Advisory Committee on Global Change, and has been part of the Chilean delegation to the UNFCCC negotiations since 1998. CC&D has played an important role in building the national stands and strategies in the UNFCCC process and helping to integrate the particular interests of various members of the National Advisory Committee in the working agenda of the Convention. CC&D has also played an integral role in development of the Clean Development Mechanism (CDM), both as a source of Chile's national proposals on this matter, as well as in the negotiations on the Framework Convention. Mr. Sanhueza served as an alternate member of the Executive Board of the CDM for two terms.

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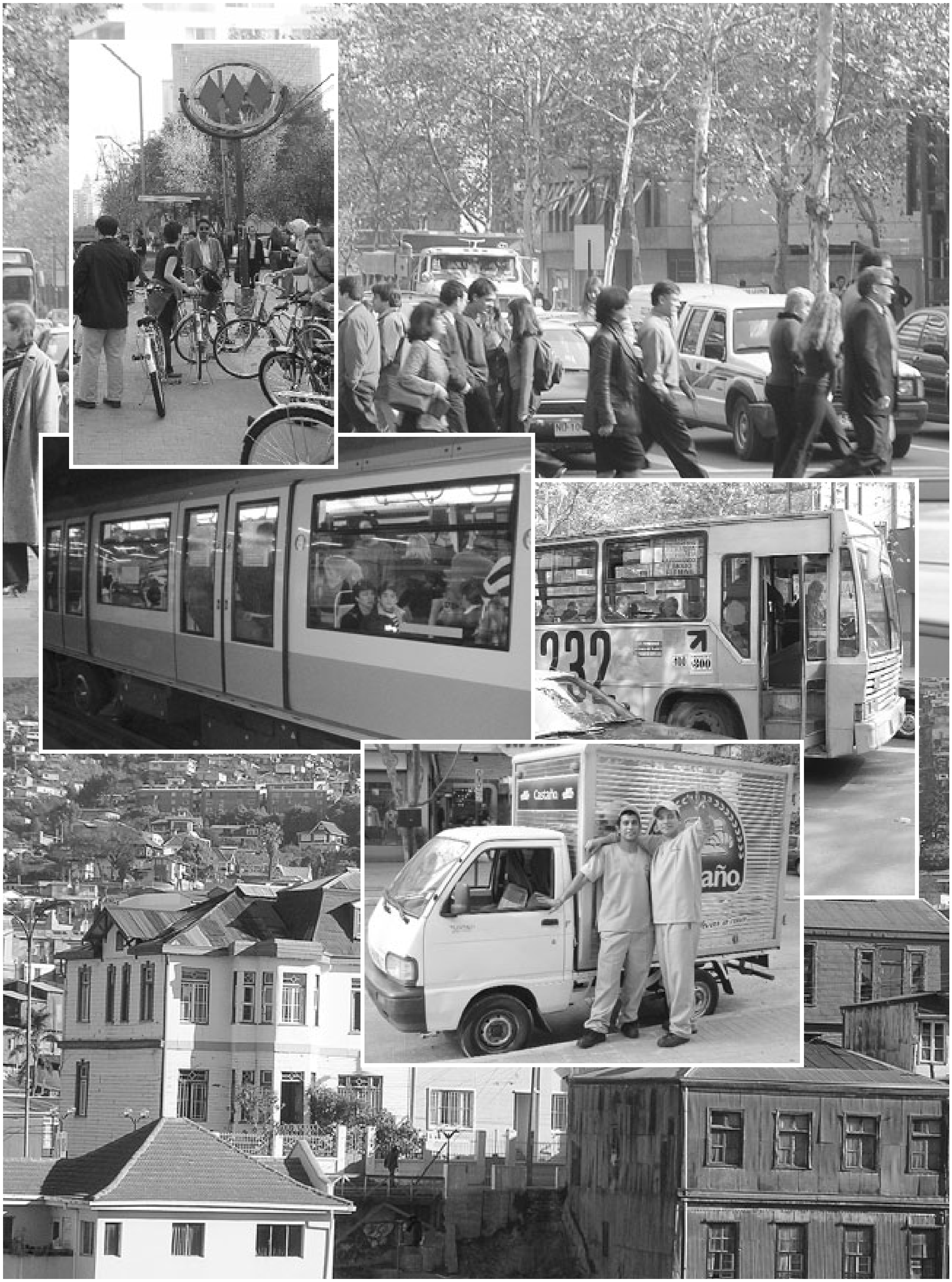
More information, background documents and the full electronic version of this report can be found on the project Web site at: http://www.iisd.org/climate/global/ctp.asp

1 A full list of institutions participating in the Steering Committee can be found in Appendix A.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Executive Summary

This report synthesizes of the findings of a study undertaken by the International Institute for Sustainable Development (IISD), Climate Change and Development Consultants (CC&D) and the Center for Clean Air Policy (CCAP). This work was funded by the Canadian International Development Agency (CIDA), in cooperation with a number of government agencies in Chile, principally Transantiago. The project examines possible scenarios for using the Clean Development Mechanism (CDM) as a tool to promote sustainable development in Chile's transportation sector. Mobility challenges, strong modelling capacity, commitment to CDM, and excellent data sets all made Chile an ideal location in which to test transportation solutions.

Globally, the transportation sector is responsible for almost one quarter of carbon dioxide emissions. This share is increasing annually, particularly in developing countries where the urban population is expected to double by 2030. This unabated growth, coupled with the many other side effects of growth in transportation including air pollution, health impacts, congestion, noise pollution and traffic accidents, underscores the importance of monitoring and reducing emissions from the transport sector.

The CDM offers the possibility to increase funding for sustainable transportation projects, enhance local planning and project evaluation capacity, and expand technology transfer opportunities. Despite their emission reduction potential, however, projects in the transportation sector have been slower to develop than those in other sectors. Such projects, especially demand-side initiatives, face significant methodological and financial barriers. This project analyzed three case studies that examined how the CDM may be used to address both technological and demand-side solutions for reducing emissions from Santiago's transportation sector.

The first case study involved a *bus technology switch* and examined the potential GHG benefits of switching bus technologies from diesel to hybrid and analyzed its feasibility as a CDM project. The second case study involved *bicycle initiatives* and assessed the methodological challenges associated with developing bikeways and networks as CDM projects. The third case study focused on *location efficiency* and involved the measurement of change in travel demand (and GHG reduction) from encouraging infill development, and discusses how the CDM could be used as an incentive for more location efficient urban development.

By delving into the key questions of the CDM including project baseline, additionality, methodology, monitoring and leakage, the case studies shed light on how a range of transportation projects fit within the current CDM and how they might work better in the future, and where other policy approaches may be appropriate. Taking the lessons learned from these case studies along with those that emerged from the International Workshop,[2] and from discussions from other professionals in the field, conclusions were developed regarding how transportation projects currently fit into the CDM framework and potential changes for post-2012. The main conclusions include:

2 The project partners and the Government of Chile hosted an International Workshop on Transportation and the CDM in August 2004 (Presentations and materials are available on the project Web site at: http://www.iisd.org/climate/global/ctp.asp)

The CDM should accommodate travel demand reduction efforts as well as policy-based and sectoral approaches

- If the CDM is to have a meaningful impact on sustainable transportation it must contribute to fundamental changes in vehicle purchases (e.g., encouraging higher fuel efficiency), fuel use (e.g., lower carbon fuels) and, most importantly, travel behaviour (i.e., slower growth in demand for motorized trips).
- Demand-side projects address the root of the transportation problem and have multiple co-benefits including air, health, noise, etc.
- Policy-based and sectoral approaches can have a major impact on emissions although they may introduce additional uncertainty, especially in forecasting GHG reductions.
- Given the low tonnage and many co-benefits of transportation projects, a unilateral approach may be more suitable for projects focused on bicycle initiatives, public transit or land use.
- Sectoral approaches have the potential to reverse the "perverse incentive" that can dissuade developing countries from pursuing GHG reduction policies and can also reduce emissions "leakage" concerns due to their comprehensive nature.

The project-based framework required by the current CDM rules is limiting and makes quantification complicated.

- Transportation sector emissions come from many small sources, (i.e., individual vehicles) that tend not to be governed or monitored by a central agency, but dependent on personal choice. Multiple small sources prove challenging to capture at the project level.
- The project-based approach may miss many important transportation emissions reductions opportunities, such as fuel economy programs, renewable fuel standards and comprehensive "smart growth" efforts (location efficiency, transit and non-motorized transport policies).
- Changes that could potentially deliver substantial reductions, for example by promoting location efficient development, are too complicated to capture in the required project-based framework.
- Non-motorized transport (NMT) projects, such as individual bikeways, do not work under the project-based framework. A comprehensive bicycle network may be feasible, but would likely fit better in a sectoral or policy-based approach.
- In the transportation sector particularly, requiring project developers to concentrate on what can be confidently quantified leads to discounting benefits from projects with the kind of long-term impact on travel demand that the mechanism aims to promote.

Most transportation projects do not fit well within the CDM as it currently functions.

- Given the high costs associated with transportation projects and the variety of co-benefits driving such investments, it is difficult to prove that the CDM, as it is currently designed, pushes many transportation projects over the margin into feasibility.
- Although they have the potential to contribute positively to long-term sustainability goals such as travel demand reduction, demand-side projects (NMT, land use, transit) don't fit well with the current structure of the CDM. This is primarily due to uncertainty over implementation of future transport plans, complexity with modelling travel/emissions impacts of policies and monitoring challenges.
- Projects that do fit under the CDM (such as fuel/technology switching) are often characterized by low emissions and typically will have minimal impact on reducing long-term emissions growth.
- Restrictive additionality rules lead to fewer transport projects being put forward for consideration.

Consideration of emissions reductions should be integrated into long term transportation planning.

- Any project based approach to emission reductions (and likely sectoral and policy approaches if and when they emerge in the future) necessitates measurement of indicators (emissions, trips, mode share) against a business-as-usual projection.
- This measurement requires a clear vision of future transportation plans and their possible related emissions. Therefore, local processes that clarify transportation plans for the future, such as Transantiago, contribute to facilitating this process.

The CDM is only one of many tools to reduce greenhouse gas emissions from the transportation sector.

- Political decisions to channel resources to land use planning, public transit, pedestrian and bicycle infrastructure are more important for long-term sustainability.
- In order to impact transportation emissions in the long term, local initiatives should be supported by international efforts, (e.g., bilateral ODA, GEF funds, etc.).
- Climate change (both mitigation and adaptation) and transportation should be more fully integrated into Poverty Reduction Strategic Papers (PRSPs), as well as into the funding frameworks of the IMF, World Bank, Regional Development Banks and others. The CDM may be used as leverage in cooperation with these other funding sources.

Chile represents an ideal testing ground for transportation CDM projects given that its mobility issues and air quality problems are quite similar to other developing countries; its transportation data and modelling capacity is strong; and the Chilean government has a strong commitment to the CDM and addressing climate change.

Despite Chile's high-quality data, advanced models and experienced professionals, transportation projects such as those explored in the case studies, particularly demand-side initiatives, face significant methodological challenges and uncertainty. These challenges could pose insurmountable barriers in the vast majority of developing countries that have poorer data, weaker models and less experience than Chile in modelling and analyzing transportation and land use projects.

Given that transportation sector emissions come from many small sources (i.e., individual vehicles), the impact of projects will be negligible unless large numbers of vehicles, litres of fuel or passengers are affected. The CDM was designed to address specific projects with quantifiable and verifiable GHG reductions. Yet, this project-based approach may miss many important transportation emission reductions opportunities, such as fuel economy programs, renewable fuel standards and comprehensive "smart growth" efforts (e.g., location efficient land use, transit and NMT policies).

Developing countries need an integrated approach in which transportation is part of a larger focus on sustainable development that also addresses housing, land use and economic development. Current infrastructure, investment and development decisions have a major impact on future emission rates; implementing sustainable solutions now can advance multiple public goals. Short-term benefits (e.g., air quality and health improvement, congestion relief) can help to make long-term sustainability solutions more politically viable. To advance these and other local sustainability goals through CDM, transportation projects and policies must fit better under the parameters of the mechanism.

In the post-2012 context, allowing for policy-based or sectoral CDM could better accommodate system-wide changes such as comprehensive transit and land use strategies, fuel economy standards and renewable fuel standards. In order to ensure long-term impact on transportation emissions, CDM initiatives will need to leverage international assistance through ODA, development banks, and other funding agencies and programs, and work hand-in-hand with local leadership to achieve this common goal.

List of Abbreviations

AAU	assigned amount unit
ADB	Asian Development Bank
BRT	bus rapid transit
CBD	central business district
CER	certified emission reduction
CDM	clean development mechanism
CH_4	methane
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CONASET*	Comisión Nacional de Seguridad de Tránsito/National Commission for Transportation Safety
CONAMA*	Comisión Nacional del Medio Ambiente/National Environmental Commission
DAC	development assistance committee (of OECD)
DOE	designated operational entity
EB	Executive Board (of the CDM)
EFE	Empresa de los Ferrocarriles del Estado/State Railroad Authority
EIT	economies in transition
EU	European Union
GEF	Global Environmental Facility
GHG	greenhouse gas
GIS	green investment scheme
GWh	giga watt hour
HFCs	hydroflourocarbons
IET	international emissions trading
JI	joint implementation
LE	location efficiency
MIDEPLAN	Ministerio de Planificación y Cooperación/Ministry of Planning
MINVU*	Ministerio de Vivienda y Urbanismo/Ministry of Housing and Urban Development
MOPTT*	Ministerio de Obras Públicas, Transportes y Telecomunicaciones/ Ministry of Public Works, Transportation and Telecommunications
MT	megatonne
MW	megawatt
NGO	non-governmental organization
NMT	non-motorized transit
N_2O	nitrous oxide
OD	origin destination (survey)
ODA	official development assistance
OECD	Organization for Economic Cooperation and Development
PDD	project design document
PFCs	perflourocarbons
PTUS	plan for urban transport of Santiago
SECTRA*	Secretaría Interministerial de Planificación de Transporte/ Interministerial Transportation Planning Secretary
SF_6	sulphur hexaflouride
TDM	transportation demand management
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollars
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
VKT	vehicle kilometres travelled
$	All dollar figures quoted in US$, unless otherwise indicated

* indicates membership on the project steering committee

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Chapter One
Introduction

Project Overview

The International Institute for Sustainable Development (IISD), Cambio Climatico y Desarollo (CC&D) and the Center for Clean Air Policy (CCAP), with funding from the Canadian International Development Agency (CIDA), embarked on a project in 2001 aimed at exploring the potential for transportation projects within the CDM, and building capacity within the Chilean transportation sector to integrate consideration of greenhouse gases into their transport planning process.

The purpose of this project was to assist the Chilean government in identifying transportation projects that could leverage CDM funding and build their institutional capacity to recognize and develop emission reducing transportation projects. More explicitly, the goals of the project were to:

- Build Chile's institutional capacity to develop, evaluate, and facilitate CDM projects and policies in the transportation sector that produce real reductions of greenhouse gas emissions (GHGs) and local air pollutants that meet the country's sustainable development needs.
- Engage Santiago's transportation stakeholders in a dialogue on the analytical findings of the study and their potential role in the CDM and other emission reducing initiatives.
- Identify and conduct a preliminary feasibility assessment of actual CDM project opportunities in Chile's transportation sector, based on the findings of the project's research phase and capacity building activities.
- Develop methods and recommendations for structuring CDM projects in the transportation sector.

The decision to partner with Chile was strategic; the country is primed for sustainable transportation projects and is considered a strong host for CDM investment. Chile has an open, stable and deregulated economy, strong annual economic growth and declining levels of poverty, but still has progress to make toward a sustainable economy. Leveraging the CDM to address these challenges, particularly in the transportation sector, is an important opportunity for Chile.

In addition, Chile has already demonstrated a national commitment to addressing climate change, with its support for the UNFCCC as expressed in the First National Communication. Chile's ratification of the Kyoto Protocol and regional leadership in attracting CDM investment is strong evidence of its commitment to pursuing these opportunities. The government has indicated a desire to move immediately to attract projects and has been recognized as a leader by the international carbon market.

Finally, Chile already possesses strong in-country capacity to address the complexity of applying the CDM to the transportation sector. Participation in the Kyoto process has familiarized government officials with issues related to climate change, as well as the framework and rules related to the CDM. If transportation could work in CDM, it should be in Chile where high-quality data and models are available to help overcome methodological challenges.

Report Structure

The report begins with a background discussion on transportation and climate and follows with an overview of the CDM and the current state of the carbon market. Chapter 3 provides an overview of the transportation sector in Santiago, past, present and future. This chapter also highlights local environmental challenges, the status of transportation infrastructure and the major institutions involved in planning and executing transportation initiatives in the city.

Through three different case studies, the project examined baseline development and questions of additionality, monitoring and data requirements for technological as well as demand-side emission reductions. Chapter 4 presents summary findings from these three case studies. The first case study examines the feasibility of employing the CDM to promote a *technology switch* from diesel to hybrid diesel-electric buses. The scenario examines the impact of additional technical improvements to the transportation plan currently under development for Santiago and are aimed at further reducing emissions. The *bicycle initiatives* case study analyzed the potential and feasibility of developing a CDM project for both a single bikeway and a comprehensive bicycle network for the city of Santiago. The final case study on *location efficiency* assessed the potential for reducing transportation GHGs by changing patterns of urban development to enable shorter trips and a shift to less polluting modes. Results from this study are based on integrated land use and travel demand modelling.

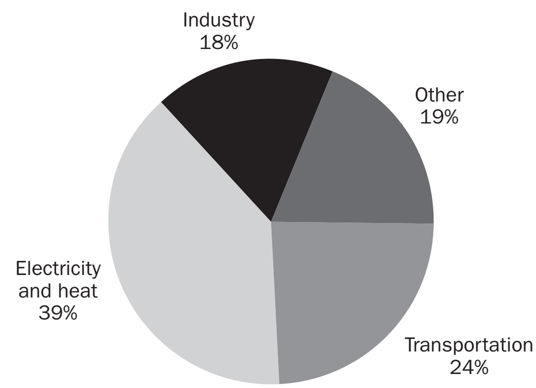
Chapter 5 of the report presents discussion of the key challenges associated with transportation sector CDM, including additionality and verification of reductions. This chapter also examines new ideas and provides transportation sector insight into the role of official development assistance in development of projects, the development of policies as projects and the potential of sectoral and unilateral CDM. Issues such as induced demand and perverse incentives are also addressed here. While CDM may contribute to development of sustainable transportation systems in the future, it is important to recognize it as one tool of many. As such, Chapter 5 also highlights some of the important emission reduction opportunities possible through investment in, and regulation of, the sector.

Finally, in Chapter 6, the report provides recommendations, based on the case studies undertaken in Santiago, aimed at domestic transportation decision makers, as well as the international CDM community.

Background

Transportation is a major contributor to the global problem of climate change. Figure 1 illustrates the dominant role of transportation in production of CO_2. This sector is responsible for almost one quarter of carbon dioxide emissions, and is the fastest growing source of GHG emissions worldwide. Transportation emissions are growing at approximately 2.1 per cent per year worldwide, and 3.5 per cent per year in developing countries.[3] With the urban population in developing countries expected to double by 2030, transportation emissions are of particular concern for cities.

Figure 1: 2001 Global CO_2 Emissions by Sector (IEA, 2003)[4]



While air, marine and ground transportation are all significant contributors to the sector's share of global CO_2 emissions, the growth in personal vehicle use and vehicle kilometres travelled is particularly concerning. Transportation forecasts project continued rapid growth in the amount driven in both industrialized and developing countries. In the EU, for example, transportation emissions are collectively 34 per cent above 1990 emissions levels.[5] Forecasted improvements in passenger vehicle efficiency and fuel carbon content are dependent upon country specific variables.

The unabated growth of the transport sector underscores the importance of monitoring and reducing greenhouse gas emissions. In Chile, as in most devel-

3 International Energy Agency. *World Energy Outlook, 2002*.

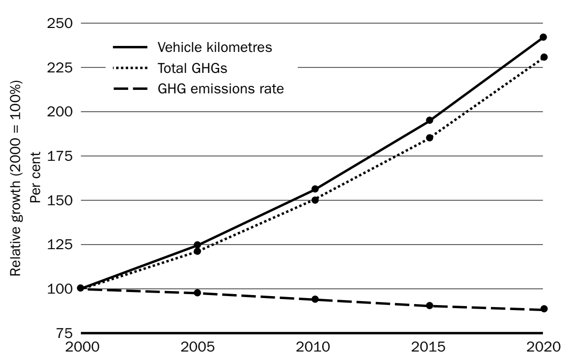
4 CO_2 Emissions from Fuel Combustion 1970/2001–2003 Edition. Paris, IEA/OECD.

5 Jurgen LeFevre, European Commission "Regulatory Development and Linkages: The European Union" (presentation at IETA meeting, November 2004).

oping countries, transportation is one of the largest sources of energy-related carbon dioxide emissions. Projected sharp increases in emissions will be accompanied by other risks including local air pollution, health impacts, congestion, noise pollution, traffic accidents and more.

The transportation sector in Chile accounts for 34 per cent of energy-related carbon CO_2 emissions—second only to the power sector at 36 per cent. In 2001, CO_2 emissions from the transport sector totalled 19.3 million tonnes.[6] At the same time, the Santiago Metropolitan Region is experiencing rapid growth in the transportation sector, signalled by increased private vehicle use. The baseline scenario projected in the 2002 Pew Center report, *Transportation in Developing Countries: Greenhouse Gas Scenarios for Chile*, shows that CO_2 emissions from the transportation sector could more than double by 2020 in absence of mitigation measures.[7] Figure 2 shows the dramatic impact of rapid growth in driving on CO_2 emissions from passenger cars in Chile, based on analysis by the Pew Center.[8]

Figure 2: GHG Emissions from Passenger Cars in Chile: 2000–2020



The Pew Center projects a 12 per cent improvement in passenger car CO_2 emissions by 2020 (bottom line), but a 141 per cent increase in vehicle kilometers travelled (VKT – top line) leading to significant growth in overall CO_2 emissions (middle line).[9] This Chile-specific scenario reflects a common trend seen in other countries around the world. Even if vehicle technology improvements were able to keep up with the growth in VKT, transportation emissions would level off at year 2000 levels. But climate scientists indicate that reductions on the order of 60 per cent below 1990 levels by 2050 are required to stabilize atmospheric concentrations of GHGs and prevent major ecological and economic disruptions.[10] Thus, in addition to vehicle technology improvements, it will be necessary to assess the potential savings from low-GHG fuel measures and from policies to slow growth in VKT. Strategic efforts to influence the design and density of cities can impact the demand for travel significantly and can potentially play a role in reducing emissions.

Demand-side projects focus on shifting travel behaviour away from cars and towards public transportation and non-motorized transportation (NMT), thereby reversing or slowing the growth in VKT and reducing emissions. Avoiding emissions through demand reductions has benefits beyond mitigating climate change; air quality improves and health problems such as asthma caused by exposure to pollutants are also reduced.

Emission Reduction Opportunities

Four key components drive transportation CO_2 emissions: travel activity (vehicle kilometers travelled, or VKT), mode share, fuel intensity and fuel carbon content (see Figure 3).

6 Conama-Dictuc-Pnud. 2001 Inventory Emissions.

7 Pew Center on Climate Change. 2002. *Transportation in Developing Countries: Greenhouse Gas Scenarios for Chile*. Washington, DC.

8 Pew Center 2002, *ibid*.

9 Note: this figure illustrates the per cent increase in emissions with respect to 2000; differing from the Kyoto Protocol requirement of an average GHG reduction of approximately five per cent below 1990 levels for industrialized countries.

10 Intergovernmental Panel on Climate Change, Third Assessment Report, 2001.

Figure 3. Determinants of Passenger Transportation Emissions: Behaviour and Technologies[11]

Emissions	=	**A. Activities** (pkm = trips x distance) Determinants: · Population · Demographics · Income · Urban form · ….	x	**S. Mode Share** (per cent pkm) Determinants: · Income · Motorization rate · Infrastructure Conditions · Service provision · Urban form · ….	x	**I. Fuel Intensity** (liters per pkm) Determinants: · Fuel efficiency · Engine type · Vehicle load · Vehicle age · Congestion levels · Capacity mix · Urban form · ….	x	**F. Fuel Choice** (emission per liter) Determinants: · Fuel type · Fuel quality · Engine type · Vehicle technology · Vehicle age · Temperature · Altitude · ….

Note: pkm = passenger kilometers

Efforts to influence travel activity patterns or mode choice are essentially behavioural in nature, while those influencing fuel intensity and carbon content aim at the technological "fix." Three components are essential in the design of potential emission reduction opportunities:

1. Vehicle Technology Improvements

Regulation of vehicle fuel economy has been a very successful policy in the U.S., Europe and Japan, and will likely be an important tool in the future. Voluntary agreements with industry may also play an important role in some countries. Efforts in Canada, Europe, Japan, and China are expected to improve the fuel economy of *new vehicles* by 23–33 per cent by 2010. New greenhouse gas standards in California are anticipated to achieve a 30 per cent reduction in new passenger vehicle CO_2 emission rates by 2016, resulting in *fleet-wide* savings of 27 per cent in 2030.[12] Unfortunately, rapid growth in driving is projected to continue to outweigh even these progressive efforts.

2. Lowering Carbon Intensity of Fuels

Use of biofuels such as ethanol and biodiesel can reduce GHG emissions because the carbon contained in the fuel was absorbed from the atmosphere by the crops. E-10 (gasoline with 10 per cent ethanol) can be used in most cars and reduce lifecycle GHG emissions by three per cent. B-20 (diesel with 20 per cent biodiesel), can be used in most trucks and reduce lifecycle GHG emissions by about 25 per cent, depending upon the crop used.[13] Full penetration of E-10 and B-20 (for example, under renewable fuel standards) would reduce transportation CO_2 emissions by about 7–10 per cent. The reduction could perhaps be higher in those countries with the appropriate agricultural, economic and political conditions (e.g., with a low-cost domestic energy crop and significant penetration of E-85 or E-100).[14]

Cellulosic ethanol, which is derived from woody plants, can result in three times the GHG savings of ethanol from corn or sugar cane (E-10 from wood would reduce GHGs by about eight per cent). More research and development will be required to bring down production costs to a competitive level. The potential GHG benefits from cellulosic ethanol will depend upon the amount of land area that is available for growing biofuel crops.

Hydrogen fuel cell vehicles have attracted much attention in recent years as a promising solution to petroleum dependence and greenhouse gas emissions. Industry and government analysts predict that it will take 25–40 years until these vehicles become commercially available, affordable and achieve significant

11 Adapted from: Lee Schipper *et al.*, *Flexing the Link between Transport Greenhouse Gas Emissions: A Path for the World Bank*, (Paris: International Energy Agency, June 2000); Sheoli Pargal and Mark Heil, "Reducing Air Pollution from Urban Passenger Transport: A Framework for Policy Analysis," *Journal of Environmental Planning and Management*, 43, No. 5 (2000), pp. 667–668.

12 See, for example, An. F. and A. Sauer, "Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around the World," Pew Center on Global Climate Change, December 2004.

13 For more information on lifecycle GHG impacts of renewable fuels, see the GREET model and its documentation, http://greet.anl.gov/publications.html

14 Brazil, for example.

market penetration. At present, hydrogen fuel cell vehicles face significant technical and economic barriers.[15] The greenhouse gas benefits of hydrogen fuel cell vehicles are uncertain as they are dependent upon the source of hydrogen. Just as with electricity, there will need to be a major increase in use of renewable energy, or technology breakthroughs in carbon capture and sequestration from coal, in order to generate hydrogen in a climate-friendly manner. In addition, investments in new infrastructure, such as hydrogen distribution networks, will be required. Through intensive research and development we may arrive at climate-friendly hydrogen vehicles. Or, as is often the case with R&D, the road to hydrogen may head in unexpected directions and lead to other important breakthroughs. A key question is what kind of technology penetration delay will there be in developing countries, and whether there are any leapfrog opportunities.

3. Slowing Growth in Travel Demand

Current infrastructure investment, development decisions and transportation policies will have a major impact on future emissions. Rapid growth in car ownership and use appears inevitable, but the availability of efficient options such as bicycle infrastructure will require deliberate planning and investment. Continuing business-as-usual policies—as opposed to investing in sustainable transportation and pursuing efficient land use policies—will impose high opportunity costs by locking in automobile-oriented travel patterns that put the world on a high-GHG pathway.

Improving vehicles and fuels will require continued R&D coupled with effective implementation policies. Slowing growth in travel demand requires efficient transportation choices, land development patterns that accommodate walking and transit, and (perhaps) complementary incentives and price signals. Research shows that people drive less in places with rich transportation choices and efficient development patterns. This leads to two fundamental questions: 1) to what extent can sustainable transportation policies slow growth in travel activity (VKT)?, and 2) what will it take to implement these policies?

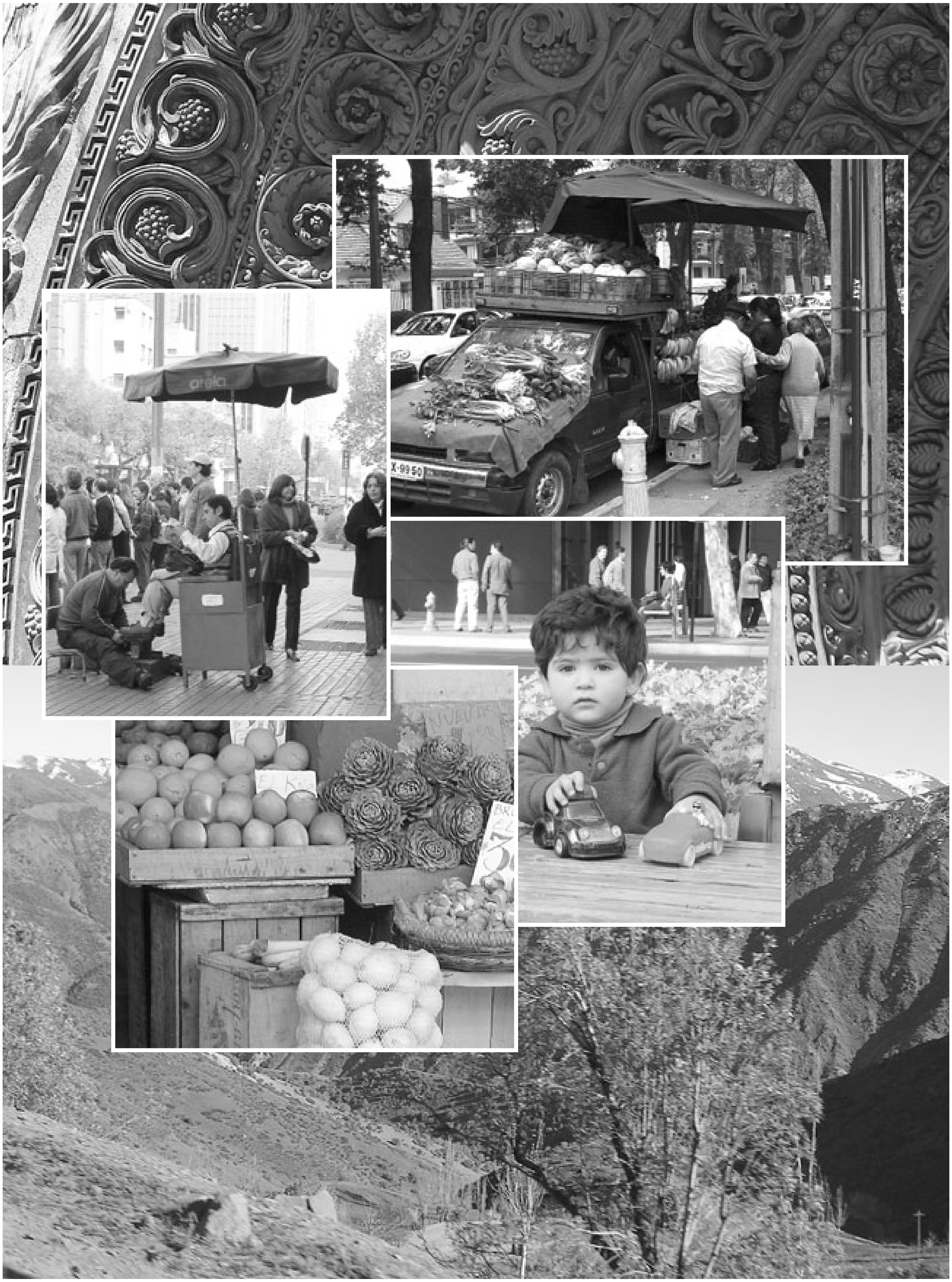
A review of regional sustainable transportation plans in the U.S. that emphasize public transit and "smart growth" land use policies indicates that such initiatives can reduce CO_2 emissions by 3–25 per cent below business-as-usual forecasts.[16] The potential savings range can be expected to be higher in developing countries, which tend to have high urban population densities, low but rapidly growing levels of car ownership, and have generally not experienced a half century of automobile-oriented suburban sprawl. Achieving significant reductions in VKT growth and CO_2 emissions from smart growth policies requires three critical elements: comprehensive regional planning, political leadership, and funding (for transit, design changes, development incentives, bike infrastructure, etc.). See Chapter 5 for more discussion.

CDM and the Transportation Sector

The Clean Development Mechanism (CDM) was created as a way to contribute to the sustainable development of developing countries while offering cost-effective emission reductions to those countries committed to GHG targets under the Kyoto Protocol. The CDM offers the possibility to increase funding for transportation projects, enhance local planning and project evaluation capacity, and expand technology transfer opportunities. However, there are difficult challenges to overcome before these projects become more feasible to undertake. To date, very few of the projects under development for the CDM have taken place in the transportation sector, in part because of the difficulties in modelling, measuring and quantifying reductions in this sector; this fact highlights the importance of further analysis. Chapter 2 provides a contextual background for the findings of the research by reviewing the structure and functioning of the CDM, and the current state of the carbon market.

15 For more information on hydrogen vehicles, see D. Sperling and J. Cannon, eds., *The Hydrogen Energy Transition*, Elsevier Press, 2004. http://www.elsevier.com/wps/find/bookdescription.cws_home/702930/description#description

16 Center for Clean Air Policy, "Smart Growth and Air Quality Primer," December 2004.



Chapter Two
CDM Context

Emerging Regulatory Regime

On February 16, 2005, ninety days following Russia's ratification, the Kyoto Protocol entered into force as an international agreement some seven years after it was first concluded in protracted negotiations in December 1997. All of the agreements elaborated in the Protocol, including (more importantly) the Bonn Declaration and the Marrakesh Accords, also came into effect. This means the rules established for the Kyoto Mechanisms for the counting, reporting and monitoring of sinks and emissions, as well as terms related to capacity building, technology transfer and adaptation, are all now binding. This represents no small accomplishment. The controversial targets notwithstanding, there is no doubt that Kyoto represents an important first step in developing a global regime on climate change, most significantly attributing value to carbon and other greenhouse gases.

Many of the countries that have ratified the Kyoto Protocol are currently developing and executing approaches to achieving their respective emission reduction commitments.[17] The Clean Development Mechanism is an important element for countries in meeting their commitments, and for creating new economic and sustainable development opportunities in host countries.

Goals and Purpose of CDM

The Kyoto Protocol was signed in 1997 by the member states to the United Nations Framework Convention on Climate Change (UNFCCC). The Protocol establishes binding greenhouse gas (GHG) emission reduction targets for each industrialized country, to an average of approximately 5.2 per cent below 1990 levels over the period of 2008–2012.[18] The Protocol covers the six key greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

The first agreement to establish legally-binding constraints on greenhouse gas emissions, the Protocol also broke ground with the introduction of three "market mechanisms," developed to reduce the cost of compliance to the commitments:

> *International Emissions Trading (IET):* allows countries to transfer portions of their allowable emissions, or "Assigned Amount Units" (AAUs)
>
> *Joint Implementation (JI):* sanctions countries to claim credit for emission reductions from investments in other industrialized countries, which lead to the transfer of "Emission Reduction Units" (ERUs) between parties.
>
> *The Clean Development Mechanism (CDM):* permits projects that reduce emissions and result in sustainable development for host countries to generate "Certified Emission Reductions" (CERs) for use by the investor or sale by the project proponent.

The CDM allows for projects to be undertaken by governments or private entities from industrialized (defined under the Protocol as Annex 1) countries that will reduce emissions in developing countries (non-Annex 1). The proponents earn credits in the

17 Four industrialized countries have not yet ratified the Kyoto Protocol: Australia, Liechtenstein, Monaco and the United States.

18 Due to the non-involvement of both the U.S.A. and Australia in the first commitment period, should the rest of the Parties meet their commitments, this average will become lower.

form of Certified Emission Reduction units (CERs), which can be applied against their own domestic national targets for emission reduction. In this way countries who host CDM projects can take advantage of sustainable development benefits, and those that invest can reap the lower cost per tonne for carbon reduction. In some cases, it may be possible for host countries to undertake projects independently and sell the credits on the market without an Annex 1 investor up front. These projects have been labelled "unilateral."

Article 12 of the Kyoto Protocol clarifies the dual goal of the CDM:

"The purpose of the clean development mechanism shall be:

1. to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and;
2. to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3."[19]

Structure of the CDM

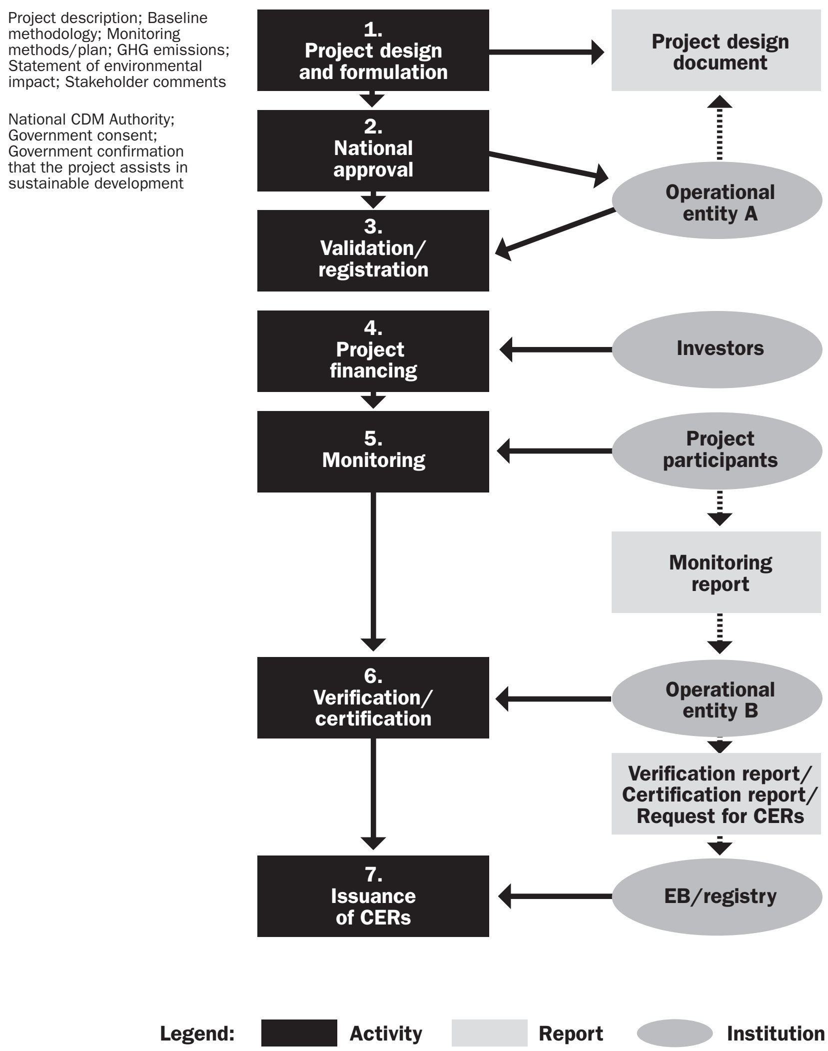
The Clean Development Mechanism is organized according to a project cycle (see Figure 4). The following chapter provides a brief overview of the steps in the *CDM project cycle*, followed by a description of the key actors in the system. It is important to note that while the diagram depicts a linear process, in reality several of these steps can be undertaken simultaneously, or in some cases the order may be slightly different.

1. *Project design and formulation:* Project proponents develop a draft Project Design Document (PDD), definition of the baseline and additionality requirements, estimation of the projected emission reductions from the project and description of a monitoring plan.
2. *National Approval:* Approval by the host country is required before the project can move to the validation and registration phase. The proponent submits the PDD to the Designated National Authority for CDM in the country, and must obtain a letter of approval following completion of the national approval process. In some cases, this process involves an Environmental Impact Assessment, stakeholder consultation and/or requirements of legal permits.
3. *Validation/Registration:* The PDD is submitted to an Operational Entity for validation. Components of the validation process include: review of public participation outcomes, comments by local stakeholders, environmental impact assessment, and review of methodology, baseline and monitoring plan.
4. *Project financing:* The financing of a CDM project can take a variety of forms, depending on the "Purchasing Agreement" signed between the project proponent and the purchaser. The investor may contribute full or partial funds for the costs of the project and receive the financial return as well as the CERs. The exact details of each purchasing agreement are not specified by the Protocol and are left to the parties involved in the transaction.
5. *Monitoring:* External monitoring of the emission reductions that take place in a CDM project must be conducted by a third party as a condition of verification.
6. *Verification/Certification:* Verification is undertaken by a second Operational Entity, and includes a review of the project documentation, on-site inspections of the activities, review of the monitoring results and analysis of baseline and emission reductions. Results from this stage of the process are publicly available on the UNFCCC CDM Web site for review.[20]
7. *Issuance of CERs:* Certified Emission Reductions (CERs) are issued by the Executive Board after completion of the verification process. CERs then enter into the accounts of buyers.

19 UNFCCC Kyoto Protocol, Article 12.2 (numbers added for emphasis by author).

20 http://unfccc.int/kyoto_mechanisms/cdm/items/2718.php

Figure 4: The CDM Project Cycle[21]



There are a number of players involved throughout the project cycle and execution of a CDM project:

Project Proponent

The project proponent is the company, government or local entity that develops and implements the CDM project. In the case of unilateral CDM, the host country itself (or a private entity within it) can be the project proponent.

CER Purchaser

The purchasers for CERs are typically Annex I governments, carbon pools or companies, interested in supplementing their domestic reductions with additional carbon units. The benefits for investing countries include the opportunity for lower cost emission reduction options than what they could achieve domestically, and participation in sustainable development initiatives. The CDM also offers opportunity to access new markets, showcase cleaner technologies and build partnerships in developing countries.

21 UNEP, Introduction to the Clean Development Mechanism, (no date), http://www.uneprisoe.org/CDMCapacityDev/ p. 12.

Host Country/National Authority

Hosting CDM projects can be an attractive opportunity for developing countries to guide investment to priority economic areas, reap associated air quality and health benefits, and gain access to clean technologies. CDM projects can lead to infrastructure improvements, increased employment, and potentially a reduced dependence on imported fuel. In the case of "unilateral" CDM projects, host countries may also gain revenues from the sale of CERs by undertaking projects (without up front investment from an Annex 1 Party) that align with domestic sustainable development goals.

The Kyoto Protocol stipulates that, in order to host projects, countries must have established a Designated National Authority (DNA or NA) for the CDM. The purpose of a DNA is two-fold: first, to regulate and approve projects that take place within their borders and, second, to promote business opportunities to the international CDM community. A well-organized, clear and efficient process of approval and facilitation of CDM initiatives stands to influence the quality and number of projects that take place in a given country. The evaluation and approval process involves assessment of the project's contribution to the sustainable development objectives of the host country. While the intent of the CDM was clearly to contribute to sustainable development, the official definition of the term was not formally negotiated as part of the Protocol. As such, it is the prerogative of each DNA to create its own set of sustainable development criteria or guidelines for CDM projects based on local priorities and needs.[22] Host countries may consider a number of criteria including social (does the project contribute to poverty alleviation and equity concerns?), economic (does the project include financial returns to local entities? will the initiative involve transfer of appropriate technology to local communities?) and environmental (does the project have co-benefits beyond the reduction of GHGs, such as positive impact on air quality, health and water quality?).

The technical and institutional capacity to review, approve, develop and promote CDM projects in a systematic manner, to assess and remove barriers to implementation, and to market project opportunities effectively is critical for host countries. While a clear line has been established under the Marrakech Accords stipulating that Official Development Assistance (ODA) can not be used to purchase CDM credits, these funds can and have been used to assist countries in creation of National Authority offices (including input into development of sustainable development guidelines), exploration of market opportunities and development of pre-feasibility studies.[23] A recent report from the Development Assistance Committee (DAC) of the OECD further stated: "…CERs resulting from ODA financed CDM projects should be considered as a return to the donor and give rise to a deduction from ODA flows. Conversely, if instead of receiving CERs, a donor has agreed with the host country not to receive any of the generated CERs, or if the project does not generate CERs (e.g., a capacity development activity), no deduction would be necessary."[24] This interpretation of the Marrakech Accords supports a more flexible use of funds toward CDM initiatives.

Executive Board

The CDM is supervised and guided by an Executive Board (EB) comprised of ten members: one representative from each of the five official UN regions (Africa, Asia, Latin America and the Caribbean, Central and Eastern Europe, and the OECD), one from the small island developing states and two each from Annex 1 and non-Annex 1 parties.[25] The EB holds regular meetings to provide guidance to parties and project proponents on development of methodologies and baselines, and to continue to establish the procedures under which the CDM will function. A separate subsection of the EB was created to deal specifically with rules and modalities on project methodologies, the "Methodologies Panel." The role of the Methodologies Panel is to provide recommendations to the Executive Board.

22 Figueres, Christiana (ed.) Establishing National Authorities for the CDM: A Guide for Developing Countries, IISD, 2002.

23 Figueres, Christiana, 2002. *ibid.*

24 OECD, DAC, "ODA Eligibility issues for Expenditures Under the Clean Development Mechanism," Proposal by the Chair, DAC High Level Meeting, April 15–16, 2004. p. 3.

25 UNEP, Introduction to the Clean Development Mechanism, (no date), http://www.uneprisoe.org/CDMCapacityDev/ accessed February 25, 2004.

Designated Operational Entity (DOE)

As part of the verification system for CDM projects, the Executive Board designates a number of domestic legal entities or international organizations to participate as outside accreditors in the project cycle. The DOE has two primary functions: to validate and register proposed project activities, and to verify that emissions reductions have taken place. Once the DOE has confirmed the reduction of emissions from a project, it requests the Executive Board to issue CERs.

Guiding Rules for CDM

The Kyoto Protocol set the framework for the CDM, however, subsequent negotiations were needed to provide details of how the mechanisms would operate. These negotiations culminated in 2001 with the establishment of the Marrakech Accords, which set the ground rules for the Clean Development Mechanism. Three fundamental guidelines exist for CDM initiatives:

1. Projects must assist non-Annex I Parties in "achieving sustainable development and contributing to the ultimate objective of the Convention."
2. Projects must result in "real, measurable and long-term benefits related to the mitigation of climate change."
3. Projects must result in "reductions in emissions that are additional to any that would occur in the absence of the certified project activity."[26]

CDM Projects are eligible for registration if they began after January 1, 2000 and may fall into the following sectors:

- end-use energy efficiency improvements;
- supply-side energy efficiency improvements;
- renewable energy;
- fuel switching;
- agriculture: reduction of methane (CH_4) and nitrous oxide (N_2O) emissions;
- industrial processes: reductions of carbon dioxide (CO_2) from cement, hydroflourocarbons (HFCs), perflourocarbons (PFCs), and sulphur hexaflouride (SF_6); and
- sinks projects (afforestation and reforestation only).

Nuclear energy is not an eligible activity under the CDM. An adaptation levy of two per cent from all CERs will be directed toward helping developing countries adapt to the impacts of climate change.

The CERs generated from CDM projects can be sold or traded on the international market. Projects may be undertaken for a fixed period of ten years or in three renewable periods of seven years each (to a total of 21 years). Countries are limited in the use of credits from sinks (afforestation and reforestation) projects to one per cent of their base (1990) year emissions. Given the growth cycle of trees, sinks projects under the CDM have a longer timeframe of either 30 years, or 20 years with a maximum of two renewals (provided the baseline is re-evaluated).

Small-scale projects frequently involve important sustainable development benefits for local communities; however, they are unable to absorb the same transaction costs as regular-sized projects. The Marrakech accords recognize the difference between small and large-scale projects, and establish rules to further facilitate their development. In an attempt to promote these types of projects and their local benefits, and to reduce the associated transaction costs involved in the project cycle, the Conference of the Parties (COP) in Marrakech further elaborated guidelines for small projects in 2003. The simplified rules apply in three types of initiatives:

1. Renewable energy project activities with a maximum capacity of 15 MW.
2. Energy efficiency projects that reduce consumption by up to 15 GWh per year.
3. Projects that reduce emissions from sources of less than 15 Kt of CO_2 per year.

Projects falling under one of these three categories are eligible for several benefits that reduce the transaction costs and approval time. Proponents may use a simplified Project Design Document (PDD). Standardized baseline analysis and simplified monitoring methodologies are two other benefits to this track, as well as the option to bundle small projects together. Finally, validation, verification and issuance of CERs can be done by a single Operational Entity.

26 Kyoto Protocol, Article 12, paragraph 5.

Defining Baselines and Verifying Reductions

Baseline Development

Project proponents must create a defensible vision of future emissions as a result of their project, as compared to a "business-as-usual" or baseline projection. In the transportation sector, this entails estimating several complicated and interconnected factors, including but not limited to: uptake of new vehicle technology, changes in fuel use, improvements in data collection, forecasting ability, incorporation of non-motorized trips, and changes in transportation or urban planning-related policy that would impact either the ability to measure or the actual production of greenhouse gas emissions from transportation. Baseline scenarios must reflect *de facto* vs. *de jure* standards, i.e., those currently in place rather than standards regulated but not enforced.

Quality, consistency and availability of basic information necessary to construct credible baselines can be key stumbling blocks. In order to assemble such complex projections of future emissions, transportation modellers need access to detailed transportation data. Consistent and comprehensive information on kilometres travelled, mode share, occupancy, efficiency of vehicles, fuel use and other factors are essential. Typically, this information is collected by government agencies over long time horizons and used for a range of other purposes from transportation planning to urban development planning and environmental assessments. Data collection of this kind is resource intensive and requires considerable budget support to be maintained and managed. In addition to comprehensive information on travel behaviour, it is necessary to have strong location-specific transportation modelling capacity.[27] This capacity to model transportation must be built, by way of investment in model development, expertise and data collection, in order to facilitate participation in CDM or other emission reduction initiatives in the future.

Static vs. Dynamic Baselines

Emission baselines can take one of two forms: they can either be set at the beginning for the project lifetime to serve as a fixed reference system ("static"), or they may be revised during the project operation ("dynamic").[28, 29] The vast majority of baselines put forward for project-based activities have been static, including the majority of projects in the AIJ phase[30] and all but one of the methodologies that have been reviewed by the Methodologies Panel of the CDM to date.[31] Static baselines are predictable and increase certainty regarding the volume of credit generation throughout the project lifetime.

Dynamic baselines are designed to be re-evaluated at points during execution of a project, in order to allow closer estimates of reductions. Rather than a set number for each year, the baseline fluctuates to account for factors that influence transportation emissions such as motor vehicle characteristics, demographics, economic variables, and other influencing projects and policies. As such, they may reflect more accurately what would have happened in the absence of the project and, therefore, in doing so, may ensure the continuing environmental additionality of a project more consistently than static baselines.[32, 33]

There are a number of benefits and drawbacks to the use of dynamic baselines. Dynamic baselines provide the benefit of increasing the certainty of measurement of the emission reductions accomplished through a given project. The downside with such an approach is that the dynamic structure introduces greater investor uncertainty by making it more difficult to predict CER volumes in advance. That said, it is possible to reduce this uncertainty by clearly outlining when, after what time interval, and upon what factors the baseline will be recalculated. While no comprehensive analysis has been done comparing the two options, it stands to reason that dynamic baselines will lead to higher administrative, monitoring and reporting costs during the life of the project.[34]

27 One of the key arguments for conducting the research in Chile was the strength of modelling and data sets already present in Santiago.

28 Ellis, Jane, "Options for Project Baseline Emissions," OECD Information Paper, 2000, p. 20.

29 Ringus, Lasse, P. Grohnheit, L. H. Nielson, A. L. Olivier, J. Painuly and A. Villavicencio, "Wind Power Projects in the CDM: Methodologies and tools for baselines, carbon financing and sustainability analysis," UNEP-Risoe, 2002.

30 Ellis, Jane, 2000, *ibid.*

31 Personal communication, Canada's CDM/JI Office, March 14, 2005.

32 Proof of environmental additionality is not required under the Marrakech accords.

33 Ellis, Jane, 2000, *ibid.*

34 Ellis, Jane, 2000, *ibid.*

That being said, there may be dynamic elements that can be added to the baseline so that it better reflects reality and minimizes some of the pitfalls of static baseline formulations. In a bicycle project, for example, using the most recent regional mode split data (for short trips) instead of the forecasted value would increase the accuracy of the emissions reduction calculation. For a large enough project, however, this simplistic approach would not work as the project itself could tend to influence the regional data.[35] It can be argued that dynamic baselines are particularly well suited for transportation, given the large number of variables outside the boundaries of the project that stand to impact the results. If so, and given the higher costs for these extra measures, this may point to another barrier to CDM involvement transportation projects must overcome.

Monitoring

Once the estimate of emissions has been made, the subsequent challenge is accurate monitoring of the changes brought about by the project. In the case of transport, the difficulty with monitoring lies in part with the large number of parties responsible for emissions: each vehicle is effectively a separate source. Developing countries need resources and capacity building to improve the quality and quantity of monitoring data collected. Ideally city-specific information would be collected for vehicle kilometres travelled (VKT), personal kilometres travelled (PKT), mode split (for passenger and freight travel), fuel carbon content, and fuel prices (see, e.g., the ASIF diagram in Figure 3, Chapter 1).

Proving Additionality

In order to be CDM eligible, proposed projects must result in emission reductions that are additional to what would have taken place in absence of the project. Before specific discussion about the particularities of this sector, it is useful to review the framework decisions guiding the interpretation of additionality under the Protocol. The concept is elaborated under the Marrakech Accords, where the term is used for the first time in official text. Decision 17/CP.7 states:

> (paragraph 43) "A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity."[36]

In addition to this text, the Marrakech Accords give the Executive Board a mandate to elaborate further and to provide further guidance on the issue of additionality. This guidance was recently made available by way of a set of tools for the demonstration and assessment of additionality.[37]

Current State of the CDM Market

As preparations for meeting national targets for the first commitment period move forward, the demand as well as the supply side of the CER market is developing rapidly. A number of countries have initiated programs for the acquisition of carbon units, and private companies and carbon funds are becoming directly involved in the market.

Two years after the European Council adopted the EU emissions trading directive, the EU trading scheme (ETS) was launched on January 1, 2005. From this point forward, CO_2 emissions will directly impact the bottom line of companies participating in the scheme. Trades have been steadily increasing in volume each week as countries complete their National Allocation Plans and enter the market. Given that CDM/JI credits can be applied in the EU ETS system (as per the "linking directive" legislated in November, 2004), the new system has effectively widened the market for carbon credits.

The demand for carbon credits by OECD countries for the first commitment period under the Kyoto Protocol (2008–2012) has been recently estimated at 2.5 billion tonnes of CO_2-equivalent.[38] Some estimates suggest CDM and JI are expected to contribute approximately 300 MT, leaving a substantial gap of 700 MT to be met through international emissions trading and purchases of credits from Economies in Transition (EITs). The compliance gap may increase as many key actors have a long way to go to meet their

35 Defining baseline parameters that are exogenous to the project (GDP, fuel prices) would avoid such baseline "contamination" but limited data on the relationships between these variables and bicycle use may be an obstacle.

36 FCCC/CP/2001/13/Add.2 p. 36.

37 Approved at the 16th meeting of the Executive Board, October 2004.

38 Newcombe, Ken, World Bank "CDM Market Development: A snapshot of status and issues" presentation to 4th IETA Forum on the State of the Greenhouse Gas Market, Oct 2004.

Kyoto targets through domestic policies (e.g., Canada, Japan, Italy, Spain, etc.), and domestic abatement costs are projected to be high. A number of factors influence the reliability of the estimated size of the CER market. Many Annex 1 Parties have not yet developed, or have not released publicly, a clear strategy for the fulfilment of their Kyoto targets. Others remain undecided on the role the flexible mechanisms will play within their strategy and have not identified amounts of credits they intend to procure. The demand for CERs will depend on the effectiveness of domestic policies and measures, as well as the opportunities available through both JI and IET.

A view into the supply of credits shows that of the 1,192 projects reportedly under development (as of February 2005), 206 have reached the PDD stage.[39] Renewable energy projects (biomass, bagasse) currently dominate, accounting for 41 per cent of all projects under development, followed closely by energy efficiency and landfill gas projects. However a better illustration of supply is found by examining the volume of credits currently under development: here we see an overwhelming majority of CERs arising from HFC_{23} and N_2O projects—both chemicals are areas of concern for NGOs due to their limited local sustainability implications and low perceived co-benefits.[40] Few Annex 1 countries have formally specified their preference for certain types of projects, although large-scale hydro power and sinks projects remain poorly received by a number of purchasing countries, largely for political reasons.

Some countries have emerged as key sources of CERs. Chile was recently rated by Point Carbon, an emissions market analyst group, as one of the top five most attractive host countries for CDM projects.[41] Along with creating a priority route for green investment dollars that otherwise may not be channelled to developing countries, the concept of the CDM offers host countries an opportunity to reduce greenhouse gases while also addressing local sustainability priorities. The benefits of locally-targeted initiatives coupled with potential increased foreign investment dollars make many countries eager to host CDM projects.

Numerous memorandums of understanding (MOUs) have been developed in support of CDM project development between host and purchasing countries. MOUs formalize an intention for long term cooperation and provide a framework of support for underlying activities. The majority of MOUs between Annex 1 countries and potential source countries for CERs have been developed with countries in South America (Costa Rica and Chile hosting a combined total of 11) and South-East Asia. India and China are also emerging as key suppliers.

The current price range for CERs is between $4–5 per tonne CO_2-equivalent. However, the transparency in the market is low as most buyers and sellers are reluctant to provide any information on prices defined in private purchasing agreements.[42] According to the OECD, overall funding for the CDM projects, analysis and related capacity building initiatives is likely to exceed $1 billion by 2012. The price for EU allowances is trading at a higher level, with current prices in the €8–10/tonne range.

The news in the fall of 2004 of Russian ratification refreshed enthusiasm for the CDM. The anticipated compliance gap for Annex 1 countries can now be satisfied, in part, with credits from Russia. However, before these transactions begin to take place there is a great deal of progress that needs to be made in Moscow; Russia must clarify internal processes and establish which government department has the right to sell Assigned Amount Units (AAUs).

An additional option for carbon allowances is emerging from Eastern Europe. Due to the economic downturn experienced in economies in transition (EIT) countries over the past decade and a half, some countries have emissions today that are substantially lower than they were in 1990 when the baseline was set. This over-compliance, however, is not due to any direct efforts to reduce emissions. As a result, a large amount of credits have been freed up for sale to other Annex 1 countries. In order to guarantee that environmental benefits accrue from these purchases, many Annex 1 countries have indicated that they will only buy AAUs if the selling countries in turn invest

39 CDM & JI Monitor, Point Carbon, October 2004.

40 CDM Watch, "Market Failure: why the CDM won't promote sustainable development," October 2004.

41 According to Point Carbon, the top ratings for CDM host countries are (in descending order): India, Chile, Brazil, Mexico, Morocco News, "CDM Host Country Rating" 29-10-04.

42 IETA, "Annex I Parties' Current and Potential CER Demand," Point Carbon, October 2003, at http://www.ieta.org February 24, 2004.

the proceeds into programs that provide real reductions in greenhouse gas emissions ("green investments"). This system has been labelled the "Green Investment Scheme" (GIS). The GIS would recycle revenues from emissions trading to further GHG reductions or other environmental purposes in countries with economies in transition. A recent report by the World Bank on a GIS for Bulgaria clarifies "the GIS is modelled on the idea of joint implementation type of projects, but GIS is more flexible. For instance, GIS could support environmental projects or activities where exact carbon emission reduction is more difficult to verify and the timing of the emission reduction could extend beyond 2012. Also, GIS could provide the flexibility to both parties to direct the funding as appropriate and to achieve the overall emission reductions in the most efficient matter and in the shortest possible time."[43] The GIS may present excellent opportunities for transportation sector projects and, as such, provide a working example of sectoral reductions (for further discussion see Chapter 5).

Market Challenges: Infrastructure and Uncertainty Post-2012

The willingness of investors to embark on lengthy and costly emission reduction projects is being impacted by the level of uncertainty about the future climate regime post-2012. There is wide consensus by observers that the success of a second commitment period is dependent on the engagement of the United States and high-emitting developing countries. Events at COP-10 confirmed that the U.S. is not prepared to consider any new commitments that might be perceived as placing a damper on its economic development. More positive indicators may be seen within the actions of the developing countries. High-emitting countries such as India, Brazil and China are taking actions to reduce their emissions, and messages from these countries at COP-10 hinted at a greater willingness to enter into the "commitment debate." Continued decoupling by China of its fossil fuel consumption and from its economic growth will provide a critical model for other developing countries.

Project developers and some governments have expressed considerable frustration at the extended delays as the Executive Board and the Methodological Panel work through review and recommendations on the large number of submissions. There have been wide calls for the Executive Board to improve the feedback loop into the process for proponents, as several months can pass before proponents receive information back from the review of their projects, and there is minimal opportunity to request clarification. Other complaints have centred around what some have viewed as overly stringent interpretations of additionality, and the recent introduction of consolidated methodologies which are argued to reduce potential project reductions in some cases by as much as 40 per cent. If anything, the expensive and time consuming experiences of project developers to date have illustrated the difficult, if necessary, role of early actors in a brand new system.

As well as criticism aimed at the mechanism's architecture, many observers have expressed serious concern over the quality of methodologies and projects submitted or under development. The recent submission of HFC methodologies, in particular, raised concerns about projects gaining credit for substantial emission reductions but that do not simultaneously contribute to shifts to more sustainable energy production and use, as may be possible through projects in the transportation sector.

It is important to recall, however, the groundbreaking nature of the Clean Development Mechanism and the monumental task that has been assigned to the Executive Board as it navigates through the process of translating theory into reality with extremely limited resources.[44] The UN does not have a long history of regulating markets; its primary focus has been the management and distribution of aid resources. Many years and considerable political sacrifice have gone into creating the architecture of the Kyoto Protocol and the CDM; calls for reform and criticism should be balanced with recognition of the fragility of the mechanism as it starts out.

43 Tangen, K, A. Korppoo, V. Berdin, T. Sugiyama, C. Egenhofer, J. Drexhage, O. Pluzhnikov, M. Grubb, T. Legge, A. Moe, J. Stern, K. Yamaguchi, "A Russian Green Investment Scheme: Securing environmental benefits from international emissions trading," Climate Strategies (no date).

44 While Parties to the Kyoto Protocol agreed to a $6.8 million two-year budget (2002–2003) for the activities of the Executive Board, only $1.6 Million was received toward this total.

Transportation Emissions and the CDM

With almost 25 per cent of global GHGs originating from the transportation sector, the potential for emission reductions are considerable. For their part, policy-makers in Chile, as in many developing countries, face the challenge of directing the future sustainable development of the country's transportation sector in order to meet the demand generated by population,

Figure 5: Current Transportation Initiatives under Development as CDM Projects[45]

Project	Location	Type	Estimated tonnes	Status
Bangladesh Natural Gas Conversion project	Bangladesh	Gasoline to natural gas conversion for 17,000 vehicles	130,000 (10 yrs)	Still in conceptual phase, developed by ADB's Algas program
Dhaka City electric vehicle project	Bangladesh	Gasoline to electric conversion for 3,000 vehicles	10–14,000 (10 yrs)	PDD under development by Bangladesh Center for Advanced Studies under the South South North project
Ethanol fuel project	Brazil	100,000 ethanol-fuelled vehicles	Not available (10 yrs)	Cost of project $43Million
TransMilenio urban transport project	Colombia	Technology switch: high capacity articulated buses running on trunk lanes and lower capacity buses operating on feeder routes	2,503,517 (10 yrs)	Developed by Dutch CDM Facility; seeking baseline and monitoring methodology approval; first transport project to submit a methodology
Gasohol project	India	Use of gasoline mixed with Gasohol produced from ethanol that is produced through biotechnology from sugar cane processing waste	Not available	Under development by Gov't of Japan
Khon Kaen fuel ethanol project	Thailand	Production of anhydrous ethanol from sugar cane molasses which will be blended with gasoline for use in transportation	525,080 (10 yrs)	Seeking baseline and monitoring methodology approval, public comment has closed
Andhra Pradesh biodiesel project	India	Use of biodiesel in vehicles	181,594 (7 yrs)	Seeking baseline and monitoring methodology approval, public comment has closed
Lima and Callao mass transit electric system project	Peru	Establishment of an electric mass transit system in Lima and Callao	9,044,326 (10 yrs)	Feasibility study completed, seeking carbon finance
Protransporte project	Peru	public transport system for low income population using high capacity buses on exclusive roads	1,997,439 (10 yrs)	Feasibility study completed, seeking carbon finance
Transantiago project	Chile	Public transportation re-organization of public transportation (subway and bus)	350,000 tonnes per year for 10 yrs[46]	PDD in development <http://www.dnv.com/certification/climatechange/Projects/ProjectList.asp>

45 Project information collected primarily from CDM Watch Web site: http://www.cdmwatch.org/project_list.php

46 Out of a total of 1,192 projects in Point Carbon's comprehensive database, only 206 have reached the PDD stage. Out of these 206, four PDDs have been developed for transportation sector projects. (Personal Communication, A. Eik, Point Carbon, February 5, 2005).

economic growth and business-as-usual development patterns without compromising human health and environmental quality. Achieving progress toward sustainable transportation requires in-depth analyses of policy options to promote technology improvements, fuel switching, development of sound transportation infrastructure and effective land-use planning, as well as the commitment of considerable financial resources.

Such improvements will also require commitment to building partnerships and overcoming the implementation challenges of funding and political will. CDM is one of a suite of tools potentially available to transportation planners to enhance sustainable development benefits to local communities while producing greenhouse gas emission reduction credits for the global market. As one of the handful of countries attracting the majority of attention to date, the opportunity for the mechanism to contribute to sustainable development objectives in Chile is even greater.

While some CDM projects are now being initiated in the transportation sector, the numbers certainly continue to be low compared to the total percentage of emissions from this sector. Transportation currently represents two per cent of emission reduction projects that have reached the Project Design Document (PDD) stage of development.[47] Figure 5 provides an overview of transport projects currently in the CDM pipeline, including the Transantiago project in Chile (see Chapter 3 for further information on Transantiago).

Recalling Figure 3 from Chapter 1 of the report, we have seen that, to date, most transportation sector projects proposed for the CDM have focused on the Fuel Intensity (I) and/or Fuel Choice components. For example, the proposal to replace 200 buses in Yogyakarta, Indonesia with Liquified Petroleum Gas (LPG) vehicles.[48] Some proposals, in particular the envisioned second phase of Bogotá's *Transmilenio* System, have aimed at the Fuel Intensity and Mode Share components: improving fuel utilization with newer and higher-occupancy vehicles (thereby decreasing fuel consumption per passenger kilometer [pkm] travelled) *and* displacing some future private motor vehicle travel with public transport travel by making public transport more attractive.[49] The challenges to estimating the mode share changes are not trivial. In the case of the *Transmilenio* project, the PDD estimates future mode share changes (due to project implementation) based on a survey of current system users that indicates 10 per cent of *Transmilenio* users previously travelled by private vehicle. Apparently, this 10 per cent figure was applied to future system patronage to estimate emission reductions due to the mode shift. Unfortunately, the available documentation does not allow a straightforward estimate of how much of the projected annual reductions of 610,000 tonnes of CO_2-equivalents can be attributed to the mode share shift. Since these effects are fundamentally behavioral and, in some cases, depend on second order influences, estimating their impacts requires behavioral modelling techniques with significant uncertainties and difficulties.

Reductions in the number and length of trips may be key areas of future relevance for the CDM in the face of rapidly growing demand for transportation and no clear technological (zero-carbon) fix on the near- to medium-term horizon. Heywood *et al*. show the relevant challenges in a recent assessment of the energy impacts of plausible vehicle technological improvements in the U.S. market.[50] Due to the existing vehicle stock and ongoing growth in private vehicle kilometres travelled (VKT), they find that even if new vehicle fuel efficiency improved at a 1.3 per cent annual rate (which runs counter to trends over the past 20 years[51]), private transportation fuel consumption would increase by 30 per cent between 2000 and 2015 (at which point fuel use would stabi-

47 O'Ryan, Raul and Jaime Parada, "Diagnostico del Plan Transantiago en el Marco MDL del Protocolo de Kyoto" presentation at workshop in Santiago, Chile, August 2004, "Transportation and the CDM," http://www.iisd.org/climate/south/ctp_seminar.asp

48 For further information on the Yogyakarta Bus Replacement Project, see http://www.cdm.or.id/en/project/?pid=1

49 Corporación Andina de Fomento (CAF) and Transmilenio, S.A., *Urban Mass Transportation System: Transmilenio*. Bogotá DC, Colombia. Clean Development Mechanism Project Design Document (undated).

50 Heywood, J. *et al*., "The Performance of Future ICE and Fuel Cell Powered Vehicles and Their Potential Fleet Impact," Cambridge, MA: Massachusetts Institute of Technology, Laboratory for Energy and the Environment, Publication No. LFEE 2003-004 RP, December 2003 (available at: http://lfee.mit.edu/publications/reports).

51 Hellman, K. H. and R. M. Heavenrich, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*. EPA420-S-04-001. Ann Arbor, MI: U.S. Environmental Protection Agency, Advanced Technology Division, Office of Transportation and Air Quality, April 2004 (available at: http://www.epa.gov/otaq/fetrends.htm).

lize). Their modelling suggests that a *combined* strategy of slower annual growth in new vehicle sales, a decline in light-duty truck market share, a 50 per cent market share of hybrid vehicles, and *no growth* in VKT would result in: a 13 per cent increase in fuel consumption between 2000 and 2010; a return to 2000 levels by 2020; and a reduction to 1970 levels by 2030.[52] This assessment leads them to the "sobering overall conclusion" that both technology improvements and reductions in travel growth are critical.[53]

For developing countries, with relatively low private vehicle mobility levels, we can logically expect much more rapid growth in vehicle ownership and use. Drawing from a recent model developed for the World Business Council for Sustainable Development (WBCSD) by the International Energy Agency (IEA), over the next 50 years per capita light-duty VKT in the OECD countries will increase in the range of 0.2 to 0.8 per cent per year, as compared to nearly six per cent in China, five per cent in India, and almost three per cent in Latin America.[54] Clearly, these rapid growth rates signify an important amount of "catching up"—the projections suggest that in the year 2050 private VKT per capita in North America will still be three times higher than in Latin America (compared to levels 11 times higher in 2000). Developing countries cannot reasonably be expected to bear the burden of GHG reduction by simply curtailing growth in their own private vehicle travel. However, if vehicle technologies alone cannot solve the GHG problem over the next half century, then some degree of reduction in private VKT growth will almost certainly be necessary in both the industrialized *and* the developing world.

Demographic trends and urban development patterns in the developing world indicate that a focus on metropolitan transportation will be critical. But, can moderation of VKT growth occur in an era of rapid urban decentralization across the developing world? In Santiago, for example, during the period 1985–1995, the urban area expanded at a rate nearly double the city population growth rate.[55] Nearly all developing country cities are following similar decentralizing land development patterns,[56] with significant implications for future travel demand and related emissions. Influencing these patterns for the purposes of reducing travel demand and emissions implies inducing behavioural changes, not technological changes. Whether the current CDM can accommodate projects that address underlying travel demand is an essential question.

52 Heywood *et al.*, *ibid.* 2003, pp. 13–14.

53 Heywood *et al.*, *ibid.* 2003, p. 15.

54 Adapted from the IEA/SMP Transport Model developed for the World Business Council for Sustainable Development Sustainable Mobility Project by the International Energy Agency. Model and documentation available at: http://wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTE0Njc.

55 C. Zegras and R. Gakenheimer, *Urban Growth Management for Mobility: The Case of the Santiago, Chile Metropolitan Region* (Cambridge, MA: Prepared for the Lincoln Institute of Land Policy and the MIT Cooperative Mobility Program, 2000), p. 20.

56 World Business Council for Sustainable Development (WBCSD), *Mobility 2001: World Mobility at the End of the Twentieth Century and its Sustainability* (Geneva: prepared by the Massachusetts Institute of Technology and Charles River Associates for the WBCSD Sustainable Mobility Working Group (2001).

Chapter Three
Chile Context

Chile is a country of over 15 million people. It has three principal levels of democratic institutions: national, regional and municipal. At the regional level, the country is divided into 13 Regions; Santiago is located in Region XIII, also known as the Metropolitan Region (*Región Metropolitana*). The Metropolitan Region plays a fundamental and continuously growing role in Chile's economy, despite government intentions over the years to decentralize economic growth.[57] The Metropolitan Region has a relatively large concentration of wealthy residents—that is, it is home to over one-half of the country's richest households and less than one-fourth of the country's poorest.[58] Nearly 90 per cent of the people in the Metropolitan Region live in what is often referred to as Greater Santiago which, unless otherwise noted, is the basic focus of analysis of this project. Figure 6 shows the distribution of households by income groups in Greater Santiago.

The most local level of government in Chile is the municipality. Municipal government is directly elected, presiding over the geographical unit known as the *comuna*, and is responsible for local land planning and regulating land use. Within their own comuna, Municipal governments have the authority to operate their own public transport services (although this rarely happens), establish their own norms regarding local traffic issues and combine with other municipalities to undertake transport initiatives.[60] Official transportation planning activities currently include 38 comunas within Greater Santiago, although ongoing urban expansion into new jurisdictions ultimately makes the definition of the Greater Santiago area a dynamic one.

Multiple levels of government, each with their own ability to affect land use and transportation patterns, implementing sustainable transportation policies requires cooperation at all levels.

Air quality is a particular concern for the residents of Santiago. Figure 7 shows the split of the share of CO_2 emissions from transportation in Chile, with private passenger vehicles clearly dominating.

Figure 6: Greater Santiago Household Distribution by Income Level[59]

	Average Annual Household Income (US$ 2001)						
	Over $92,000	$30,000 –$92,000	$8,000 –$30,000	$5,000 –$8,000	$2,800 –$5,000	Under $2,800	Total
Households	4,502	80,724	444,728	378,236	372,832	232,915	1,513,938
% of Households	0.3%	5.3%	29.4%	25.0%	24.6%	15.4%	

Note: Converted to annual income based on average exchange rate of 650 pesos to US$1

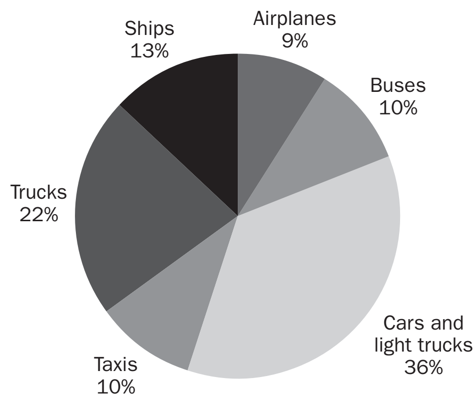
57 Zegras, C. and R. Gakenheimer, 2000. *ibid*.

58 Zegras, C. and R. Gakenheimer, 2000. *ibid*.

59 SECTRA, Mobility Survey 2001: Executive Report, Santiago de Chile: SECTRA and Ministerio de Planificación y Cooperación, 2004.

60 Zegras, C. and R. Gakenheimer, 2000. *ibid*.

Figure 7: Chile's Transportation CO_2 Emissions by Mode[61]



Increased vehicle use, along with the meteorology and topography of the region (which prevent the dispersion of pollutants) conspire to make the city's air pollution problem comparable to that of Mexico City and Sao Paulo. The region's transportation sector is the single largest source of nitrogen oxide (NO_x), carbon monoxide (CO) and respirable particulate matter (PM_{10}) (See Figure 8). Additionally, the rapid growth in vehicle use and ongoing suburbanization has had a number of environmental repercussions, including the loss of fertile agricultural land and fragile ecosystems, added pressures on wetlands, water pollution and depletion, increased noise pollution and the loss of green space.

Figure 8: Inventory of Annual Pollutant Emissions in Santiago (per cent of total) – 2000[62]

Source	PM_{10}	CO	NO_x	VOCs	SO_2	NH_3
Buses	27.6	3.2	37.9	3.1	8.8	0.0
Trucks	18.5	1.8	17.1	3.0	5.2	0.0
Light Duty Vehicles	9.3	87.9	30.7	24.5	10.2	3.1
Off-Road Vehicles	1.0	0.8	1.6	0.3	0.1	0.0
Mobile Sources Total	56.4	93.8	87.3	30.9	24.3	3.2
Point and Area Sources	43.6	6.2	12.7	69.1	75.7	96.8

Climate Change, the CDM and Chile

Climate change is a pressing issue for Chile and the government has long recognized its vulnerability to accelerated climate change. This recognition led Chile to take a proactive role in developing a national climate change policy as well as actively participating in international climate efforts. Important dates in this regard include:

> *December 22, 1994* – Chile ratified the United Nations Framework Convention on Climate Change.
>
> *April 13, 1995* – The Convention became Law of the Republic of Chile.
>
> *March 29, 1996* – Chile decreed the creation of the National Advisor Committee on Global Change which included relevant ministries, universities, researching institutions and the private sector. Operation of this group began in 1998.
>
> *November, 1999* – Chile submitted its First National Communication to the UNFCCC.
>
> *August 26, 2002* – Chile ratified the Kyoto Protocol.
>
> *May 27, 2003* – The Directive Council of the National Environmental Commission announced as the DNA of Chile.
>
> *August 24, 2004* – Chile and Canadian energy firm TransAlta sign the agreement that completes Canada's first purchase of Certified Emission Reductions under Kyoto from Chilean agricultural giant Agrosuper.

Chile has made a significant contribution to international climate change discussions since the UNFCCC negotiations in the early 1990s. This involvement has been particularly prevalent in the development of modalities and procedures for the CDM.

A Directive Council of the National Environmental Commission was developed in 2003 to become Chile's Designated National Authority (DNA). The role of the committee is to review projects seeking national approval for participation in the CDM, including assessing their contribution to Chile's sustainable development. This committee is chaired by the Executive Director of the National Environment Commission (CONAMA) and includes one repre-

61 Direct CO_2 Emissions only. Adapted from Pew, 2000, p. 33.

62 CONAMA Región Metropolitana de Santiago. Evolución de la calidad del aire en Santiago 1997–2003. Área Descontaminación Atmosférica, December, 2003. http://www.conama.cl/rm/568/article-29215.html

sentative from five participating institutions: CONAMA, Ministry of Foreign Affairs, Ministry of Agriculture, National Energy Commission and National Council for Clean Production. In the event that proposed projects involve other ministries or public services, the committee involves representatives from other relevant institutions.

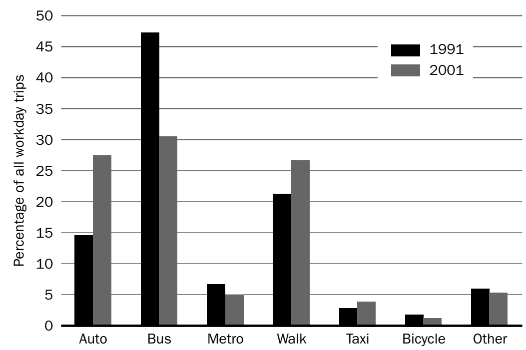
Chile is a regional leader in development of CDM projects and is consistently rated as one of the top five countries in Point Carbon's host country rating. This leadership position is supported by a number of Memorandums of Understanding (MoUs) on CDM between Chile and Canada, France and Denmark. Other MOUs with Germany, Austria, Italy and the Netherlands are under development. In addition to the enhanced partnerships created through these MOUs, since 2003 CDM opportunities in Chile have been promoted by Pro Chile, a specialized agency linked to the foreign trade department. The portfolio of CDM projects underway or envisioned in Chile fall primarily in the area of methane recovery, but also include reductions from renewables, fuel switching and large hydro. The Chacabuquito hydroelectric project is one of the better known Chilean CDM projects.[63] A subsection of the Transantiago plan will be the first CDM transportation sector project in Chile, and is currently in the PDD development phase.

Santiago's Transportation System

Consistent with trends in other rapidly growing economies, in the past ten years Santiago has experienced increased private vehicle use and a corresponding decrease in public transport use. As indicated by data collected by the Chilean government in the 1991 and 2001 Origin-Destination Surveys (see Figure 9), private vehicle use grew from 15 per cent of total trips to nearly 30 per cent. Over the same time period bus use decreased from 45 per cent to 30 per cent; Metro trips declined slightly; and walking trips increased.[64]

The number of private vehicles in the Santiago region is close to one million; the city-wide motorization rate increased from 94 private vehicles per 1,000 residents in 1991 to 143 in 2001.[66] Since the early 1990s, Chile has embarked on an ambitious transport infrastructure concession program, with most major highways being built and/or upgraded by the private sector via build-operate-transfer mechanisms. The controversial Costanera Norte Highway, scheduled to open in 2005 will run east-west through the heart of Santiago. The project was built via concession, albeit with important government subsidies implicit in guarantees. Other concessioned highways in Greater Santiago are under development or in advanced planning stages.

Figure 9: Mode Share Evolution for Santiago 1991–2001[65]



Public transportation in Santiago consists of a subway network (*Metro*), privately-operated buses, taxis and fixed-route shared taxis, or *colectivos*. The metro, a rubber-tired heavy rail system that opened in 1975, serves areas of major commercial activity and central residential areas. Three lines—including underground, at-grade and elevated segments—with 52 stops cover 40 kilometres and carry about 700,000 passengers daily. *Metro* is currently undergoing considerable expansion plans, extending several lines and adding a fourth. Bus service in Santiago is provided by approximately 8,000 buses (officially) that service 285 routes on 1,500 km of urban road. In 1995, the government built five kilometres of segregated bus lanes and created "bus only" lanes throughout the

63 http://www.cdmwatch.org/country_list.php

64 SECTRA, 2004, *ibid*. For additional detail on survey methodology and ongoing plans see: E.S. Ampt and J. de D. Ortúzar, "On Best Practices in Continuous Large-scale Mobility Surveys," *Transport Reviews*, Vol. 24, No. 3 (May 2004), pp. 337–363.

65 SECTRA, 2004, *ibid*.

66 SECTRA, 2004, *ibid*.

downtown area to facilitate the flow of pubic transportation. In 1996, there were officially 50,000 taxis serving the metropolitan area.[67]

No comprehensive network of dedicated bicycle lanes exists in Santiago. Bicycle facilities are limited to some unpaved routes in urban parks, and a small number of bikeways and bike lanes along major roadways. In the 1990s, Metro began implementation of a plan for bike lanes and parking linked to certain stations, but these were never completed.[68] Most of Santiago's streets have pedestrian facilities (i.e., sidewalks, crosswalks, timed signals), particularly in the central business district and the commercialized areas of Providencia and Las Condes. In the most heavily urbanized areas of the city, pedestrian signals exist and well-demarcated crosswalks are becoming increasingly common.

Chilean Transportation Authorities

Despite attempts to decentralize functions, politically and administratively, Chile remains a highly centralized country. This is perhaps even more acutely the case in Greater Santiago, due to the region's economic and political importance. Regional authorities have limited power (they are not elected) and the regional arms of the national Ministries often act as *de facto* extensions of central authorities. A number of the government ministries and other institutions that are integral to the planning and implementation of transportation policies are described in Figure 10.

Government

Ministry of Housing and Urban Development (MINVU)[70] – develops regional land use development

Figure 10: Institutions Involved in Urban Transportation and Urban Development[69]

	Area of Influence	Government Entity		
		National Level	Regional Level	Municipal Level
Transportation	Infrastructure Construction & Maintenance	MINVU (SERVIU) MOP		Municipalities
	Planning	MINVU MOP SECTRA MIDEPLAN	SEREMITT SERPLAC	Municipalities
	Operations	MINTRATEL METRO EFE	SEREMITT UOCT	Municipalities
Land Use	Planning	MINVU MIDPEPLAN	SEREMI–MINVU GoRe SERPLAC	Municipalities
	Development	SERVIU		Municipalities (Cordesan in Santiago)
Environment	Planning	CONAMA	COREMA GoRe – (OTAS)	
	Enforcement	CONAMA MINTRATEL MINSALUD	COREMA SESMA	

67 Lanfranco, P., R. Quijada, L. Sagaris, R. Alvarez, E. Rivera, C. Quijada, D. Fuccaro, R. Planzer, G. Montero, L. Basso, P. Donoso, R. Fernandez, C. Garrido and C. Palma, *Muevete por tu ciudada: una propuesta ciudadana de transporte con equidad*. Cuidad Viva, Santiago, Chile, 2003.

68 Zegras and Gakenheimer, 2000, *ibid*.

69 Zegras and Gakenheimer, 2000, *ibid*.

70 http://www.minvu.cl

plans and regulations, approves municipal land use plans, and administers various housing subsidy programs; also builds urban transport infrastructure through its Housing and Urbanism Service divisions (SERVIU).

Ministry of Planning (MIDEPLAN) – Establishes project evaluation criteria and techniques against which major investments are measured and justified.

Ministry of Public Works, Transportation and Telecommunications (MOPTT)[71] – Supervises transport operations, including public transport, ports and airports and manages the construction and maintenance of large-interurban facilities, including through its concession program.

National Commission for Transportation Safety (CONASET)[72] – Develops safety plans for pedestrians, cyclists, drivers and passengers and promotes programs to reduce the number of accidents. Also oversees bicycle planning for the region.

National Environment Commission (CONAMA)[73] – Leads the development and proposal of environmental policies and pollution control plans and administers the program of environmental impact assessments.

Transantiago,[74] *formerly Santiago Transport Coordination Committee (CGTS)* – Implements the transportation plan for the Santiago Metropolitan Region through the integration of all of the above ministries (see the following section for more information).

Transportation Planning Secretary (SECTRA)[75] – Drafts metropolitan and inter-urban transportation plans, develops models (e.g., ESTRAUS) and evaluation methodologies for transportation demand analyses, collects and disseminates information on transportation and land use (Origin-Destination or OD Survey) and forms transportation policies.

Transportation operators and private sector actors

The private sector plays a major role in public transportation service provision in Chile. Buses are all privately owned and operated, without explicit government subsidies. Since the early 1990s, the government has gradually re-introduced regulation via concessioning bus routes which has induced incremental improvements, reducing the overall number of vehicles, stabilizing fares and improving the quality of service.[76] Many private sector transportation consulting firms exist; the government has been active in promoting their development through outsourcing of relevant data, model development, project development and evaluation activities. *Metro S.A.* is a publicly-owned company that receives government subsidies for infrastructure construction but covers its operating costs with revenues.

Non-Governmental Organizations (NGOs)

Non-governmental organizations have become increasingly active in urban transportation-related issues over the past 15 years. One of the relevant NGOs is *Ciudad Viva*[77] (Living City), a group of community leaders and expert advisors from a variety of fields including transport engineering, planning and architecture. The organization supports sustainable transportation, heritage preservation, waste management, reduced noise pollution, improved safety, and local economic development. The *Movimiento Furiosos Ciclistas*[78] (Movement of Furious Cyclists) promotes increased bike resources for Santiago's citizens, including bikeways, exclusive bike lanes and bike parking. The organization supports integrating the bike plan for Santiago with other modes of transport.

71 http://www.moptt.cl

72 http://www.conaset.cl

73 http://www.conama.cl

74 http://www.transantiago.cl

75 http://www.sectra.cl

76 Dourthé, A. *et al.*, "Santiago de Chile's Experience with the Regulation of the Public Transport Market," Paper prepared for the 79th Annual Meeting of the Transportation Research Board (TRB), Washington, DC, January 2000.

77 http://www.ciudadviva.cl/

78 http://www.mfc.cl/

Development Agencies

The World Bank through the Global Environmental Facility (GEF) provided financial support that began in 2002 to implement an urban transport plan in Santiago for 2000–2010. Part of this initiative is a focus on mitigation of the air quality and GHG impacts of transportation. Specifically, the GEF project agreed to finance six feasibility studies aimed in part at achieving GHG reductions in the sector: bikeways and bicycle use promotion; alternative fuel technologies for buses; land use schemes to reduce travel demand; road pricing; travel blending; and environmental evaluation techniques for urban transport program analyses.[79]

Academia

Chile has a very strong post-secondary educational system, with many universities active in areas of transportation engineering, environmental engineering and urban planning. Both the University of Chile and the Catholic University of Chile have renowned transport engineering departments with a strong capacity for transportation analysis. The universities have been active in working on government projects, often through related consulting arms. For example, the Program for Scientific Investigation and Technology at the School of Engineering (DICTUC)[80] at Catholic University has been in charge of travel survey development and related data management work, while LABTUS, a transportation modelling laboratory at University of Chile, has developed and maintains an urban land use model for integration with transportation forecasting models.[81]

Planning Capacity

Relevant Plans and Policies

Over the past several years, all levels of government have made a concerted effort to improve transportation conditions, manage urban growth and mitigate Santiago's air pollution problem.

A major initiative of the Chilean government to improve transportation system performance involved the development of the "Plan for Urban Transport (PTUS) for the City of Santiago 2000–2010" released in late 2000. The plan finds its origins in a 1994 plan elaborated by SECTRA which identified strategies and investments for the period 1995–2010. The plan's stated purpose is to "improve the quality of life in the city and promote social equity among its citizens." Key goals of the PTUS included promoting public transport, encouraging responsible use of private vehicles, influencing land use decisions with the objective of reducing trip length and coordinating the efforts of agencies working on transportation. To meet these objectives, the plan established programs to modernize public transport, invest in roads and traffic control, re-locate schools, change residential land-use patterns, promote non-motorized transport, monitor progress and encourage public participation.[82]

As is often the case in multi-jurisdictional issues with unclear planning and implementation responsibilities, full PTUS implementation continues to face considerable barriers and delays to full realization. The public transport component of PTUS is now referred to as "Transantiago," encompassing several programs including bus fleet and company modernization, route restructuring, fare and service integration with the Metro, and the development of specialized infrastructure (dedicated bus lanes and intermodal transfer stations). Transantiago will redesign the bus network to have five *troncales* (main routes) and ten *alimentadores* (feeder zones) that link to the troncales. This network improvement is designed to meet all demand for public transportation in the city. Different classes of buses, of varying size and capacity, will accommodate variations in demand on the different routes. In one service zone, covering downtown, the fleet will consist of clean technologies (compressed natural gas, hybrid diesel-electric). The proposed new service marks a considerable departure from the existing system which has, itself, been under a gradual evolution from the near chaotic state at the end of the 1980s through incremental improvements in regulations. Not surprisingly, implementation of the plan has faced technical and political challenges, the latter not only in the form of opposition from existing operators, but also—somewhat surprisingly—

79 http://web.worldbank.org/external/projects/main?pagePK=104231&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P073985

80 http://www.dictuc.cl/

81 http://www.labtus.cl/site/

82 *Plan de Transporte Urbano para la Ciudad de Santiago* 2000–2010.

from the Metro, which apparently feared loss of revenue control. Transantiago is currently envisioned to be implemented in three phases: August 2005 to May 2006, when the new operating companies will take over, including with the introduction of 1,200 new buses replacing roughly 3,500 existing units; May 2006 to August 2006, when an integrated fare card technology will be introduced; and from August 2006 onward, when full implementation will take place. The Transantiago plan is guided by Transantiago the institution, which oversees these phases and other aspects of the plan's implementation.

Of course, Transantiago and transport development in general is also influenced by other plans, in particular urban highway infrastructure concession plans as well as land use management plans. Historically, there has been an important disconnect between the relevant visions, in part due to some degree of inter-institutional competition. For land use plans, the major metropolitan plan was published in 1994 and modified in 1997 to include a rapidly suburbanizing area directly north of Greater Santiago. The metropolitan land use plan guides comuna-level land use plans. Historically, considerable disarticulation between land use planning (under MINVU) and transportation planning (under SECTRA and MOPTT) has been the norm.[83]

In terms of the environment, the General Environmental Framework Law of 1994 created a legislative foundation for environmental protection at the national level. The law establishes the basic conditions for environmental regulations, including setting the framework for establishing pollutant concentration norms and the process by which areas violating those norms should come into compliance. Currently, air quality standards exist for respirable particulates, total suspended particulates, lead, carbon monoxide, ozone, nitrogen dioxide and sulphur dioxide.[84] The General Environmental Framework Law also established the System for Evaluation of Environmental Impacts under the purview of the National Commission on the Environment (CONAMA) (the relevant environmental authority which the legislation also created).

Based on the 1994 environmental legislation, the Santiago Metropolitan Region was declared in violation (*zona saturada*) of established norms for total suspended particulates (TSP), respirable particulates (PM_{10}), ozone (O_3), and carbon monoxide (CO) and at risk of violation (*zona latente*) for NO_2. Due to this declaration, authorities developed a pollution reduction and prevention plan in 1997, which has been updated periodically. The transportation sector is responsible for 56 per cent of PM_{10} and 87 per cent of NO_x, a precursor to ozone (transport is responsible for 31 per cent of VOCs, the other ozone precursor) (see Figure 8 earlier)—the two most serious problems of air pollution in the capital city.

In the past ten years, the government of Chile has focused on reducing transportation air pollutant emissions by improving fuel quality and strengthening vehicle emission standards, using U.S. Environmental Protection Agency and European standards as a guideline. These standards are supported by the implementation of a country-wide inspection regime for vehicles. As a result, heavy vehicles and buses have made significant progress in meeting regulations, with buses showing a marked improvement. Concurrently, Santiago has shown important improvements in pollutant concentrations. New stationary sources (over established thresholds) are required to offset their emissions by as much as 150 per cent. This scheme has successfully led to declines in severe pollution days. For example, since implementation of the pollution control plan of 1997, the city has experienced a 18–34 per cent drop in average winter time PM_{10} concentrations (the city suffers from a thermal inversion) measured at seven monitoring sites across the city. Ozone concentrations have proven to be more tenacious, with the number of days exceeding the norm staying relatively constant (40–46 per year) over the past six years.[85]

Despite these successes in reducing local pollution levels, command and control regulations are becoming increasingly expensive. Modelling has estimated that creation of a domestic emissions trading system for Chile could lead to a savings of more than $180 Million over a period of ten years. These savings, as well as the opportunity to provide more flexible compliance options for the private sector, led the government to begin development of a formal Emissions Trading System. The first phase of the ETS proposes

83 See Zegras and Gakenheimer, 2000, *ibid*. for more detail.

84 More details on current ambient air quality standards can be found at: http://www.conama.cl/portal/1255/propertyvalue-10316.html

85 CONAMA Región Metropolitana de Santiago, 2003, *ibid*.

to apply a cap and trade framework to large stationary sources (primarily manufacturing), public transportation and industrial processes, and would cover PM_{10}, NO_x in the metropolitan region, and possibly SO_x and CO.[86] The legal framework for the establishment of the ETS is still under discussion by Chile's parliament.

Modeling Capability

Chile's advanced modelling capacity is a key resource for Santiago to analyze regional transportation plans.

ESTRAUS is an urban transport planning model developed by SECTRA in the 1980s specifically for Santiago. ESTRAUS represents the "state-of-the-art" in practice, including: a simultaneous equilibrium formulation for trip distribution, mode split and assignment which ensures consistency among these sub models; a detailed representation of the public transport network, including vehicle capacity constraints; the possibility to introduce modelling of departure time choices; among other innovations.[87] While ostensibly the "official" model for transportation planning purposes in Santiago, the transportation model EMME/2 has also been used by planning authorities in MOPTT, in particular to plan regional highway networks and the rapidly expanding northern suburbs.

During the 1990s, researchers at the University of Chile developed *MUSSA*, a behavioural land use equilibrium model.[88] It was designed to forecast the expected location of agents, residents and firms in the urban area in order to simulate the economic impact on the real estate market of demographic and economic growth, the application of urban management policies, the execution of real estate or transport projects and changes in the structure of behaviours of consumers.[89] Transportation system performance (e.g., outputs from ESTRAUS) serve as inputs into MUSSA's location model, providing an integrated transportation land use modelling platform. SECTRA is currently planning on using MUSSA together with ESTRAUS in order to assess potential future transportation infrastructure investments. Again, MOPTT has also used other integrated land use transportation models, most notably MEPLAN, in the development of regional-level forecasting activities for the Metropolitan Region.

In recent years, SECTRA has also led the development (by the University of Chile) of MODEM a vehicle emissions model, that translates public and private transport flows (by network links and using average speeds) from a travel forecasting model (such as ESTRAUS) into estimates of atmospheric pollutant emissions. MODEM considers some 60 different vehicle types and seven pollutants (PM_{10}, CO, total hydrocarbons, NO_x, nitrous oxide, methane, ammonia) as well as fuel consumption. The outputs from MODEM (e.g., emissions by link and time period) can be incorporated into air pollution dispersion models, which environmental authorities in Santiago currently operate. SECTRA has been working on finalizing a model (MODEC) to quantify the economic implications (human morbidity and mortality) of transport pollutant concentrations, focusing on respirable particulates and ozone. Currently, the actual economic costs to be used in MODEC are still being debated by authorities, but ultimately this platform will offer an important tool to evaluate local pollutant co-benefits.

Freight traffic (trucks) is currently excluded from travel as well as pollutant emissions modelling.

Data Availability in Santiago

The primary transportation data used in the modelling (as well as this study) come from household origin destination surveys, which exist for Santiago for 1977, 1991 and 2001. The last two surveys have been carried out under the auspices of the national transportation planning secretariat (SECTRA). The 2001 O-D survey included 15,000 households (roughly one per cent of Greater Santiago), 12,000 surveyed during the "normal season" and 3,000 during the summer time. The survey included all trips in the public space made by all household residents (including infants) and included weekend trip-making. The survey contains information on educational level,

86 Chile: Emissions Trading System, IEA, 2003, http://www.iea.org/textbase/work/2003/ghgem/CHILE.PDF

87 de Cea, J. *et al.*, "ESTRAUS : A Computer Package for Solving Supply-Demand Equilibrium Problems on Multimodal Urban Transportation Networks with Multiple User Classes," Washington, DC: paper presented at the Annual Meeting of the Transportation Research Board, 2003.

88 http://www.mussa.cl/E_general.html

89 Martínez, F. and P. Donoso, "MUSSA: a behavioural land use equilibrium model with location" externalities, planning regulations and pricing policies," University of Chile. http://tamarugo.cec.uchile.cl/~dicidet/fmartinez/Mussa.PDF

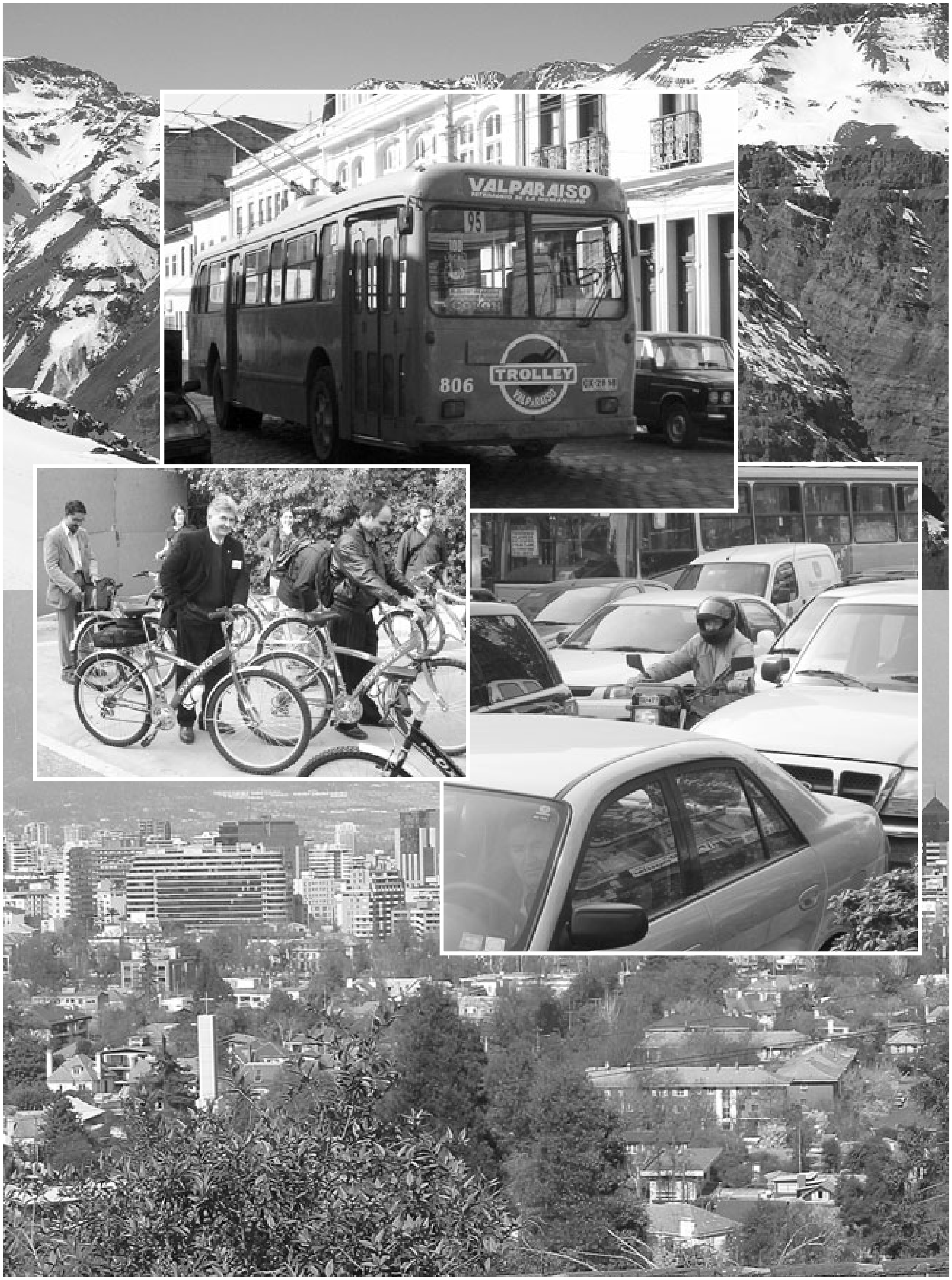
income level, 13 different trip purposes (e.g., work, errands, study), and 28 different travel modes (e.g., auto driver) or combination of modes (e.g., auto passenger-Metro).[90] The household information is geocoded in a geographic information system (GIS) (allowing for detailed spatial analysis), at the center of the census block (nearly 50,000 blocks),[91] while the trip origin and destination information is also geocoded. For land uses, a recent effort has been made to compile relevant information from national tax records and business and land use permits (as reported to Municipal governments). Information (e.g., type of use, floor space constructed) is now available for roughly 1.3 million residences and 400,000 non-residential land uses, geo-coded at the street address level or sometimes the census block level. For pollutant emissions, authorities have local vehicle testing facilities and have developed drive cycle profiles for Santiago, which have fed the development of MODEM.

Conclusion

Despite several years of progressive engagement on transportation initiatives by a wide range of actors, there is still room for sustainability improvements in a number of areas of Chile's transportation sector. Considering the rapidly growing and increasingly urban nature of the country's population, new and difficult challenges will be emerging over the next decade as demand for transport grows. Initiatives such as Transantiago, and the suite of GEF-funded components currently underway are contributing to framing—and making progress toward—the goal of more sustainable transportation. Subsequent chapters of this report explore in more detail how similar initiatives aimed at tackling both local and global sustainability concerns in the transportation sector may become even more commanding when placed in the context of global climate change.

90 SECTRA, 2004, *ibid.* and Ampt and Ortúzar, 2004, *ibid.*

91 The census blocks range in size from 0.00097 to 4,000 hectares, with an average of 1.5 hectares.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Chapter Four
Case Studies

Introduction

The project analyzed three case studies of how the CDM may be used to address both technological and demand-side solutions for reducing GHG emissions from Santiago's transportation sector: A) Bus Technology Switch, B) Bicycle Initiatives, and C) Location Efficiency. The three case studies were selected by the Project Steering Committee after review of 16 initial project ideas. The final three were chosen based on the use of selection criteria including sustainable development impact, cost-effectiveness, CDM eligibility, GHG reduction potential, replicability, and feasibility (see Appendix B). The Committee made a point of including both technology and demand-side measures to reflect the range of options necessary to reduce emissions, and also as a way to maximize learning opportunities from the case studies. The list of project ideas did not include the TransSantiago bus rapid transit (BRT) system, as this was already being examined by the GEF project.

Through an analysis of key CDM components including project baseline, additionality, methodology, monitoring, and leakage, the case studies provide working examples of potential transportation CDM projects. These examples serve to enrich discussion of how transportation projects fit within the modalities and procedures as they currently stand, how they might contribute to a future mechanism, and in which cases an alternative policy approach may be most appropriate. Each case study includes the following elements: Background/context; Analysis; Quantitative results; and Discussion. The case studies are followed by a short comparison of results, with conclusions and recommendations explored in depth in Chapter 6.

A. Bus Technology Switch and the CDM

Background/Context

Why Bus Technology Switch?

While buses represent only about 10 per cent of Chile's transportation greenhouse gas (GHGs) emissions,[92] the mode contributes to high levels of local pollution in Santiago. In 1991, buses were used for almost half of all trips, but just under a third of trips in 2001.[93] While the share of bus trips has diminished, the total number of bus trips increased by more than 10 per cent. These trends of decreasing mode share, but increasing number of trips, are expected to continue in the short to medium term.

Consequently, bus technologies that decrease or replace fossil fuels with other less GHG-intensive fuel sources are a significant part of a comprehensive strategy to control GHG emissions growth in the transportation sector. Such a change can provide important local co-benefits, such as improved air quality, that are of high interest for developing as well as developed countries.

Current Buses Policies/Programs in Santiago

As discussed in Chapter 3, the Government of Chile is currently embarking on a comprehensive effort

92 Cifuentes, B., "Cuantificación y Proyección de Escenarios de Emisiones de Gases de Efecto Invernadero en el Sector Transporte en Chile," memoria para optar al grado de Ingeniero Civil Industrial, Universidad de Chile, 2000. As cited in: Pew Center of Global Change, *Transportation in Developing Countries: Greenhouse Gas Scenarios for Chile*, Table 11.

93 SECTRA, "Encuesta Origen Destino De Viajes 2001."

aimed at modernizing the public transportation system of Santiago. The Transantiago plan will improve the overall provision of services as well as the region's air quality.

Under Transantiago, bus service provision will be publicly tendered within a framework of stringent regulations that must be met for each of the service areas. The number and size of buses, efficiency standards and frequency of service will all be regulated. These requirements will result in approximately 20 per cent of the buses (nearly 1,250 vehicles) being replaced with new vehicles at the start of the plan in mid-2006. The fleet will be progressively renewed from the inception date, with the target of replacing the entire vehicle population by 2010. Engines in all new buses will need to comply with stringent emission standards (Euro III or EPA 98), transmissions must be automatic and vehicles must use hydraulic or power steering. It is worth noting that the local feeder service area in the Central Business District (CBD) will have additional requirements of cleaner technology vehicles (compressed natural gas (CNG), hybrid or electric). Service providers for this district will be compensated for this additional requirement by being granted a longer-term concession.

Through this comprehensive restructuring of public transportation service management for the city, Transantiago will substantially reduce the number of vehicles required to offer an improved quality of service to users. This, jointly with a progressive fleet renewal with stricter technology standards aimed at improving air quality, will also result in an important reduction of GHG emissions. Although Transantiago standards are imposed primarily for air quality, road use optimization and congestion improvement purposes, the associated GHG reductions will amount to significant co-benefits.

It is important to note the potential trade-off between improvements in local pollutant levels and reduced fuel efficiency—some emission control technologies increase vehicle energy use and CO_2 emissions. However, the overall system improvements (e.g., reduced number of vehicles, higher capacity buses) more than offset this and lead to a net decrease in overall *per passenger* emissions. While not currently included in the Transantiago plan, hybrid diesel-electric buses offer the potential to lower both *per vehicle* and *per passenger* emissions due to reduction of fuel consumption.

Policy Precedents

The use of policies for improving the quality of public transportation services are not new, however, Transantiago (together with its predecessor PTUS[94]) is the first comprehensive effort to address public transportation in Santiago. Other cities in Latin America have also taken up the challenge of improving public transport services and increasing co-benefits for residents. Perhaps the most outstanding approach to this issue are the efforts in Curitiba (Brazil) and Bogotá (Colombia) that have focused their attention on the optimization of the management of the service through large-capacity buses, segregated infrastructure (exclusive busways), and bus and station design that allows for rapid boarding. The design of Transantiago is based in part on the Columbian example of TransMilenio, a comprehensive overhaul of Bogotá's public bus system that began in 2000. TransMilenio has introduced 48 km of segregated busway, described as a "surface metro system," with an additional 346 km planned by 2016. The cost effective, consumer-oriented nature of Bus Rapid Transit (BRT) has contributed to an apparent reduction in private car and taxi use, and significant increases in public transit passenger trips. Two years after its inauguration, TransMilenio had cut travel times for users by 32 per cent, lowered traffic accidents by 80 per cent, and cut noise pollution by 30 per cent. TransMilenio has also improved air quality readings in Bogotá's capital: SO_2 levels dropped 43 per cent, and both NO_2 and particulate matter were reduced by 18 per cent.[95] In the first four years of the initiative, estimates suggest that CO_2 reductions have been in the order of 694 metric tonnes per day; if the projected benefits of the changes mode split is projected forward (assuming current plans are realized), the reductions will rise to 5,688 metric tonnes per day by 2015.[96] Similar to TranSantiago, TransMilenio is planning a CDM component to their initiative—project developers are currently seeking approval for the methodology.

94 For more information on PTUS and the evolution of Transantiago, see Chapter 3.

95 Peterson, Lisa, "Experts Outline Benefits of Better Bus System," ITDP, April, 2003.

96 Diaz, Oscar Edmundo, "Estimated Greenhouse Gas Emission Impacts of Bogota's BRT, TDM and NMT Measures," see: http://www.itdp.org/read/GEFbackground_nairobi2002.pdf

Analysis

The Case Study

The proposed project examines the role of the Clean Development Mechanism (CDM) as a potential new source of financing to promote an improvement of technology for the bus fleet. In particular, the study assesses a technology switch from diesel to hybrid diesel-electric buses, as applied to the feeder areas within the Transantiago plan. Hybrid diesel-electric engines are more efficient and have lower GHG emissions than traditional diesel engines. Diesel technology is currently envisioned for use in all surface services included in the Transantiago plan, with the exception (as discussed above) of the central business district where vehicles must meet higher performance standards.[97]

The selection of the technology to be studied took into account the local pollutants Transantiago intends to abate, the security in the supply of the fuel involved and the renewal costs for obtaining new buses. The methodology described below is applicable to any section of the Transantiago system; however the analysis focuses specifically on bus feeder areas because data required for quantitative emission reduction estimations were most readily available for these cases.

This study examines the possibility of a new financing source from the sale—within the framework of the Kyoto Protocol or other parallel carbon reduction systems—of the certified GHGs emission reductions (CERs) resulting from the reductions attributable to this technology switch. Further discussion of how these credits fit within the international structure of climate change mitigation can be found in Chapter 2.

Method

The approach used to quantify the impact of the CDM from the bus technology switch includes three components: 1) evaluation of incremental costs, 2) evaluation of emission reductions, by discussion or comments on a) determination of baseline emissions, and b) justifying additionality, and c) monitoring protocol, and finally 3) calculations of emissions and costs.

1. Evaluation of Incremental Costs

A technological switch can impact expenses and revenues associated with service provision in the Transantiago system. The cost analysis undertaken included the following elements:

- vehicle procurement (bus purchase price);
- taxes;
- fuel;
- operational costs (battery, tires, lubricants maintenance, repairs etc.); and
- salvage value (at the end of the life cycle).

Any costs that remain constant between the new and original technology, such as salary of the driver, parking costs, etc., were excluded from the analysis. Service revenues are assumed to remain constant as the fare is set for the system as a whole, independent of the technology used.

A number of factors and assumptions were used to calculate the incremental costs of the technology improvement:

- Funding for technology procurement is borrowed from the bank and the associated bank credits and expenses are calculated in the typical manner.
- Bus salvage value of 10 per cent of the procurement value.
- The use of presumptive capital tax as a percentage of the buses" value in the total capital goods of the company, considering their (lineal) depreciation over the project lifespan.
- A formula was developed to estimate annual fuel and operating expenses based on the number of buses, trip lengths, and service frequencies at different times of day.

2. Evaluation of Emission Reductions

Three elements are involved in evaluating the volume of emission reductions possible from the project:

a) Determination of Baseline Emissions

An essential requirement established by the CDM is comparison of GHG emission reductions achieved by a project activity against those that would have happened without the project activity.

To create a scenario that reasonably represents the anthropogenic GHGs that would have happened

97 See Chapter 3 for more details.

in absence of the proposed project activity—referred to as the baseline or reference scenario of a CDM project activity—the CDM modalities and procedures prescribe the use of one of the following three possible approaches:

a. existing actual or historical emissions, as applicable; or

b. emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment; or

c. the average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.[98]

Given that Transantiago represents a departure from previous programs and can be considered unique, no actual or historical account of emissions exists and, therefore, the first option is not suitable. Neither is the third option viable, as there are few examples of systems similar to Transantiago and comparisons would be difficult due to the significant impact of variations in local conditions. As such, the second option is deemed most appropriate in this case. Transantiago sets the technology requirements for companies bidding to provide services; as such it is unlikely that bids will go beyond these requirements. Given the application of this approach, the baseline for a technology switch project in Santiago should take into account emissions from the use of diesel technology, with progressive improvements to standards (EURO III or EPA 98) as outlined in the Transantiago plan.[99]

Transantiago is establishing a regulatory framework for the operation and characteristics of public transportation that will remain in effect for at least five years. If there is a change in the regulatory framework subsequent to the fifth year, the validity of this base scenario is protected by a recent decision of the CDM Executive Board. This decision established that "in case there are national and/or sectoral policies or regulations that give competitive advantages to technologies that are less intensive in GHGs emissions compared to more intensive technologies; and if they were implemented after the adoption of modalities and procedures for the CDM on November 11, 2001, the reference scenario must refer to an hypothetical situation without considering this policy or regulation as being in force."[100]

Carbon dioxide emissions are calculated from the fuel consumption and exhaust emissions based on a carbon balance. In principle, this balance considers that the carbon content in the fuel is oxidized as CO_2 and carbon monoxide (CO) or that it is transformed into volatile organic compounds (VOC or hydrocarbons) and particulate matter (PM). However, due to the difficulty in monitoring actual emissions of CO, VOC and PM resulting from combustion, this equation was simplified.[101] As such, CO_2 emissions are directly proportional to fuel consumption (0.0026 tonnes per liter of diesel fuel). Nitrous Oxide (N_2O) and Methane (CH_4) are not considered in this study due to the lack of available information estimating the specific drive cycle under consideration. However, typically emissions of N_2O and CH_4, (expressed in terms of CO_2 equivalent), are less than one per cent and 0.2 per cent, respectively, compared to the CO_2 emissions per liter of diesel fuel.[102]

98 FCCC/CP/2001/13/Add.2, p. 37 Decision 17.CP7.

99 Note: TranSantiago is a comprehensive program, undergoing revisions and further development at the time this case study was undertaken. As such, the version used to calculate baseline emissions for the illustrative bus case study may or may not be identical to the final version as implemented in Santiago.

100 Report from the Sixteenth Executive Board Meeting, Annex 3.

101 This simplification would impact on the results by less than 0.02 per cent according to: Universidad de Chile, Departamento de Ingeniería Mecánica, "Analisis Ambiental del Escenario que Considera Diseño del Sistema de Transporte Publico Elaborado en Febrero 2003 (Escenario 5b)" (Santiago, 2003) Anexo C, p. C-8.

102 Intergovernmental Panel on Climate Change, *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, p. 1.75, Table 1-32.

Fuel consumption depends on the efficiency of the bus engine as well as the local driving conditions or drive cycle. A drive cycle attempts to represent the effects of localized driving conditions (speed, acceleration, geography, etc.) on emissions. Sufficient data are available to accurately calculate per-kilometer fuel consumption for buses circulating in Santiago, as a function of their mean speed and the emission standard for their engine type.[103]

The proposed methodology uses a *dynamic baseline* equation to estimate the baseline emissions derived from fuel consumption per kilometer at the mean performance speed of the bus fleet. Data collected by the Transantiago GPS system will contribute to calculations of the mean speed of buses on various routes. In turn, project GHG emission reductions are calculated based on actual fuel consumption of the fleet, using newly available technology. The use of a dynamic equation allows the baseline to reflect actual operating conditions at the time of the emissions savings (as opposed to an *ex ante* forecast), thus maintaining greater environmental integrity and strengthening the predictions of reduction volumes. Further discussion of dynamic vs. static baselines can be found in Chapter 5.

b) Additionality

The sole reference to additionality in the Marrakech Accords is found in Decision 17 CP.7 para. 43, which states "A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity."[104] Additional guidance was provided by the Executive Board in 2004, in the form of (optional) tools that can be used to demonstrate how proposed project activities are additional to the project baseline.[105] The tools provide a step-ways approach to additionality assessment, and suggest choosing between an *investment* or *barriers* analysis as a key step in building an argument for a proposed project. An investment analysis determines whether the proposed project activity is economically or financially less attractive than other alternatives without the sale of CERs (in other words, that the investment needs the CERs to become viable). A barriers analysis is used to determine whether the proposed activity faces barriers that prevent widespread implementation of this activity (thus preventing the baseline scenario from occurring).[106]

In the case of the bus project, while financial analysis indicated that the activity was financially viable, lack of implementation on the ground highlighted the barriers to practical implementation in Chile. The key implementation barrier is unfamiliarity on the part of potential users with the hybrid diesel-electric technology, and lack of information on actual capital and operating costs in Chile. In addition, Chilean mechanics do not have experience repairing hybrid diesel-electric vehicles and there is uncertainty about the availability and cost of spare parts. Finally, as hybrid electric buses are unproven in the local setting, there is a hesitancy to be the first to introduce the new technology and potentially face financial risks or operational challenges. As such, non-financial barriers were selected as the primary reason for additionality of the bus case study.

c) Monitoring Protocol

In order to verify and certify the GHG emission reductions, the project must include a methodology for monitoring project impacts. Monitored emissions are then compared with those that would have occurred in the baseline scenario to determine project savings.

The estimation of emissions in the baseline scenario is achieved by tracking the distance travelled by buses in the region, in combination with the service frequency established for the feeder areas under the Transantiago plan. This approach

103 The discrepancy between calculated values and actual values using this formula is approximately 1.13 per cent, according to: Universidad de Chile, Departamento de Ingeniería Mecánica, "Actualización del Modelo de Calculo de Emisiones Vehiculares" (Santiago, 2002), Chapter 3 , p. 54.

104 "Modalities and procedures for a clean development mechanism as defined in Article 12 of the Kyoto Protocol," FCCC/CP/2001/13/Add.2 Decision 17/CP.7.

105 "Draft consolidated tools for demonstration of additionality," Annex 3, 15th Meeting of the Executive Board Report, Annex 3.

106 CDM Executive Board Meeting 15, Annex 3 "Draft consolidated tools for demonstration of additionality," September, 2004.

draws on information available in Transantiago's global positioning system (GPS) operations control unit, and allows for the calculation of the mean speeds of buses. This speed data enables a more accurate calculation of baseline emissions.

The dynamic baseline equation is based on estimation of actual emissions through automatic collection of vehicle operation data. The data on actual fuel consumption would be collected from billing data from fuel purchases, either on a per vehicle basis or through a source agency in the case of fleets that have a centralized system for refueling. In some cases this data is already being collected in Santiago, therefore, past records may assist in determining reductions.

3. Calculations of Costs and Emissions

Data and Assumptions

The methodology described has been applied to nine of the ten local feeder areas covered by the Transantiago network, where a technological switch diesel to hybrid diesel-electric was possible according to the requirements stipulated by Transantiago. However, for simplicity reasons, we will refer in the following just to one of those areas, feeder Area 3 (as currently outlined in the Transantiago plan). Area 3 was selected as a representative example of services and fleet size covered by the other Areas. In addition, the requirements for service (technological specifications of vehicles for the route) outlined for Area 3 best match with the technical data currently available. In this way, the methodology could be developed using the fewest assumptions.[107]

The basic assumptions adopted for the calculation are as follows:

- The buses in the project scenario project and in the reference baseline are new 12-meter long buses. In the reference case, they comply with EURO III Standards.
- The fleet size requirement, length of service and frequency stipulated by Transantiago for the chosen area are strictly complied with during the next 10 years.
- The mean speed of buses is derived from the fleet size, service length and frequencies for peak hours as stipulated by Transantiago for Area 3, and is also valid for off-peak and nighttime hours. This information, together with the frequency requirements for these hours, provides the fleet size for those hours.
- The equation that correlates the fuel consumption factor and the mean speed of the diesel EURO III buses in Santiago, derived by SECTRA for the current conditions of the drive cycle in this city, is also valid for the area under study and its traffic characteristics.[108]

The inputs to the calculation of emissions from the project are derived from a number of local sources:

- The terms and conditions for bidding as published by Transantiago for Area 3 covering the levels of service and their lengths, peak, off-peak and evening frequencies as well as fleet size during peak hours.
- Procurement and operating cost data were drawn from values provided by Eletra, a bus manufacturer of diesel and hybrid technology in Brazil. No data were available specific to the Chilean market. The Eletra numbers are more optimistic than previous studies in terms of fuel savings and vehicle costs. However, they are consistent with the general trend of how the technology is evolving over time. In other words, with more experience, technology and manufacturing improvements appear to have improved the technology performance and reduced its costs. In addition, a recently published paper in an international journal used the same source.[109] The cost figures used are presented in Figure 11.

107 The feeder area selected was #3, in part because the bidding requirements stipulate the possibility to use all 12m buses (as opposed to a combination of 8m and 12m). Because the majority of existing technical information for diesel hybrid-electric buses is for 12m versions, this influenced the selection of the specific route area.

108 This relationship is: Fuel Consumption Factor (gram/km) = 1,391.325 * $V^{(-0.4318)}$

109 D'Agosto, M. De Almeida and Suzana Kahn Ribeiro, "Performance evaluation of hybrid-drive buses and potential fuel savings in Brazilian urban transit," *Transportation* 31: pp. 479–496, 2004.

Figure 11: Assumed Vehicle and Operating Costs

	Diesel	Hybrid
Vehicle (US$)	$90,000	$115,000
Operation (US$/km)	$0.03142	$0.02236

- A fuel consumption (and thus GHG) savings rate of 25 per cent, based on values reported by Eletra.
- An interest rate of eight per cent has been applied to the bank credit used to procure the fleet. The price of $0.644 was assumed for one litre of diesel fuel, a presumptive capital tax of one per cent of the company's equity was applied.
- Discount rate of 10 per cent for the financial analysis.[110]
- A ten-year project lifetime was assumed.

Quantitative Results

The application of these assumptions and data to evaluate the incremental cost associated to the technology switch for the 462 buses required by Transantiago for Area 3 gives the results presented in Figure 12 (at present value and in U.S. dollars). It is important to note that adoption of the new technology leads to both additional costs and additional savings (as represented by negative values) over the course of the ten year project. In Figure 12, we see the savings outweigh the additional costs for hybrid diesel-electric beyond the standard Euro III technology.

Figure 12: Incremental Costs for Hybrid Diesel-electric Buses (Transantiago Specific)

	Incremental Costs (US$)
Vehicle procurement	$10,576,586
Taxes	$407,869
Fuel	- $ 17,900,598
Operational costs	- $1,970,862
Salvage value	- $445,302
Net incremental cost	- $9,322,307

This scenario results in overall cost savings of $9.3 million relative to the base case, with fuel cost savings more than offsetting increased capital costs. These fuel savings would result in a reduction of CO_2 emissions by 11,717 tonnes per year. The net present value of the revenues from the sale of the reductions, at a hypothetical market price of $10 per CER would be US$719,957 at a discount rate of 10 per cent. Thus, the implementation of the CDM project as outlined could provide a financial benefit to the project proponent (from a combination of fuel savings and CER sales) of $10,052,264 (minus transaction costs).

Comments

The analysis shows that hybrid diesel-electric buses are economically attractive in their own right, despite the fact that the technology is not in use in Chile. These findings lead to the conclusion that financial barriers are not the primary impediment to penetration of this technology. Instead, potential users lack key cost and technical information, and are concerned about the risks of introducing a new technology. The contribution of additional revenues obtained through sales of CERs could, in theory, provide an added incentive that might make some bus companies more willing to purchase and use hybrid diesel-electric buses.

That being said, revenues from the sale of CERs are likely to be relatively modest in comparison to total technology costs (depending on cost assumptions). There are two primary reasons for this: first, the low impact that the technology switch produces on the emissions reduction in absolute terms and second, the current market price for CERs. The reduction in consumption of fuel gained by switching to hybrid diesel-electric technology saves the project proponent US$0.64 per litre. A small but additional US$0.03 per litre can be gained through the sale of CERs. As such, the benefits gained through lower fuel costs are clearly a larger influencing factor on the overall incremental savings.

It is possible that the CDM—despite its limited financial impact—may play an important role in overcoming awareness barriers. Considerable efforts have gone into capacity building and information sharing around the potential opportunities available through the CDM (see Chapter 3). These efforts have contributed toward a greater understanding among the private and public sector of the carbon market,

110 A discount rate of 10 per cent represents the alternative value of the use of the same funds.

and the added profile of pursuing a project under the CDM. The effect has been to assist the private sector to overcome concerns and explore novel ideas, to become more open-minded to new information and to rediscover old technologies. The interest and investment from other countries is contributing to this pioneering spirit. This shift may help to overcome the awareness barriers discussed earlier that currently prevent penetration of hybrid diesel-electric bus technologies in Chile.

That said, as we have learned in Chapter 2 and will explore further in the Location Efficient case study, overall technological improvements will not take us the full way toward estimated required atmospheric carbon concentrations over at least the next 50 years. To this end, a reduction in the length or number of bus trips would deliver more substantial reductions over time than a switch of technologies.

Discussion

Within the framework of the existence of a long-term regulation, and given the level of demand and management infrastructure established by Transantiago, the study finds that it is indeed possible to establish a methodological framework that satisfies the requirements established by the CDM for baseline and monitoring of the results of a transportation project involving a technology switch. That said, in this case the reductions shown and the additional cost of the technology may produce a return attractive enough to lead to investment, particularly given the possibility that CDM can encourage increase in awareness in the potential of new technologies.

Improvement of bus technology offers less GHGs saving opportunities in the long term than reducing the number of buses or displacing car trips, a concept that will be explored further in the location efficiency case study (Chapter 4c).[111] Large-scale and comprehensive approaches to redesigning provision of public transportation services, such as the Transantiago plan and others currently underway, offer valuable contributions to CDM efforts by establishing clearer future plans (baseline) and often by collecting and managing data necessary for monitoring of reductions.

The methodology developed for the bus case study could be re-applied to assess the feasibility of larger-scale implementation, use of a different fuel source or technology, or even different types of vehicles (e.g., taxis, light trucks, etc.). These analyses may indicate greater reduction potential than were possible in the case of the hybrid diesel-electric buses.

B. Bicycle Initiatives and the CDM

This case study explores the feasibility of using the Clean Development Mechanism (CDM) as a means to increase bicycle use in Santiago. It examines methodologies used by other countries that have successfully incorporated non-motorized transportation (NMT) in their cities, and assesses how the CDM could potentially facilitate bicycle promotion and bike lane development.

CDM projects that address travel demand, including bicycle initiatives, have not yet been considered by the CDM Executive Board and, therefore, no methodological precedents exist. As discussed in Chapter 2, of the handful of transportation sector CDM projects currently under development the majority pertain to vehicle technology, maintenance or alternative fuels. An important point of distinction between these projects and a CDM project that addresses travel demand such as NMT, is that the former are typically private sector, for profit, initiatives. An NMT CDM project, on the other hand, would most likely be funded by the public sector whose main goal would be societal gain rather than financial gain. In many cases, NMT type projects could be promoted as “unilateral” CDM initiatives.

Background/Context

Why Bicycles?

Bicycles are an efficient, pollution free and inexpensive mode of transportation. Comprehensive bicycle programs increase cycling demand through the provision of a safe travelling environment and facilities, allowing for a faster, safer and more convenient option for commuters. There are many co-benefits attributable to the implementation of NMT projects such as improvement in urban air quality, as well as promotion of healthier lifestyles and environmental sustainability. As short automobile trips are replaced

111 The Transantiago initiative is expected to reduce CO_2 emissions by about 350,000 tonnes per year (personal communication, Eduardo Giesen, December 21, 2004).

by bicycle trips the reduction in local vehicle kilometres travelled (VKT) corresponds with a reduction in emission of greenhouse gases, CO, NO_x and VOCs.

Current Bike Policies/Programs in Santiago

Cycling accounts for 2.1 per cent of total trips in Santiago,[112] compared to 1.5 per cent in Bogotá,[113] 24 per cent in New Delhi,[114] 48 per cent in Beijing,[115] 33 per cent in Amsterdam,[116] and 1.3 per cent in Ottawa.[117] In addition to a lack of infrastructure, there are many other barriers that contribute to low bike ridership, including distance (trip length and travel time), hill slope and safety (absence of safe places to ride, lack of secure bike parking facilities and fear of crime).[118]

While there has been some recent progress with the development of GEF funded bike lanes and a bikeway along the Alameda, currently there are only approximately 20 km of disconnected bike lanes in the city. Despite the modest three per cent slope eastward, most of Santiago has no major hills and has a climate favourable to cycling. However, bicycle initiatives have been hampered for a variety of reasons in Santiago, including concerns over safety, lack of proper bicycle shelter facilities, limitations of existing infrastructure (street widths too narrow for lanes), and cultural bias against the use of bikes (i.e., cycling perceived as a reflection of low socio-economic status). Perhaps the most significant barrier, however, is lack of funding. Until recently, transportation priorities in Santiago have not favoured the expansion of bicycle infrastructure. This case study explores the extent to which the CDM may help overcome this barrier.

A 1999 study, conducted by the Catholic University of Chile, found the number of bike bicycle trips could increase to 5.8 per cent of all trips with the provision of a dense bikeway network of 3.2 km of path per square km.[119] If even a small percentage of these trips were diverted from motorized modes, the reduction of fossil fuel consumption, greenhouse gases and air pollution could be reduced. The study noted high potential of bicycle use as a feeder to subway and trunk bus services.

Policy Precedents

There are many examples from around the world of cities with high bicycle ridership (e.g., Amsterdam) and where comprehensive bicycle programs have met with success (e.g., Bogotá, Columbia and Portland, Oregon).[120] A wide variety of policies and programs have been used to increase safety and accessibility for cyclists. Examples of municipal level initiatives include the development of bicycle lanes and bridges, effective signage and traffic signal improvements, promotion programs and facilities for cyclists (i.e., showers, parking and lockers).[121, 122] Educational and promotional campaigns are integral to the success of such initiatives. Campaigns can help to improve the image of cyclists, educate the public to the advantages of bicycles and raise awareness about traffic safety. As part of an integrated strategy to decrease automobile

112 SECTRA, "Encuesta Origen Destino De Viajes 2001."

113 Based on traffic count data; lower than some other estimates. Personal communication from Carlos Pardo, *Fundación Ciudad Humana*. July 30, 2004.

114 Tiwari, G., "Pedestrian infrastructure in the city transport system: a case study of Delhi," *World Transport Policy & Practice*, Volume 7, Number 4, 2001.

115 Data from, http://www.ibike.org/statistics.htm

116 Rietveld, P. and V. Daniel, "Determinants of Bicycle Use: Do Municipal Poicies Matter?" *Transportation Research Part A*. 38 (2004), pp. 531–550.

117 UN Millennium Database, as cited here: http://www.sactaqc.org/Resources/literature/transportation/mode_split.htm

118 Ortúzar, J. D., A. Iacobelli and C. Valeze, "Estimating the Demand for a Cycle-Way Network," *Transportation Research Part A*. 34 (2000), pp. 353–373.

119 *Ibid*. Ortúzar *et al*. found that as a maximum potential market share, individuals reveal a willingness to bike for 13 per cent of all trips. They also found that the most willing cyclists were young, with low income, no car and low education. This highlights the need for promotional campaigns to change attitudes and suggests a potential problem for the future as increases in income, education and car ownership are expected for the future. As an additional challenge, the study found that weather conditions can reduce the number of trips by 18 per cent.

120 Portland's BikeCentral initiative http://www.trans.ci.portland.or.us/bicycles/BikeCentral.htm

121 Berkley Bicycle Promotion Program, http://www.ci.berkeley.ca.us/transportation/Bicycling/BikePlan/PromotionPrograms.html

122 Portland's BikeCentral initiative *op cit*.

use, the City of Bogotá has for example introduced a strategy to promote bicycle use within the capital. This program includes the development of a segregated bicycle path network of over 250 kilometres, the largest in South America.[123]

There is some evidence that concerted policies can produce significant results. For example, in Germany bicycle mode share increased from eight per cent to 12 per cent between 1972 and 1995 due to integrated use of:

- segregated, well-demarcated bicycle networks, reaching principal commercial/residential center;
- networks of "traffic-calmed" streets;
- "bicycle streets," which permit motorized traffic, but give bicycles priority;
- bicycle priority at intersections;
- a broad public education program on traffic safety and focusing on the personal, social, and environmental benefits of cycling; and
- adequate parking, with large facilities in central locations, and wide coverage in other parts.[124]

Pucher *et al.*[125] make the following similar recommendations for improving bicycling prospects in North America, including increasing the cost of auto use; clarifying cyclists' legal rights; expanding bicycle facilities; making all roads bikeable; holding special promotions; linking cycling to wellness; and, broadening and intensifying political action.

Analysis

This case study explores the potential for the development of bike lanes as a CDM project at two scales: 1) individual bikeway, and 2) a comprehensive bicycle network.

Data and Assumptions

The same basic data and assumptions are used for both analyses, including emission factors and baseline mode split as discussed below.

Emission Factors: For passenger cars the analysis assumes an emission rate of 330 g CO_2 per *vehicle*-km. An average loading of two people per car assumes a reduction in the number of car passengers and does not necessarily imply a reduction in number of car trips. This results in an emission factor of 165 g CO_2 per *passenger*-km.

For buses, the study assumes an emission rate of 1,270 g CO_2 per *vehicle*-km.[126] An average loading of 30 people per bus, which while high for a daily average (i.e., including off-peak times), is intended as a conservative assumption, as it minimizes emissions savings from displaced bus trips.[127] As an additional conservative assumption, no displaced emissions are assumed from other motorized modes—metro, taxis, and colectivos.

Infrastructure Costs: The research indicates that infrastructure costs for *segregated bikeways* typically range from \$70,000–100,000 per km of bikeway. Costs can be higher depending on factors such as lighting, maintenance, signs, intersection modifications, traffic signalling and enforcement. In some cases, some of these costs are already covered by the municipality (e.g., lighting). Less substantial *bike lanes*, which often consist of a painted line on a street, can cost only five per cent of segregated bikeways.[128] For this analysis a value of \$80,000 per kilometre was assumed for the individual bikeway and \$58,000 per kilometre for the network which included both bikeways and bike lanes.[129]

123 For more information, see http://www.itdp.org

124 Pucher, John, "Bicycling Boom in Germany: A Revival Engineered by Public Policy," *Transportation Quarterly*, Vol. 51, No. 4, Autumn 1997.

125 Pucher, J., C. Komanoff and P. Schimek, "Bicycling renaissance in North America? Recent trends and alternative policies to promote bicycling," *Transportation Research Part A* 33 (1999), pp. 625–654.

126 This value is the same as the one used in the bus case study, expressed in km (1.98 km per litre).

127 Marginal impacts are not considered here.

128 Personal communication, C. Garrido, CONASET, August 2004.

129 While there is a continuum of bike facility possibilities, this research focuses on two forms: bike lanes (painted lines along a road) and bikeways (bikeways segregated from the road through construction of a barrier).

Methodology

The approach used to quantify emissions reductions from bicycle initiatives for the purposes of the CDM includes five steps.

1. Forecasting Bicycle Use

It is essential to determine potential project impacts with a reasonable level of certainty. For technology and fuel switching projects this can be a fairly straightforward undertaking, by determining how many vehicles will be retrofit and then estimating their annual usage. For demand-side projects, forecasting is considerably more complicated. There are a number of approaches to predicting bicycle use including: 1) rough estimates (comparison studies, aggregate behavior studies, rules of thumb and adjustment factors); 2) revealed and stated preference surveys (attitudinal or hypothetical choice); 3) discrete choice models (e.g., logit); and 4) regional travel models.[130] Each of these approaches runs into significant hurdles in forecasting NMT travel demand due to data limitations and historical focus of forecasting models on motorized travel.[131]

A. Individual Bikeway

This analysis is based on a hypothetical 4.5 km *bikeway* and assumes 1,000 users per day. A segregated bikeway was chosen for this analysis given that it is consistent with initiatives already taking place in Santiago. Further, the assumption of 1,000 users per day is comparable with the range of users attributable to a variety of different bike facilities as identified in a survey of American cases.[132] This round number also allows for scalability of results.

B. Comprehensive Bicycle Network

This analysis considers a range of estimates for future bicycle mode share: conservative, moderate, aggressive and break-even. The conservative estimate shows bicycle mode share would increase from the current 1.9 per cent to three per cent by 2015. Based on the 1999 Catholic University study, the second analysis assumes a six per cent mode share for bicycles. Calculations from a much more aggressive scenario illustrate what Amsterdam-type mode share would mean in the context of Santiago. Also included was a calculation of the break-even mode share where project costs could be entirely covered by CERs.

2. Baseline Determination

The baseline scenario describes travel that would have occurred without the project. Mode split is the most important variable in the forecast equation, i.e., what percentage of trips would occur by bicycle in the absence of a project. It is important, particularly for CDM project proponents who are concerned with the bottom line, to balance precision with practicality while acknowledging uncertainty in forecast methodologies.

Developing countries typically have limited data on non-motorized travel, often due to the fact that origin and destination (O-D) surveys are rarely undertaken for developing country cities. Even when surveys do exist, many times non-motorized transport is not included (an omission noted in industrialized countries as well). Moreover, O-D surveys are often too infrequent to provide timely baseline data. Given these limitations, the methodology developed for this case study was designed to accommodate NMT data of differing quality levels.

> *Ideal Data: Projected mode split for short trips along the affected corridor or in the specific neighbourhood of project implementation*. In the case of Santiago, the regional travel model, ESTRAUS, can provide mode share data for origin-destination pairs. However, the model does not provide very accurate data on short (e.g., intra-zonal) trips and cannot provide projected mode share for short trips on a specific corridor. This is a common problem with regional forecasting.[133]

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130 For more information see: United States Department of Transportation, Federal Highway Administration, *Guidebook on Methods to Estimate Non-Motorized Travel*, July 1999. http://www.fhwa.dot.gov/tfhrc/safety/pubs/vol1/title.htm

131 The Ortúzar Catholic University study used household surveys (stratified sample), stated preference mode choice survey, and a logit model on willingness to cycle. These were applied to trip matrices from the regional travel model, ESTRAUS to determine the effective number of bicycle riders.

132 University of North Carolina Highway Research Center (prepared for the Federal Highway AdministratIon), *Compendium of Available Bicycle and Pedestrian Trip Generation Data in the United States. A supplement to the National Bicycling and Walking Study*. October 1994. Table 8-1.

133 In their 1999 study, Ortúzar *et al.*, using ESTRAUS O-D matrices, determined that 48 per cent of the potential new bicycle trips in 2005 would shift from motorized modes (cars, bus, metro, and *colectivos*, does not include car or taxi passengers).

Acceptable Data: Current mode split for all short trips in the region. The O-D survey, conducted every ten years, is a valuable source of data for Santiago. Current short-trip mode split is available in the 2001 O-D survey; a forecast could be based on extrapolation of historic trends (e.g., 1991–2001). Such an extrapolation, however, will not effectively capture changes in the many factors which may influence evolution in trip-making behaviour.

Best Available Data: Current mode split for all trips in the region. This approach would be a better option for regions with less comprehensive basic survey data than Santiago, where data is available on short trips. This approach is likely to overestimate emissions savings because motorized modes constitute a lower portion of short trips than of all trips.[134]

At a conceptual level, a baseline is constrained by the fact that it remains a projection, no matter how comprehensive the data or sophisticated the forecast technique. Baselines can be designed to be either *static* (a fixed reference point) or *dynamic* (a function of variables that change over the course of the project). Dynamic baselines in the context of bicycle initiatives could be adjusted periodically to reflect *actual* mode split data. While this may lead to higher costs, it can also ensure predictability of credits and confirm environmental additionality. Whether a baseline is static or dynamic, a key challenge is defining future scenarios well enough that bike count data can be used to assess travel and emissions impacts. Again this comes down to balancing robustness with feasibility, and conservativeness with accuracy. A baseline is not practical if it is defined in such fine resolution that it becomes impractical (either financially or because of data supply) to update it or monitor project impacts.

For the individual bikeway and comprehensive network scenarios considered here, the analysis used the "acceptable" approach for the sample calculations. Data from the 2001 O-D survey were used for trips shorter than three kilometres.[135] The 2015 short-trip mode split was based on an extrapolation of 1991–2001 growth trends for all trips, which was then applied to the 2001 short-trip mode split; this is depicted in Figure 13. The share of trips by bus decreases over time, while the share by car increases. The percentage share of bike trips is assumed to remain constant; however, this still represents a large increase in the total number of trips by bike. This forecasted mode split was applied for both scenarios: 1) individual bikeway, and 2) comprehensive network.

Figure 13: Baseline Mode Split Assumptions for Sample Calculations

Baseline Mode Split Assumptions (< 3km)			
Mode	**2001 (O-D survey)**	**2015 (estimate[136])**	**% Change 2001–2015**
Bikes	2.5%	2.5%	0.0%
Bus	9.1%	6.0%	-3.1%
Car	17.5%	27.0%	9.5%
Walking	62.2%	56.3%	-5.9%
Metro	1.9%	1.7%	-0.2%
Taxi (plus collectivos)	6.3%	6.0%	-0.3%
Other	0.5%	0.5%	0.0%
Total	100.0%	100.0%	0.0%

Note that we have not accounted for any induced travel due to increased road capacity from displaced trips. This effect is likely to be negligible for an individual bikeway, but might manifest in the case of a comprehensive network (which, in theory, could be estimated using the regional travel forecasting model, ESTRAUS). Alternatively, the bike network may take up space on the roads themselves, thereby trading off any additional road capacity. (See Chapter 5 for more discussion of induced demand.)

3. Additionality Assessment

In order for any CDM project to go ahead it needs to be deemed additional (see Chapter 2). An important criterion for this research was selection of an example that was fundamentally viable to pursue as a CDM initiative, i.e., that it met the additionality require-

134 In Santiago, buses made up about nine per cent of trips less than three km vs. 31 per cent of all trips and cars were used for about 18 per cent of trips less than three km but 28 per cent of all trips.

135 Short-trip mode split data was provided by the Program for Scientific Investigation and Technology at the School of Engineering (DICTUC) at Catholic University. http://www.dictuc.cl/

136 Note: this estimate does not include Transantiago.

ments as outlined in the Marrakech accords. Of the three new advances in bicycle policy in Santiago—the GEF bike lanes, the Alameda bikeway and the proposed Santiago-wide network, only the latter appears to be appropriate to consider as additional. Both the GEF and the Alameda projects cannot be considered as additional because they are already funded and moving forward. The proposed bike network however falls into a grey area; while there is a master plan for the network, currently there is no funding and little political motivation for its implementation. These are strong arguments in favour of the comprehensive network counting as additional.

New bicycle projects however are considered as additional for several reasons. First, there are no regulations in place in Chile requiring development of bikeways. Second, there is currently very limited investment in bikeways in Santiago, such that international investment (i.e., GEF) has been needed for some of the existing bike lanes. Finally, cultural and image barriers appear to prevent greater bicycle use in Santiago.

4. Development of a Monitoring Approach

Every CDM project must include a monitoring plan to verify emissions reductions below the baseline scenario. The most basic approach to assess bicycle ridership is to physically count the number of bicycles passing a survey point. The primary challenge of a good monitoring plan is to balance robustness with practicality and the cost of monitoring should ideally be commensurate with the values of the CERs generated. It is important to determine what frequency and duration of bicycle counts is methodologically sufficient to meet EB approval and to translate any new bicycle use into quantifiable GHG reductions. Hudson *et al.* note that frequent short-duration counts are more useful than less frequent counts of a longer duration, for capturing change over time.[137] So, for example, it might be desirable to count bicycles on two weekdays per week for five weeks than to count for two full weeks in a row. Beyond bicycle counts, surveys can be helpful to establish trip length, purpose, and route. Survey teams can ask riders what alternative mode or route they would have taken without the project. This can help corroborate the baseline and identify new riders. It is important to consider whether other influencing variables such as population, economic growth, traffic in surround areas should also be tracked as part of a monitoring plan.

A. Individual Bikeway

For an individual bikeway, bicycle counts could be conducted at several locations along the route on a periodic basis (e.g., every quarter). A robust plan may also necessitate monitoring of bicycle and motorized traffic along routes parallel to the bikeway. Isolating the impacts of specific small-scale projects may be overly resource intensive. The basic survey work involving manual traffic counting conducted by the GEF project to assess current bicycle use in selected corridors in Santiago, for example, cost upwards of $30,000. Automatic bicycle counting may be one tool to reduce these costs.[138, 139] Monitoring costs could also potentially be lowered by leveraging existing survey data, bike counts, tools and practices.

B. Comprehensive Bicycle Network

Comprehensive bicycle policies can be tracked with regional data on vehicle-km travelled and mode split. NMT data and survey techniques from the O-D survey would be appropriate to apply in this case. The continuous survey approach proposed by Ampt and Ortúzar may provide a useful basis for monitoring NMT projects and policies.[140] A comprehensive network or policy may be a good candidate for a dynamic baseline that includes demographic and traffic data. Again, this would account for actual mode split data as opposed to a baseline that was calculated in advance of the project.

5. Calculation of Avoided Emissions

Calculating avoided emissions entails subtracting actual project emissions from those (baseline) that

137 Hudson. M. *et al.*, *Bicycle Planning: Policy and Practice,* (1982).

138 Macbeth, A. G., "Automatic Bicycle Counting," IPENZ Transportation Group Technical Conference, September 2002. Available at: http://www.ipenz.org.nz/ipenztg/ipenztg_cd/cd/2002_pdf/34_MacBeth.pdf

139 Pneumatic tube counters have low capital costs but may require frequent maintenance. Piezoelectric counters are relatively expensive (almost US$10,000 per sensor), highly accurate in the short-term, but accuracy can diminish significantly with wear. U.K. Department for Transportation, "Automatic Traffic Counting Equipment," Available at: http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_504707-03.hcsp

140 Ampt, E. S. and J. de D. Ortúzar (2004), *ibid.*

would have occurred without the project. In the case of an NMT project, there are no project emissions, so the calculation entails determining emissions that would have occurred had new cyclists travelled according to the baseline mode split. Larger and more complicated bicycle plans may be very data intensive and may require considerable computational effort. This method uses generalized figures and assumptions to develop a scenario similar to what is currently in place in Santiago, however it may be applied at different levels of detail.

A. Individual Bikeway Project

The analysis considered a 4.5 km segregated bikeway with average round-trip length of six km. Assuming 1,000 users per weekday and 260 weekdays per year, the 2015 baseline mode split for short trips and emission factors presented above, we calculate emissions savings of 73 tonnes CO_2 per year. Applying the baseline mode split (Figure 13) means that for 1,000 bicycle trips on the new bikeway, 25 (2.5 per cent) were existing bicycle riders, 60 bus riders, 270 car drivers or passengers and 563 pedestrians.

Assuming infrastructure costs of $80,000 per km, and a 21-year project lifetime, emission reduction calculations result in a cost of $212 per tonne CO_2. At $10 per tonne CO_2, CERs contribute only about five per cent of total infrastructure costs in this scenario, or about $735 per year. Given that transaction costs such as project registration would likely be significantly higher than this amount, this value sheds doubt on the viability of a project of this scale.

B. Comprehensive Bicycle Network

This scenario considered a 1,200 km bicycle network, based on the master plan under development by the National Commission for Transportation Safety, CONASET. Not yet finalized or funded, the network is assumed to consist of 600 km of bikeways and 600 km of bike lanes as well as traffic calming, painted lines and bike parking. It is assumed that total trips double from 2001 to 2015 (based on the trip growth rate from 1991–2001). The 2015 short-trip mode split was based on an extrapolation of 1991–2001 growth trends for all trips, which was then applied to the 2001 short-trip mode split to create an estimated baseline scenario for ridership. This estimation resulted in a 2015 baseline mode split of 2.5 per cent of short trips by bicycle, six per cent by bus, 27 per cent by car and 56 per cent by foot (as depicted in Figure 13). Reductions from any additional bike lanes would be measured against this future scenario.[141]

Emission savings were calculated under four different ridership scenarios as described above: conservative, moderate, aggressive and break-even. The results are presented in Figure 14. An infrastructure cost estimate of $58,000 per km was based on information provided by CONASET. Note that this is lower than the typical range for bikeways, because the plan includes a mix of bikeways, bike lanes, and supportive policies.

Figure 14: Avoided Emissions Calculation for a Comprehensive Bicycle Network

Scenario	New bicycle mode share	Tonnes CO_2 per year	Cost per tonne CO_2	Annual CER revenues ($10/tonne)
Conservative	3%	27,300	$111	$273,000
Moderate	6%	99,600	$30	$996,000
Aggressive	33%	795,000	$4	$7,950,000
Break-even	65%	1,523,400	$2	$15,234,000

Based on these calculations, a comprehensive bicycle network could lead to savings of approximately *27,000 to 100,000 tonnes CO_2* per year in the conservative and moderate scenarios, with infrastructure costs of *$30 to $111 per tonne CO_2* (assuming a 10 per cent discount rate and a 21-year project lifetime). These do not include transaction or monitoring costs.[142] Thus, the CDM could offset approximately nine to 33 per cent of the project at a CER price of $10/tonne. In this type of public project, CDM could provide a funding stream to leverage other sources. Obviously, higher CER prices would increase the financial benefits of the CDM. Total costs could be lower if the same bike use could be achieved with fewer kilometres of bikeway, for example, with more bike lanes and promotional campaigns. Including an analysis of the value of co-benefits (e.g., reduction of air pollution) would make bike projects more attractive from a broader societal perspective, and might be useful in attracting more project funding (e.g., utilizing public health funding for bike promotion).

141 Note that this mode split assumes that about 35 per cent of bicycle trips come from bus, car and metro, which is significantly lower than that modelled by Ortúzar (48 per cent), therefore, this can be seen as a conservative estimate.

142 Projects with 21 (or 14) year timeframes will incur additional costs for re-validation of the baseline by the Operational Entity.

Conclusions and Recommendations

Input from the International Workshop

Participants at the international workshop noted the importance of providing adequate, secure bicycle parking at intermodal transfer points, and that changing the cultural image of cyclists should be the highest priority for increasing bicycle use in Santiago (e.g., through promotional campaigns). CONASET suggested that the CDM could have a significant impact if it could help foster the master plan for bicycles in Santiago. In addition, participants noted the importance of land use policies for enabling shorter trips suitable for bikes.

Conclusions

Bicycle projects and policies can play an important role in advancing sustainability in Chile through reducing dependence on motorized, polluting forms of transportation. This can contribute to reducing air pollution and GHG emissions, as well as increasing mobility and accessibility for low-income residents and reducing dependence on imported oil. Recognizing the synergies and understanding the commonality of goals among government ministries opens the door to potential funding partnerships and the development of NMT projects.

However, bicycle projects and policies face serious barriers to successful integration with the CDM. Bicycle ridership forecasts are imprecise, emissions quantification is uncertain and monitoring may be expensive. At this point it is unclear whether conservative assumptions can minimize uncertainty sufficiently enough to gain approval of the Executive Board of the CDM.

Individual bikeways do not fit well as a CDM project given current rules and the market value for credits. Specifically, the costs of a credible monitoring effort plus transaction costs would be much higher than the value of the CERs. Automatic bicycle counting may help reduce monitoring costs. A broader effort to improve NMT data quality in the region might also reduce monitoring costs.

Most bikeway projects, however, are likely to be small-scale projects, the methodologies for which allow simplified baseline and monitoring requirements, less comprehensive additionality and lower costs. Further, with a small-scale project activity there is also the opportunity to bundle numerous smaller NMT projects together into one simplified Project Design Document (PDD).

A comprehensive network of segregated bikeways and bike lanes may be more attractive to a CDM project developer given the larger scale of the impacts, particularly if monitoring costs can be reduced through use of existing data collection mechanisms. For example, project impacts could be tracked with regional data on vehicle-km travelled and mode split, such as from the O-D survey, especially if the continuous survey methodology for Santiago could be easily modified for this purpose. NMT data improvements may facilitate participation in the CDM by increasing confidence in monitoring and could also help foster broader sustainable transportation solutions. For this to result in a significant increase in ridership at the regional scale, however, comprehensive policies and projects, beyond the development of new infrastructure, are necessary. They include: promotional campaigns to improve the image of cyclists; adequate, secure parking at intermodal transfer points; and land use polices that enable shorter trips suitable for bicycles. However, in order for such a wide-ranging effort to fit within the CDM, *changes are required to the current CDM modalities and procedures to allow for policy-based and/or sectoral CDM approach*. These concepts are further explored in Chapter 5 of this report.

Another concept that could aid project implementation is a revolving loan approach that could be used to recycle funds back into individual projects when CERs are sold. This approach may be particularly useful for publicly-funded CDM projects, such as the bicycle network and other NMT projects that may have difficulty attracting private funding. Further, the CDM could be used as a leveraging tool for projects where the CERs only cover a small percentage of project costs, and will thus require some additional financial and policy support. Given all the co-benefits associated with the development of a comprehensive bike network, such a CDM project could contribute to a cost sharing plan with, for example, air quality improvement programs, public health programs or other transportation infrastructure projects. In this way, bicycle projects and policies are good candidates for unilateral CDM.

Rapid growth in car ownership and use appears inevitable; but a concerted effort to impact this trend by looking to more efficient options such as bicycle infrastructure will require deliberate planning and investment. Developing bicycle networks, pursuing promotional campaigns and fostering supportive land use patterns can advance multiple sustainability goals (this latter point is the focus of the next case study).

While comprehensive policies, coordinated planning and strategic investments will likely be necessary to reduce transportation GHG emissions over the long term, the CDM may be able to play a useful part in this transition. Broader issues, such as potential modifications to the CDM, are discussed in more detail in Chapter 5.

C. Location Efficiency and the CDM

Background/Context

Why Location Efficiency?

This CDM case study rests on the basic premise that influencing urban land use patterns—the location of urban development projects within a metropolitan area (*meso*-scale effects) and the form that development takes (such as the density and diversity of land uses, or *micro*-scale effects)—can produce fundamental changes in individual travel behaviour (e.g., modes used, distances travelled) and, thereby, influence transportation greenhouse gas emissions (GHGs). Interest in the potential role of land use to specifically influence transportation energy consumption date back to at least to the energy crises of the 1970s, and in today's climate-concerned world the possibilities need to be thoroughly considered.

In contrast to typical CDM projects, this initiative differs in a *fundamental* way in that, instead of focusing on technological changes to reduce GHGs, the location efficiency (LE) CDM aims at changing individual behaviour. In this sense, the LE CDM faces significant methodological and implementation hurdles relative to technology-oriented CDM projects in this sector. For a technological CDM project, the estimated impacts on GHG emissions are (relatively) straightforward to calculate and verify. In the case of an LE CDM on the other hand, we expect changes in land use to influence the distances people travel, as well as the relative attractiveness and the occupancy of different modes. Since these effects are *behavioural* and, in some cases, depend on second order influences (such as the influence of density on auto ownership and thus use), estimating their impacts requires modelling techniques that introduce significant uncertainties and difficulties.

Despite the inherent challenges, the role of behavioural change in mitigating GHG emissions looms importantly in the face of likely technological evolution in the sector, as discussed earlier. Inertial forces play a pivotal role here, as new vehicle technologies require time to be produced and achieve widespread market penetration in the face of existing vehicles' relatively long life-times (e.g., 15 years). This reality leads naturally to an examination of the potential role of urban form in reducing private VKT growth—thus the LE CDM. Beyond the potential global benefits, the LE CDM also offers potentially important long-term co-benefits, such as open space preservation, improved air quality and public health, reduced needs for transportation infrastructure investments, etc. Furthermore, we need to situate the LE CDM within the overwhelming demographic reality of developing world urbanization over the next 30 years. For example, the United Nations projects that the developing world's urban population will *double* by 2030, meaning that measures to improve the urban form of developing country cities could bring important quality of life improvements for nearly two billion *additional* urban dwellers in the next 25 years.[143]

Relevant Policy Landscape

Although Chile is already a highly urbanized country, with roughly 85 per cent of the nation's population living in urban areas, even moderate future urban growth has important implications. For example, a 1.25 per cent annual population growth rate in the Santiago Metropolitan Area would imply an additional one million new households locating in the city over the next 30 years. Given current urban growth trends—from 1985 to 1995, the urban area expanded 70 per cent more rapidly than population growth[144] (a rate which has most likely increased)—the distribution of future population growth and related land uses will greatly influence underlying urban travel behaviour for generations of *santiaguinos*. Today, the contiguous urban area of Greater Santiago's 34 municipalities covers approximately 70,000–85,000 hectares (700–850 square kilometres). The gross population density is roughly 65 persons per hectare, while the net population density is on the order of 85 persons per hectare, with considerable range across the metropolitan area.

143 United Nations Secretariat, Population Division of the Department of Economic and Social Affairs, *World Population Prospects: The 2002 Revision and World Urbanization Prospects: The 2001 Revision* (http://esa.un.org/unpp), August 2, 2004.

144 Zegras, C. and R. Gakenheimer, 2000, *ibid.*

Multiple, often inter-related factors have contributed to Santiago's urban growth patterns in recent years. Income growth, bringing concurrent motorization and demand for residential space, strengthens suburbanization pressures. These are mutually reinforced by real estate company growth and widespread land speculation, producing large scale office, residential and industrial projects. Transportation infrastructure development plays a clear role, by providing access to previously undeveloped land. Another expansionary pressure comes from continuous demand for lower-income housing, typically located on the urban fringe where land is relatively cheap. From a public policy perspective, a number of initiatives have produced somewhat countervailing effects. For example, the urban renovation subsidy program created incentives for the development of some 22,000 new apartments in the central city since 1992. At the same time, the 1997 modification to the metropolitan land use regulatory plan, in response to real estate developers and large-scale land speculators, opened up almost 20,000 hectares for urban development on the rapidly expanding northern urban fringe. As part of the plan's modification for the northern fringe, authorities introduced conditional development zones, aimed to induce "self-sufficient" real estate projects. Authorities have also employed, in a somewhat ad-hoc approach, impact fees in the area in an attempt to charge developers for the necessary trunk road infrastructure and even some degree of transport air pollution resulting from this fringe development.[145] Most recently, the GEF-supported "Sustainable Transport and Air Quality Project," included a "location efficiency" component, although the concept remains in initial stages of development. This research will, hopefully, help feed into that and future work in Santiago and throughout the country.

Analytical & Policy Precedents

The idea of using land use to influence travel demand is not new. At the broadest *metropolitan*-scale, analyses focus on overall measures of urban density and urban size, allowing the comparison of different cities (cross-section) at a point in time and/or across time (time series) and an assessment of influencing factors. Examples include analyses of the influences of: net urban area residential densities on auto ownership and transit use across cities in the U.S.,[146] population density and central city employment on transit ridership in U.S. and Canadian cities[147] and similar type efforts examining patterns across an international spectrum of cities.[148] These types of studies typically use aggregate-level data and correlation or regression techniques including broad-brush measures of metropolitan structure such as overall urban population densities, size of the urban area and central city concentration of jobs. The studies differ in many ways, including the extent to which they: control for influencing variables (e.g., travel times and costs by different modes); adjust for potential correlation among influencing variables (i.e., multi-collinearity) and/or simultaneity in effects (i.e., do people choose residential locations and then auto ownership levels or vice versa); and, attempt to distinguish between links in causal chains (e.g., effects on car ownership levels and subsequent effects on vehicle use). The results do allow for some broad generalizations. Bento *et al.*, for example, find that even in heavily auto dependent U.S. cities, metropolitan structure does influence travel demand and suggest that the differences between cities (e.g., Atlanta versus Boston) impact the amount of household automobile travel (VKT) by as much as 25 per cent.[149] Lyons *et al.*, drawing from international city data, propose a generalized urban transport emissions model based on the relatively

145 Zegras, C., "Financing Transport Infrastructure in Developing Country Cities: Evaluation of and Lessons from Nascent Use of Impact Fees in Santiago de Chile," *Transportation Research Record* 1839 (2003), pp. 81–88.

146 See Beesley, M. and J. Kain, "Urban Form, Car Ownership and Public Policy: an Appraisal of Traffic in Towns," *Urban Studies*, 1, No. 2 (1964), 174–203; Kain, J. and M. Beesley, "Forecasting Car Ownership and Use," *Urban Studies*, 2, No. 2 (1965), pp. 163–185.

147 Schimek, P., *Understanding the Relatively Greater Use of Public Transit in Canada Compared to the U.S.A.*, Cambridge, MA: unpublished PhD dissertation, Department of Urban Studies and Planning, MIT, June 1997.

148 See, e.g.: Ingram, G. and Z. Liu, "Motorization and the Provision of Roads in Countries and Cities," Policy Research Working Paper 1842 (Washington, DC: World Bank, Infrastructure and Urban Development Department, 1997) http://econ.worldbank.org/resource.php?type=5; Kenworthy, J. and F. Laube, "Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy," *Transportation Research* A, Vol. 33 (1999), pp. 691–723.

149 Bento, A. M. *et al.*, "The Impact of Urban Spatial Structure on Travel Demand in the United States," Working Paper EB2004-0004 (Boulder CO: University of Colorado, Institute of Behavioral Science, Research Program on Environment and Behavior, January, 2004) http://www.colorado.edu/ibs/pubs/eb/eb2004-0004.pdf

strong positive empirical relationship between total VKT and urban area size.[150] Their results lead them to the broad policy recommendation of containing urban area physical expansion to reduce emissions, a result which naturally leads to the need for densification (the "compact city") in the face of ongoing population growth.

While metropolitan-level comparative analyses do apparently support the relatively intuitive policies of containing urban expansion and increasing metropolitan area densities to reduce private motorized travel demand, moving towards more concrete policy prescriptions for specific cities typically requires more detailed analyses at the intra-metropolitan, or meso-scale. Such analyses aim to assess the degree to which the relative location of land uses within a city (e.g., inner-city versus suburban) influences travel demand. The policy relevance of such research comes from the potential to guide where, more specifically, in a metropolitan area development should be encouraged and at what intensity. The analytical approaches employed vary from simulations of hypothetical city forms (e.g., channelling development along transport corridors, clustering of housing and jobs in different centers of a metropolitan network); cross-sectional empirical analyses looking at how different development patterns within a metropolitan area influence relevant outcomes (such as automobile ownership and use), using, for example, multivariate regression techniques; and traditional travel forecasting models, which can be used to show, for example, how alternative land use scenarios in a given forecasting period will alter future expected travel patterns.[151] Results from such studies differ significantly in terms of estimated impacts. One extensive review of many, primarily cross-sectional, empirical analyses suggests a "typical" regional accessibility elasticity (measured by accessibility to employment opportunities in the region) of -0.20, meaning a 10 per cent increase in the regional accessibility of a given location would produce a two per cent decrease in VKT.[152] A recent analysis of data from the Toronto (Canada) metropolitan area suggests average household transportation GHG emissions in inner city areas are 42 per cent to 64 per cent lower than in outer suburban areas.[153]

As *meso*-level analysis aims essentially to assess the impacts of relative location of land uses within a city, *micro*-level analysis attempts to gauge the impacts of specific neighbourhood-level development patterns.[154] The relevant micro-level factors of potential influence can be categorized along three dimensions, sometimes referred to as the "Three Ds"[155] for: Density of various land use types (e.g, dwelling units, retail stores, jobs); Diversity, or mix, of different land uses/activities (such as mix of commercial, residential, etc.); and Design of the built environment (e.g., sidewalk provision, block size, street layout, etc.). In reality, the distinction between meso- and micro-scales of analysis is somewhat blurred, in part due to the variation in the degree of spatial aggregation of relevant characteristics in different studies and, even, the difficulty in isolating the micro-level influences from the meso-level. Again, a review of primarily cross-sectional empirical analyses suggests "typical" elasticities of neighbourhood-level "three Ds" on the order of

150 Lyons, T. J. *et al.*, "An international urban air pollution model for the transportation sector," *Transportation Research Part D*, Vol. 8 (2003), pp. 159–167.

151 Reviews of techniques and results can be found in, e.g., Handy, S., "Methodologies for Exploring the Link Between Urban Form and Travel Behavior," *Transportation Research D*, Vol. 1, No. 2 (1996), pp. 151–165; Crane, R., "The Influence of Urban Form on Travel: An Interpretive Review," *Journal of Planning Literature*, Vol. 15, No. 1 (August 2000), pp. 3–23; Badoe, D. and E. Miller, "Transportation-land-use Interaction: empirical findings in North America, and their implications for modelling," *Transportation Research Part D*, Vol. 5 (2000), pp. 235–263.

152 See Ewing, R. and R. Cervero, "Travel and the Built Environment: A Synthesis," *Transportation Research Record 1780: Land Development and Public Involvement in Transportation* (2001), pp. 87–113. In this case, regional accessibility to employment is measured through a traditional gravity-type model formulation using the total number of jobs in different potential destination zones as a proxy for general zonal attractiveness.

153 IBI Group, "Greenhouse Gas Emissions from Urban Travel: Tool for Evaluating Neighborhood Sustainability," Healthy Housing and Communities Series Research Report prepared for Canada Mortgage and Housing Corporation and Natural Resources Canada, February 2000. The range accounts for differences in neighbourhood types; the estimates control for other influencing factors such as income and household size.

154 Note that neighbourhood does not have a rigorous geographical/spatial/operational definition; we use it here simply to refer to local-level urban design characteristics.

155 Cervero, R. and K. Kockelman, "Travel demand and the three Ds: Density, Diversity and Design," *Transportation Research Part D: Transport and Environment*, Vol. 2 (1997), pp. 199–219.

-0.13, meaning a 10 per cent increase in combined measures of the "three Ds" would produce a 1.3 per cent decrease in VKT.[156] Some efforts have been made to incorporate *micro*-level measures into formal, traditional *meso*-level travel forecasting exercises. For example, some cities, such as Portland (OR) and San Francisco (CA), have developed the pedestrian environment factor (PEF), a subjectively scored measure that aims to capture the influence of local design factors on relevant stages of the trip decision process (such as vehicle ownership and/or mode choice). Others have taken a "post-processing" approach, utilizing the relationships suggested in the "typical" elasticities to modify travel forecasting model outputs to reflect how local design characteristics would influence motorized trip rates.[157]

The presentation of "typical" elasticities, derived primarily through cross-sectional analyses, of the influence of land use on travel behaviour should be viewed with caution. Several analyses have shown little or no micro-scale influence on travel patterns.[158] Researchers have highlighted problems with the relevant studies, including weaknesses in the underlying methodologies and data, exclusion of important variables (particularly related to transportation service levels), and the lack of an appropriate theoretical framework.[159] An important problem relates to the potential for household "self-selection." In analyzing cross-sectional household data to assess locational influences on travel behaviour, one is essentially assuming that people choose their housing location and this location then produces travel outcomes. But, households may well choose their locations, at least in part, due to their preferred travel outcomes. In other words, instead of local-level land use patterns determining household travel behaviour, desired travel behaviour determines where a household will locate and, thus, the relevant locational characteristics (e.g., someone who prefers biking will locate in a neighbourhood that is conducive to bicycle travel). If this were the case, then the analysis would be inappropriately "crediting" land uses for producing outcomes that were more truly a result of individuals' and households' travel preferences. Several innovative research approaches to dealing with this issue have produced somewhat varying results;[160] suffice it to say that some degree of self-selection definitely exists, which can complicate matters related to, for example, baseline calculations. Indeed, in adequately assessing the influence of land use on travel behaviour, we must face the reality that we are ultimately aiming to predict a complex system involving family life-cycle (e.g., single, household with no children, retirees, etc.), automobile ownership decisions, etc. This has led some researchers to suggest that the proper analysis of the impacts of urban form on travel behaviour requires a fully-integrated urban model.[161]

Even if one can confidently predict the influence of land use on travel behaviours, the ability to influence relevant outcomes, however, hinges critically on the institutional and policy setting. In Singapore, for example, where the government maintains strong control of land development, a policy of shaping development patterns to match desired transportation outcomes likely stands a greater chance for success than in countries with more laissez-faire tradi-

156 Ewing and Cervero, 2001, *ibid.*

157 Swenson, C. J. and F. C. Dock, "Urban Design, Transportation, Environment and Urban Growth: Transit-Supportive Urban Design Impacts on Suburban Land Use and Transportation Planning," Report #11 in Series Transportation and Regional Growth Study (Minneapolis, MN: University of Minnesota, Center for Transportation Studies, March, 2003) http://www.cts.umn.edu/trg/research/reports/TRG_11.html

158 In the Dutch context, see, van Diepen, A. and H. Voogd, "Sustainability and Planning: does urban form matter?" *International Journal of Sustainable Development*, Vol. 4, No. 1 (2001), pp. 59–74; in the U.S. context, McNally, M. and A. Kulkarni, "Assessment of Influence of Land Use-Transportation System on Travel Behavior, *Transportation Research Record 1607* (1997), pp. 105–115.

159 See, e.g., Crane, 2000, *ibid.*; Badoe and Miller, 2000, *ibid.*

160 Krizek uses longitudinal panel data (following a household in time) to find some evidence that travel behaviour does change with changes in local design characteristics (Krizek, K. "Residential Relocation and Changes in Urban Travel," *APA Journal*, Vol. 69, No. 3 (Summer 2003), pp. 265–281; Kitamura *et al.*, using specifically designed household surveys, found that people's attitudes are more strongly associated with travel land use characteristics, suggesting the need to change residents' attitudes together with land use patterns (Kitamura, R. *et al.*, "A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area," *Transportation*, Vol. 24, No. 2 (1997), pp. 125–158; Bagley and Mokhtarian, using a system of structural equations find that attitudinal and lifestyle variables dominate travel demand, while residential location type had little impact (Bagley, M. and P. Mokhtarian, "The impact of residential neighborhood type on travel behavior: A structural equations modelling approach," *The Annals of Regional Science*, Vol. 36 (2002), pp. 279–297.

tions regarding land development. Even among the Western European nations known for fairly aggressive land planning policies the ultimate impacts on travel behaviour are varied and not always "as expected." For example, by one estimate the Dutch policy during the 1970s–80s of "concentrated decentralisation" actually increased daily private VKT for commute trips and decreased walk and bike use in favour of public transport.[162] As for direct relevance to emission reduction regimes, the United States experience with local air pollution offers an interesting precedent, in particular the need to ensure state conformity with air quality regulations. U.S. EPA guidelines suggest that land use can be included as a transportation air quality control strategy if the effects are quantifiable, surplus (i.e., "additional"), enforceable, permanent, and adequately supported.[163] Such requirements suggest a direct precedent for the relatively stringent project-based requirements of the CDM (and also suggest that the precedent exists for Annex I countries to pursue relevant approaches for their own domestic offsets). Few concrete examples of using land use initiatives for achieving specific transport pollutant reductions in the U.S. exist however. One project, the proposed redevelopment of a 138-acre former steel mill site in central Atlanta (Georgia), offers a promising example: modelling techniques were used to predict both *meso*- and *micro*-level influences (estimated to achieve reductions on the order of 15 to 67 per cent and four to six per cent, respectively);[164] and the project developer agreed to several monitoring, verification and contingency measures.[165] Still in early development stages, the project's ultimate transport air quality effects cannot yet be evaluated.

Analysis

In the face of the above-mentioned analytical and practical challenges, the IISD team contracted with a local land use and transportation planning laboratory (LABTUS), affiliated with the University of Chile. The overall purpose of the work was to explore how land use development patterns might be modified via the CDM to produce measurable reductions in GHG emissions. LABTUS conducted initial empirical analysis of relevant travel behaviour in the city, developed a transport demand model with sensitivity to meso-level land use variations, established a framework for identifying different land use scenarios that influence transport emissions, produced a novel method to generate optimal land use scenarios with regards to emission reductions, estimated the level of subsidies (which ostensibly could be financed via the CDM) needed to produce those land use scenarios, and designed and applied an evaluation procedure for each scenario.[166] The approach has the merit of integrating land use and transport decisions of the population. Due to the modelling approach taken, a meso-scale simulation of the land use-transportation interaction, potential micro-scale effects on travel behaviour were initially explored but ultimately not included in the final analysis.[167]

Data

The primary data underlying the analysis come from the 2001 origin-destination (O-D) survey and the land use census, carried out and compiled under the auspices of the national transportation planning secretariat (SECTRA) and described in more detail in Chapter 3 of this report. Estimating the model required approximated transportation costs for all origin-destination pairs for all mode types, which were

162 See, e.g., Schwanen, T. *et al.*, "Policies for Urban Form and their Impact on Travel: The Netherlands Experience. *Urban Studies*, Vol. 41, No. 3, (March 2004), pp. 579–603.

163 United States EPA, *EPA Guidance: Improving Air Quality Through Land Use Activities*, Washington, DC: United States Environmental Protection Agency, Office of Transportation and Air Quality, January 2001, pp. 40–42.

164 Walters, G. *et al.* "Adjusting Computer Modeling Tools to Capture Effects of Smart Growth: Or 'Poking at the Project Like a Lab Rat'," *Transportation Research Record 1722* (2000), pp. 17–26.

165 United States EPA, "Project XL Progress Report: Atlantic Steel Redevelopment," Washington, DC: U.S. Environmental Protection Agency, Office of the Administrator, EPA 100-R-00-026, January, 2001, last accessed on-line, August 11, 2004: http://www.epa.gov/projectxl/atlantic/index.htm

166 LABTUS, "Location Efficiency and Transit-Oriented Development: A Potential CDM Option in Santiago de Chile. Final Report," Santiago: Universidad de Chile, Laboratorio de Modelamiento del Transporte y Uso de Suelo, October 2004. Full report available at: http://www.iisd.org/climate/south/ctp_documents.asp

167 In particular, efforts were made to model the influence of various local land use descriptors (e.g., various measures of zonal-level land uses at the origin and destination zones) on walk mode choice—although preliminary, these explorations showed that the land use descriptors had either insignificant explanatory power or had signs that were counterintuitive.

derived from a previous (2001) transportation model run (using SECTRA's model, ESTRAUS[168]). Vehicle occupancy factors, vehicle types, distances travelled and average speeds are derived from ESTRAUS, the household O-D Survey and related surveys (e.g., traffic counts) carried out complementarily to the O-D survey. Emissions factors are derived from a locally-developed vehicle emissions model (MODEM[169]). The Metro has been considered a "non-polluting" mode, although the electricity used by the system (for 2001) implies CO_2 emissions on the order of 62,000 tonnes annually, approximately 1.8 per cent of all passenger transport emissions.[170]

Methodology

The empirical analysis of the 2001 O-D survey suggested three basic strategies for intervention: (1) increase non-motorized transport for non-work trips by locating shopping and services closer to residential areas; (2) increase non-motorized transport for school trips by allocating schools closer to residential areas; and (3) increase public transport usage (particularly Metro) for medium- to long-distance trips.

The modelling framework consists of three linked models. The first is a transport demand model, consisting of an integrated multi-stage set of discrete choice models (multinomial logit models), which essentially predict an individual's choice from among a set of available choices.[171] The model *simulates equilibrium*, building from the relationships observed in the travel survey and the land use census to predict how future travel patterns will evolve under different land use scenarios. An *optimization* model identifies land use patterns that would minimize transportation GHG emissions; at each stage of this procedure, the transportation simulation model updates the transport equilibrium. Once arriving at the optimum, the third model calculates the subsidies that would be required to make households and firms locate according to the "optimized" city.[172] As such, travel distances and the spatial distribution of activities are modelled in an integrated fashion, accounting for relevant factors influencing residential and non-residential location decisions (such as location externalities for residential location and agglomeration economies for non-residential location). Particular effort was made to effectively model walk trips, given the empirical evidence of this mode's importance (37 per cent of all weekday trips; 23 per cent of AM peak trips[173]), its clear distance dependency and its naturally non-polluting nature. The modelling approach simplified the travel behaviour process into three stages: (1) trip generation or the number of trips produced and attracted in different zones of the city; (2) trip distribution, or where those trips actually begin and end; and (3) mode choice. Except for route assignment, the model considers the full set of relevant choices: residential and firm location, and passenger travel demand. The model produces, for given time periods, a land use-transportation equilibrium—a non-trivial accomplishment given the multi-dimensionality of the problem, the complex non-linearity associated with the interdependency between location and trip choices, and the important effects of land rents.

The basic units of analysis are 409 "intermediate" zones of ESTRAUS (larger than the EOD zones reported in Chapter 3), 13 household categories

168 For more information on ESTRAUS, see: http://www.sectra.cl/contenido/modelos/Transporte_urbano/Analisis_sisttransurb_cuidad_gran_tamano.htm

169 For more information on MODEM, see: http://www.sectra.cl/contenido/modelos/medio_ambiente/estimacion_emisiones_fuentes_moviles_moden.htm

170 Metro energy consumption includes all electricity for lighting, motive power, buildings, etc. See Metro, *Statistical Appendix 2003*, (Santiago: Metro de Santiago, 2004) available at: http://www.metrosantiago.cl/Portal/Contenido.asp?CodCanal=120&TipoCanal=A. Note that available information disaggregates the energy for motive power from energy for lighting, escalators, etc. Practically, however, the Metro cannot operate one without the other. The long-term average (1982–2003) energy consumption per passenger for the Metro is 0.57 kWh (ranging annually from 0.48 to 0.67), implying, based on average composition of the national electricity grid in Chile, CO_2 emissions on the order of 0.26 kg per passenger. The relationship between Metro energy consumption and total passengers is fairly linear (r=0.86), so that one could expect over the long-run future increases in Metro ridership to carry not insignificant growth in CO_2 emissions.

171 Discrete choice models have an over 30-year history of use in transportation analysis. A multinomial logit model basically works under the assumption of random utility, predicting the probability that a consumer will choose—from among a set of alternatives—the alternative that provides the greatest relative utility. See, e.g., M. Ben-Akiva and S. Lerman, *Discrete Choice Analysis: Theory and Applications to Travel Demand*, Cambridge, MA: MIT Press, 1985.

172 Such subsidies are obtained imposing the land use equilibrium conditions.

173 SECTRA, *op. cit.*

(stratified by income and auto ownership), three trip purposes (Work, Education, and Other), and 11 modes. The basic procedure employed the model to: (1) establish the baseline, which assumes trend growth in travel demand as a function of household growth (estimated at 1.47 per cent annually) and concurrent growth in residential and non-residential land uses;[174] and (2) estimate travel emissions reductions resulting from several meso-scale scenarios of changes in household, educational, and other land uses. Emission reductions derive directly from reduced total VKT, due to a shift from motorized to non-motorized travel and a change in trip destination choices.

The emissions effects of several alternative land use scenarios were analyzed: (1) a "pre-optimal" scenario, which attempted to model the city performance if an optimal land use re-location were possible—in other words, to provide something of an "upper limit" of potential emission reductions without constraints on future land use patterns; (2) an "education-oriented" scenario, which relocated educational facilities directly proportional to residential location patterns; (3) a "non-residential-oriented" scenario, which redistributed non-residential land uses proportional to residential location patterns; and, (4) a "sub-center scenario," which concentrated a high share of residential and non-residential land uses into defined sub-centers on the urban edge. The urban equilibrium theory underlying Santiago's land use model (MUSSA[175]) was then used to estimate subsidies that would be required to induce the land use changes associated with different scenarios. Due to data shortcomings and subsequent model estimation challenges, the subsidies estimated were "demand-side" subsidies (i.e., those required to induce changes in households' and non-residential land users' locational decisions); in this sense, the subsidies work in a way similar to the urban revitalization subsidies mentioned above.

The modelling assumed that the various land use scenarios could be realized within a period of five years, most likely an unrealistic pace of change given the magnitude of the restructuring implied, the inertia of current trends (and existing land uses) and the uncertain reaction of how the demand subsidies might translate into actual consumer (and developer) behaviour. In the case of slower implementation (technically, realization of the scenario), the total benefits to a project proponent would be reduced, which could be particularly troublesome for a project with a proposed short (e.g., seven year) time frame. Each of the first five years was modelled and the difference between the project and baseline emissions reductions was calculated. After the fifth year, the differential emission reductions (achieved at year five) are assumed to perpetuate. The ultimate impacts of the contemplated land use changes would certainly extend well beyond year five, as the built environment and related transportation behaviour would endure for at least a generation. These extended effects are considered in the results presented in the next section.

Quantitative Results

The analysis suggests that considerable emissions reductions relative to the baseline can be achieved under the different scenarios: education, 12 per cent; non-residential, 21 per cent; sub-centers, 40 per cent; and the "pre-optimal" scenario, 67 per cent. Different scenarios reveal that at year 10, the estimated cumulative emissions reductions range from 4.4 million tonnes (education scenario) to 21.1 million tonnes (pre-optimal scenario) and at year 21, the estimated cumulative reductions range from 11 million (education scenario) to nearly 57 million tonnes (pre-optimal scenario) (See Figure 15). The relatively high total reductions apparently obtainable under both the pre-optimal and the sub-center scenarios should be viewed as extreme upper bounds of possibilities: the significant city restructuring implied in these scenarios make their implementation unlikely-to-impossible. This is reflected in the estimated subsidies that would be required to achieve these scenarios (remember that the subsidies are those estimated to produce the land use changes implied in the scenario): almost US$5 billion over five years in the sub-center case and US$15 billion in the pre-optimal case. On the other hand, the estimates suggest that the relatively more moderate emission reductions in the education-oriented scenario and the non-residential scenario could be more viable. In fact, the education scenario appears to be quite feasible, with the required subsidies implying a cost under US$10 per tonne over a seven-year time frame. Bear in mind that the subsidies achieve a permanent city restructuring, implying

174 Due to lack of relevant information, planned projects and policies, such as those designed for Transantiago, were not included in the baseline.

175 For more information on MUSSA, see: http://www.labtus.cl/site/modelos.php

a permanent change in travel demand. As such, as the project lifetime is extended, the estimated total cost per tonne reduced declines (see Figure 16) (note, however, that monitoring and verification costs are not included in the estimated project costs—these costs would imply somewhat higher costs per tonne for future years). If implemented under a single 10-year accreditation period, the education-oriented scenario would be an attractive CDM investment at current market values for CERs.

Figure 15: Cumulative Tonnes (millions) Reduced Under the Different Scenarios

Scenario	Year 7	Year 10	Year 14	Year 21
Education	2.8	4.4	6.6	10.9
Non-Res	5.4	8.1	11.9	19.4
Sub-Centers	8.6	13.6	20.7	34.6
Pre-Optimal	12.7	21.1	33.2	56.5

Figure 16: Estimated Cost per Tonne (US$) Under Different CDM Project Time Periods[176]

Scenario	Project Time Period (Years)			
	7	10	14	21
Education	9	6	4	2
Non-Res	147	139	121	91
Sub-Centers	921	848	724	538
Pre-Optimal	2,930	2,989	2,645	2,014

Assumptions, Strengths and Limitations

One must view the above results as preliminary, given the analytical and data limitations which forced various assumptions and simplifications. In terms of data, the major problems arose from the lack of necessary information (that is, changes in travel costs) on the impacts of future proposed transportation interventions (e.g., Transantiago). The lack of these data, which were not yet available from authorities (SECTRA), significantly hampers the estimation of a true baseline by not allowing for the inclusion of such programmed projects.

From the modelling perspective, first we must keep in mind the errors inherent to modelling individual behaviour, which is influenced by changes in tastes, constraints on choices, supply of relevant options (both land use and transportation), regulations, prices, etc. Any practical modelling effort of the complex urban system must simplify in at least some of these dimensions, which will naturally produce some errors. In using models and interpreting their results, we must remember that models are abstractions of reality that, while certainly useful in informing and analyzing policies, will always be approximations. More concretely, and in this particular case, lack of data and time—not to mention computational burden—required that the model focus on home-based trips made during the A.M. peak period of a normal work week. Expansion factors are then used to extrapolate from this period, ultimately to represent the entire year. This approach is roughly consistent with current travel forecasting practices in Santiago, which for logical reasons are primarily concerned with assessing options to reduce peak-period congestion. For system-wide GHG emissions estimates, however, this extrapolation may be a source of inaccuracy. For example, the majority of household shopping, recreation and social trips occur during off-peak periods and/or on weekends and such trips may have significantly different travel patterns than those modelled during the A.M. peak.[177] The trip-based focus also made it impossible to account for potentially important influencing factors, such as trip-chaining (i.e., people carrying out various trip purposes—like dropping kids off at school on the way to work—during a single trip).

As mentioned above, the modelling did not include actual network performance (i.e., vehicles on the streets)—or route assignment, typically the fourth step in travel modelling. As such the analysis does not account for relevant influencing factors, such as changes in vehicle speeds. Such speed changes not only influence emissions but also potentially influence mode choice (by changing the relative attractiveness of different modes) and/or trip generation (e.g., the time of day of travel). In terms of the influences of land use on mode choice, the modelling approach ultimately only captures the effect of trip distance changes on walk trips (and subsequent substitution for motorized mode trips). In other words, land use

176 Calculated based on estimated cumulative emissions reduced up to the indicated year, using the present value of the total subsidies required (over the corresponding project implementation period) to achieve the Scenario.

177 Based on extrapolation from O-D survey results, travel on Saturdays and Sundays accounts for approximately 25 per cent of total annual passenger transport GHGs in the city.

effects are assumed to not influence relative attractiveness of modes other than walking. This ignores important effects, such as the variation in vehicle occupancy rates brought about by land use changes. A related simplification stems from the complexity in estimating the emissions effects from changes in demand for different modes, such as bus or taxi. In the model application, bus fleets and frequencies are assumed to adjust quickly to demand, thereby producing emissions reductions.[178] Other issues that were, by necessity, left out of the analysis include system interactions and potential second order effects, such as increased effective roadway capacity (due to reduced congestion) being filled up via additional induced travel (which is akin to the "rebound effect" or "leakage"). Finally, the impacts on commercial traffic (e.g., freight trucks) have been excluded from the analysis.[179]

The above-mentioned limitations to the modelling approach must be viewed in light of the modelling accomplishments. To effectively assess the CDM's role in location efficiency, a "complete" model of the city was attempted, one that could effectively account for the interactions within the land market (residential and non-residential effects) and between the land market and the transportation system. In this way, consistent choice patterns arise from actual prices and costs within the system and the calculated subsidies reflect the "summary" of a number of complex pecuniary and technological forces operating in the system. The optimization procedure that searches for the land use pattern that generates transport demand with the lowest possible CO_2 emissions considers all choices (except route assignment), including: modes, trip destination, and location and building supply options.

Possible Extensions and Refinements

The effort undertaken for this project provides a demonstration of applying state-of-the-practice techniques in transportation and land modelling to estimate the potential for emissions reductions through land use changes. Nonetheless, shortcomings and limitations inevitably arose due to difficult analytical and methodological barriers and lack of necessary data—to some degree these could be overcome with additional time and resources. With more of the latter, several useful extensions to this work could be undertaken, such as:

1. including multimodal transportation network assignment and link-by-link performance characteristics to ensure more accurate emissions estimates and to better capture transportation system behaviour and interactions;
2. extending the analysis to account for off-peak travel and weekend travel and, ultimately, the effects of trip chaining;
3. incorporating commercial traffic and its potential interaction with land use variations;
4. including potential evolution in vehicle technologies in order to understand their potential role in reducing emissions relative to land use options;
5. assessing more thoroughly the degree to which micro-level urban design (the "Three Ds") might influence travel behaviour and, if so, working to incorporate such effects into forecasting;
6. improving the evaluation methodology to fully include all social benefits and costs (e.g., "co-benefits");
7. developing a vehicle ownership model that also reflects sensitivities to land use variations;
8. expanding the spatial context being modelled, to account for current rural and semi-rural areas, where future urban expansion is likely; and, ultimately
9. generating a set of feasibility and policy constraints in order to produce more realistic land use patterns, identify an acceptable pace of change, and clearly identify the political and institutional implications.

Implications and Lessons

This examination of land use as a potential transportation CDM project illuminates two very different realities: on the one hand, urbanization and economic

178 In other words, the very significant challenge of how changes in potential bus services would actually occur in the face of, for example, concession requirements is ignored.

179 Trucks in Santiago account for roughly 16 per cent of estimated total transportation CO_2 emissions (Based on 556,000 annual tones of truck CO_2 emissions in O'Ryan *et al.*, *Transportation in Developing Countries: Greenhouse Gas Scenarios for Chile*, Pew Center on Global Climate Change (August 2002), p. 33.

growth in the developing world means that—without significant intervention in current urbanization patterns—more people will be making more motorized trips over greater distances. On the other hand, if we want to effectively intervene in this area utilizing an instrument such as the CDM with stringent requirements regarding baselines, etc., then we will confront fairly significant challenges due to the time and resources required to develop adequate analytical tools and—critically—the data necessary to use those tools. Furthermore, even with fully-operational analytical tools for forecasting expected effects, it remains unclear whether any urban area has the institutional capabilities (i.e., a fully responsible, empowered and accountable agency) to implement such an initiative.

In the early 1970s, at the beginning of the first global oil crisis, analysts in the U.S. decried the urban development patterns of the previous thirty years (i.e., immediately post-World War II) which had led to a dependence on highly fuel-intensive passenger travel patterns.[180] Now, thirty years onward, development patterns in nearly all the world's cities have, if anything, only intensified in their decentralization and suburbanization trends.[181] The question then becomes, can we really do anything about these trends and, if so, what? While the analysis conducted for this case is clearly preliminary, the results show the magnitude of potential results. In the case of the education scenario, for example, the estimated subsidies required to achieve the changes in land uses indicate potential CDM feasibility. Perhaps the major uncertainty in this case stems from the degree to which consumer demand (for educational opportunities) would comply with the model predictions, since the model does not account for the variation in educational quality and subsequent impacts on school travel (some degree of "school choice" exists in Chile, so that highly proximate educational facilities will not necessarily be chosen). In the case of the non-residential scenario, in which non-residential land uses develop proportional to household location patterns, the costs per tonne escalate significantly, in the range of US$91 to 150.[182] The value of potentially significant co-benefits—including local air and noise pollution, travel time savings, reduced demands for infrastructure investments and reduced pressures on remaining open lands—could, however, reduce this cost.

The latter results, presented in light of the analytical challenges and data limitations outlined above, seem to underscore a fundamental challenge: *people and companies would apparently demand significant compensation in order to change their location behaviour to induce more "GHG-efficient" travel patterns*. This result should not necessarily be surprising, given empirical evidence from Chile and elsewhere that suggests that travel behaviour figures only moderately in most households' residential location choices and, quite often, in choices about where to shop or send children to school.[183] Maybe desires for suburban-style, large-lot single family housing and automobile ownership simply outweigh the broader negatives that such desires imply. This points to the issue, raised earlier, of people's attitudes, and the related point of self-selection. If people's attitudes are what determine preferred lifestyles and living situations,[184] then either attitudes must be changed before alternative urban forms can be expected to spontaneously produce important changes in travel behaviour (this does not discount the fact that those urban forms must be available for those people to choose) or such attitude change has to be replaced by very strong incentives as the modelling here predicts.

Despite certain technological improvements, in all likelihood vehicle fuel efficiency gains will not be capable of solving, on their own, the GHG challenge in the face of continuing VKT growth. Some reduction in motorized transport demand will almost certainly be necessary (as discussed in Chapter 2).[185] In

180 See, e.g., Orski, K., "The Potential for Fuel Conservation: The Case of the Automobile," *Transportation Research*, Vol. 8 (1974), pp. 247–257.

181 As discussed in Chapter 2; see also, e.g., World Business Council for Sustainable Development (WBCSD). Mobility 2001: World Mobility at the End of the Twentieth Century and its Sustainability (Geneva: prepared by the Massachusetts Institute of Technology and Charles River Associates for the WBCSD Sustainable Mobility Working Group (2001).

182 The range depends on the project life-time (see Figure 18).

183 See, e.g., Weisbrod, *et al.*, "Tradeoffs in residential location decisions: Transportation versus other factors," *Transport Policy and Decision Making*, Vol. 1 (1980), pp. 13–26; Hunt, J. D., "Stated Preference Analysis of Sensitivities to Elements of Transportation and Urban Form," *Transportation Research Record 1780* (2001), pp. 78–86.

184 Kitamura, *et al.*, 1997, *ibid*.

185 Even if a "silver bullet" to transportation's emissions problems could be found, cities would still face the problem of ever-increasing amounts of land dedicated for transportation infrastructure in lieu of, for example, public spaces and greenspaces.

rapidly growing cities, the urgency is arguably more acute, as inattention now to land use as a travel demand management measure virtually locks cities into systems with fewer options: a car-dependent city cannot easily break its car-dependency—physically, functionally or culturally. In this sense, land use options need to be considered a key component in a broader suite of tools including improved pedestrian facilities, transit services and vehicle technology improvements.

Location Efficiency, the CDM and Beyond

It does seem clear, from the case analyzed here, that the current CDM modalities and procedures imply very detailed analytical capability to understand the multiple interactions, second order effects and unanticipated consequences that may arise from attempting to influence land uses for achieving measurable reductions in transportation greenhouse gas emissions. The approach detailed here has taken a city-wide perspective under the assumption that one must aim to capture the complete effects due to interventions in the land use-transport system. An alternative might be a "project-based" approach; under such an approach, however, it would be difficult if not impossible to predict how a particular project—such as subsidies to promote development in a certain part of the city—will cascade through the system in time (being influenced by and influencing the rest of the relevant land use and transportation markets). This provides a strong argument in favour of the system-wide, city-wide modelling approach; such an approach, however, still poses challenges. Some of these relate to the modelling complexities and data and resource requirements, as discussed above. Nonetheless, perhaps an even larger question remains: where do you draw the model boundaries? For example, the case modelled here did not include areas of potential future urban expansion; all future residential and non-residential activities were spatially constrained in their locations to the existing urban area. In this case, the project results ultimately depend critically on future authorities and their willingness and ability to ensure current regulations regarding areas for urban expansion remain in force. Otherwise, the interventions implied in, for example, the non-residential scenario, might produce market changes that would ultimately create pressures to expand the urban area and thereby change the expected results. The broader issues of boundaries in this area is complex: how can we be sure that promoting certain development patterns in Santiago might not induce demands in other urban markets in the country, with implications for transport GHG emissions? This question of "where to draw the boundaries?" certainly is not unique to this type of project and, though it may appear to be somewhat excessive, we need to at least explicitly recognize it as we are looking at a global contaminant: if we "squeeze" emissions over here will they simply "pop out" elsewhere, with no net impact on the global atmosphere?

For the specific Santiago case, this modelling effort provides useful guidelines for land use management for transportation efficiency although analytical improvements could certainly be made, as outlined above. Even so, considerable implementation doubts remain, largely as a result of unclear formal policies and the multi-jurisdictional, multi-sectoral government structure covering the relevant sectors which, among other impacts, affects monitoring and verification. *Additionality* in this case poses one challenge. Clearly, no policy of such broad coverage as that envisioned in any of the LE scenarios currently exists, although the Transport Plan for Santiago (PTUS, see Chapter 3) contains three program areas specifically focusing on changing land use patterns: one focusing on educational facility location, another on new areas of commercial and services, and one on changing residential location trends. It is not clear whether the existence of these announced programs thus constitute a violation of the additionality concept (none of the relevant PTUS programs currently exists in detail in terms of mechanisms to be used, etc.). A related challenge stems from the potentially changing baseline: land use regulations evolve (exemplified by the 1997 amendment to the Metropolitan Plan) and these modifications can be implemented by various levels of government (national or Municipal, depending on the scope of the changes considered). No all-encompassing government authority over all relevant land use or transportation changes exists, so that, while this initiative requires a city-wide implementation, it is not at all clear what agency would be accountable.

The latter point resonates strongly in terms of *monitoring and verification* requirements. This initiative, as envisioned, takes behavioural modelling results to predict emissions reductions over relatively long time-frames. One could envision the project functioning in the following way. A project proponent would use the modelling results (actually, a refined version of them) to attract an investor interested in carbon offsets. The investor would finance the subsidies required[186] (estimated, in this case, as necessary to achieve the envisioned urban restructuring) and the investor would essentially assume the risks relating to the reliability of the modelling results.[187] In other words, if the modelling proves inaccurate, fewer—or no—reductions result. For the project proponent and any interested investor, however, success hinges upon accurate monitoring and verification (M&V) of emissions reduced (which are what ultimately get sold on the market or counted towards reduction commitments). In this case, while the model can help provide an *ex-ante* estimate of the emissions to be reduced, the proof (and the money) rests in *ex-post* validation. No straightforward M&V program likely exists; perhaps the most reasonable would be annual surveys (household O-D surveys, intercept surveys, and land development surveys), designed specifically to gauge whether land uses and travel patterns are responding as expected (from the model). Land development could be monitored, at least in part, via existing building permit issuances and tax records, in a complementary way to existing activities carried out by authorities. The idea of using annual travel surveys for M&V may fit well with existing Chilean government plans to implement a continuous travel survey instrument for Santiago (approximately 5,000 households per year).[188] In theory, this survey instrument could be adapted to satisfy the CDM requirements, including, for example, through stratification according to household location. This would still require non-trivial decisions on the part of the CDM regime (EB) regarding acceptable levels of confidence. Furthermore, local authorities would likely need to be convinced that additions to the survey would not distract from the primary purpose (e.g., updating trip matrices). Since the survey would ostensibly be financed by the CER seller (financed, presumably, through CER revenues), this might be an attractive benefit to local authorities who may otherwise be reluctant to finance data collection.[189] Indeed, enhanced local data collection and quality (always a problem in transportation) could be a strong "co-benefit" to local countries of relevant CDM activities. Given the level of emissions reductions estimated (in, for example, the education scenario), the required resources for a survey instrument (perhaps $250,000 to 500,000 per year if 5,000 households are included) could still be accommodated within the estimated revenue stream—in the case of a 10-year project lifetime this would imply an additional cost of less than US$1 per tonne. Of course, the instrument would have to be independently implemented and validated.

Finally, the issue of the *project lifetime* has interesting implications in this case. Essentially, all of the scenarios exhibit declining costs per emissions reduced in time. As such, any project proponent would have the incentive to target the longest possible project lifetime. In the case of the three seven-year renewable project lifetimes (i.e., a total of 21 years), however, the project baseline must be updated at the time of project renewal. This offers an opportunity to "check" the effectiveness of the project and possibly even qualify for more (or less) emissions credits than those initially estimated.

The location efficiency CDM as envisioned here could, perhaps most feasibly, operate as a unilateral CDM initiative, with a city-wide authority establishing concrete goals for achieving transportation emission reductions and selling the resulting CERs. The relevant authority could determine which urban development projects contribute to achieving those goals and reward them appropriately. The authority would also ultimately bear responsibility if the emission reductions were not fulfilled. *The great vacuum*

186 Note, that the project does not require the subsidies for implementation. The government could, in theory, use other mechanisms, such as taxes or regulations to achieve the same land use results. In such a case, the government could sell the resulting emissions reductions and use the revenues as desired. The subsidy approach, however, may well be the most politically feasible implementation tool.

187 In a way, then, this obviates the need to judge what modelling techniques would be acceptable to relevant CDM authorities to approve a location efficient project. We know that no model of this complex land use-transport system can accurately predict what will happen over a 25-year period. Models can really only be used to predict the range of possible futures and the impacts that policies today may have on the future, with the results varying significantly depending on the modelling approach used (See, e.g., Hunt, J.D. *et al.*, "Comparisons from Sacramento Model Test Bed," *Transportation Research Record 1780* (2001), pp. 53–63). In this case, the project proponent and/or investor must be willing to "gamble" on the reliability of the model (at the same time, however, the proponent/investor has a strong incentive to ensure a "good" modelling approach).

188 Ampt, E. and J. de D. Ortúzar, 2004, *ibid.*

189 In fact, there is some indication that the delay in implementing the planned continuous survey design in Santiago arose from relevant authorities' unwillingness to dedicate the necessary resources.

in this case, however, is exactly the lack of such a relevant authority, in Chile or elsewhere. Ultimately, such an initiative could be combined with a broader process of "visioning" the city and its neighbourhoods, in an attempt to ensure that the ultimate customers, the citizens, play a central role in designing their city (linked to recommendation number 9 outlined under "Possible Extensions and Refinements" above). Our analysis has shown that under the current CDM rules and global CER market, location efficiency may prove a viable CDM option, but not without analytical and institutional complications. It is possible that some of these complications could be overcome through introduction of policy-based approaches that can more effectively encompass sectoral achievements. Nonetheless, the ongoing urbanization process and the long-term travel behaviour patterns embedded in the resulting development patterns suggest that we cannot give up in looking for ways of combining the local with the global. If the CDM is to adhere to its dual goals of reducing GHG emissions *and* promoting sustainable development, then bringing the CDM to bear on the effort to define more sustainable city futures is critical: a city's development today dictates the city of tomorrow, not only in terms of issues like infrastructure development, but also its induced culture.

Case Study Conclusions

Quantitative Comparison

The case studies considered represent a wide range of GHG reductions and costs, as depicted in Figure 17.

Financial and technical analysis of two of the three case studies showed them to be challenging fits within the current CDM framework. The bus technology switch case emerged as the most viable CDM option, by yielding a negative cost per tonne. This result indicates that the project is financially attractive *without* the supplemental income generated by CERs. As such, the sale of CERs would increase its attractiveness to investors, and potentially help them to overcome barriers to project implementation.

Both the bus technology and bikeway projects would result in CO_2 reductions lower than the 15,000 tonne per year threshold for 'small scale projects', and thus could take advantage of using simplified baseline and monitoring requirements. A comprehensive bicycle *network* could result in savings of up to 100,000 tonnes CO_2 per year, and location efficiency efforts as outlined by the modeling could save on the order of 500,000 to 1,200,000 tonnes CO_2 per year. By comparison, the bus rapid transit (BRT) project currently

Figure 17 Comparison of Case Study Results[190]

Case Study	Project Scale	Annual CO_2 Savings (tonnes)	Project Time Period (years)	Cost per tonne* CO_2	Annual CER Revenues (US$10/tonne)
Bus Technology	462 buses	11,700	10	-$80	$117,000
Bikeway project	4.5 km (1,000 cyclists)	73	21	$212	$735
Bicycle network	1,200 km	27,300 to 99,600	21	$30 to $111	$273,000 to $996,000
Location Efficiency: Schools**	Greater Santiago (34 communas)	500,000 to 650,000	21	$2	$5,000,000 to $6,500,000
Location Efficiency: Non-Residential**		850,000 to 1,200,000	21	$27	$8,500,000 to $12,000,000

* Assumes a 10 per cent social discount rate for each case study. Transaction and monitoring costs are not included. Projects with 14 or 21 year timeframes will incur additional transaction costs for preparing and submitting renewal applications and updating the baseline.

** Annual savings grow over the 21 year time frame.

190 The CO_2 savings from these case studies can be scaled to represent higher implementation levels. They can also be used as a rule of thumb to provide order-of-magnitude savings potential. For example, on a per-bus basis, the CO_2 savings are about 25 tonnes per year, so for 1,000 buses annual savings would be 25,000 tonnes CO_2 with CERs worth $250,000 per year. Similarly, the bikeway are based on 1,000 cyclists per day, so are easily scalable to estimates other levels of use. This type of quick screening can be useful for determining if a project is worth pursuing in terms of GHG reduction or CER revenue stream.

underway as part of the TranSantiago plan is expected to reduce on the order of 350,000 tons CO_2 per year by affecting a larger number of passengers and displacing more trips than cases considered in this study. Further discussion of the implications of the challenging fit between CDM and the transportation sector can be found in Chapter 5.

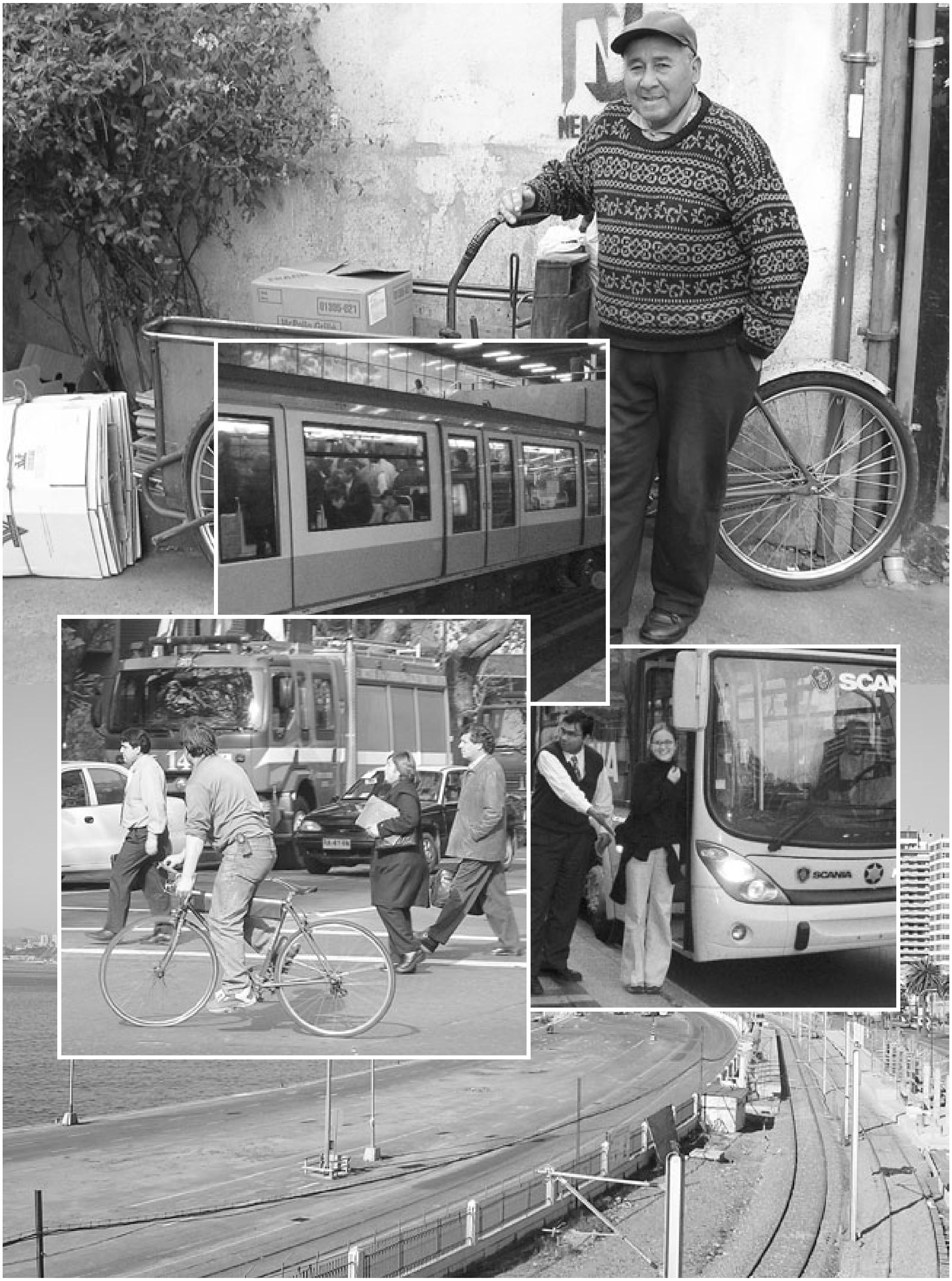
Discussion

Given these results, the bus technology switch project was determined to be appropriate for the CDM. The bicycle and land use projects face serious challenges working within the rules currently in place for the mechanism (i.e., imprecise forecasts, uncertain emissions quantifications, expensive monitoring, and high transaction costs). A comparison of the three case studies shows a key difference, i.e., that quantification and monitoring of emission reductions can be done with much more certainty for the bus technology project than for the two demand-side projects. The primary reason for this difference is that the baseline scenario for the bus project is defined by regulatory guidance from Transantiago, however, the baselines for the bicycle and land use cases are drawn from projected trip characteristics that are inherently uncertain. Even when actual ex-post travel is monitored, comparison with what would have taken place in absence of the project is very challenging, and the margin of error may make estimates ineffectual.

The bicycle and land use cases lay out methodologies using some of the most advanced models and high quality data available, yet the emissions reductions calculations are still considerably less certain than for the bus technology case. Uncertainty in quantifying emissions reductions raises significant environmental additionality concerns in a CDM context, and certainly would pose challenges in the approval process. However, this uncertainty does not mean that the methodologies are without merit or use. In fact, methodologies from all three case studies can be very useful in assessing the impacts of projects critical to important sustainable transportation and economic development. All three of the methodologies can be applied in other locations or countries as they are or in adapted projects. For example, the bus technology switch methodology could be easily modified to apply to other measures such as private cars or freight vehicles. The bicycle and location efficiency cases reinforce calls for the CDM to become more accommodating for demand side projects, and contribute to discussions on moving beyond the CDM for promoting sustainable development. These ideas and recommendations are developed in more detail in Chapters 5 and 6 below.

This research yields that CDM projects in the transportation sector, with some possible exceptions, do not appear to be revenue generating initiatives. This is in part because many of the benefits that accompany improvements in technology, mode shift and increases in efficiency do not correspond directly to income for project developers. Instead, these benefits take the form of non-tangible improvements for local citizens, such as better air quality, reduced noise and injuries from traffic, increased "liveability" of areas of the city, etc. In fact, in each of the case studies CERs only contribute a small portion of total project costs—from about one to 33 per cent. As such, other funding sources will be required to bring the projects to fruition, potentially by accessing funds earmarked for health, air quality, transportation, or infrastructure. In this way, the CDM could become a useful financial leveraging tool to help develop public sector projects that tend to be under funded, like the bicycle network or location efficiency.

Chapters 5 and 6 provide further discussion of the conclusions and recommendations of the research.



Chapter Five
CDM and Transportation: Examining Key Issues

CDM projects in the transportation sector face a number of methodological challenges that impede them from achieving a greater share of the potential CER market. This chapter reviews the particular issues and potential solutions to these transportation specific problems. It subsequently discusses a range of options for promotion of transport projects within current and future iterations of CDM, including unilateral initiatives, sectoral or policy-based approaches, and options for post-2012.

Additionality

Additionality is one of the primary challenges with transportation projects under the CDM for several reasons.

1. Baseline development involves predicting the future emissions path of transportation sources—a future that will never eventuate if project intervention is successful. In any sector the challenge of estimating baseline emission scenarios is difficult. However, given the multitude of factors influencing transportation, it is even more challenging. Transportation planning and policy-making regularly depends on travel forecasting models to understand future travel demand and evaluate different investment and policy interventions. Despite their sophistication, these models suffer from well-known shortcomings inherent in any attempt to model complex real world socioeconomic systems. Baseline development requires both excellent data collection over time and a clear understanding of "business-as-usual" transportation plans. In many cases both of these components are unavailable or incomplete, and event the most robust planning processes can result in emission profiles that vary greatly from projections. The results obtained can vary significantly depending on the type of modelling framework employed.[191]

2. Frequently, even the best informed estimates of future transportation development plans (and hence emission paths) do not unfold as planned for a variety of reasons. In many cases, stated plans and policies do not materialize into projects and initiatives due to changes in political direction, budget, economic well-being, and availability of outside sources of funding. The scope for change (and, therefore, variation from baseline) is very broad in the transport sector, where public planning decisions, technology transfer, and numerous other factors influence future transportation emissions. Other projects, such as methane capture projects in the energy sector, are far more isolated from the effects of larger political and social development than the transport sector. Comparing the impacts of CDM projects against an emission scenario that is unclear (or incorrect) leads to difficulty in determining potential credit volume.

   In determining additionality for transportation projects (and others) it is important to consider the presence or absence of funding for planned initiatives as a measurement tool. Projects or policies planned *but not funded* should not be considered "business-as-usual."

3. An alternate interpretation of the text from paragraph 43 of the Marrakech Accords is that proponents must illustrate that a CDM project

191 See, for example, J. D. Hunt *et al.*, "Comparisons from Sacramento Model Test Bed," *Transportation Research Record 1780* (2001), pp. 53–63.

(including the emission reductions) would not have gone ahead without the influence of the CERs. The reason for this rule is clear; free-ridership (awarding credits for non-additional reductions) is contrary to the spirit of the Kyoto Protocol and harmful to the regime. However, the issue of additionality is rarely black and white; overly strict interpretations of additionality can make beneficial projects infeasible and discourage meaningful action on climate change.

Financing

Financing for project development continually serves as a barrier in transportation but also in other sectors. Capital for the project itself, as well as the transaction costs associated with the CDM, is required. Transaction costs are the expenses incurred by proponents in order to complete the project cycle. This typically entails evaluation to certification of credits, but does not include costs associated with assessing the technical feasibility, project design or implementation costs. Most of these are one-time costs and are fixed, with the exception of monitoring and verification, which can vary according to project size and duration.[192] Transaction costs are estimated to vary between US$155,000 and US$215,000, depending on the nature and size of projects.[193]

Transportation projects typically involve high infrastructure costs and long time horizons between initial investment and the onset of emission reductions. These challenges, in addition to limited financial return on public transit projects and low current value of CERs, mean that CDM is not likely to push transportation projects over the edge to becoming profitable. It is important to clarify that financial additionality was explicitly dropped from the Marrakech accords. Many transportation projects are not strictly financially viable to begin with, at least within the 10 or three seven-year time frames as dictated by Kyoto. Governments undertake transportation projects for a wide range of reasons, primarily for social and economic benefits that result from transportation improvements—benefits that are not strictly valued in the financial market. If we examine the important co-benefits arising from transportation and—by taking a "full cost accounting" approach—include their added value to society in the formula to determine feasibility, it may be possible to increase the *overall* profitability of the project for society. The use of ODA to fund the added social benefit from these projects could be an important step toward making their CDM-ability feasible.

The Role of ODA

A clear line was established under the Marrakech Accords stipulating that ODA cannot be used to purchase CDM credits. However, there are many activities and initiatives that can be funded that contribute to creating a climate attractive to private sector resources for climate change and/or development of unilateral CDM activities.The technical and institutional capacity to review, approve, develop and promote CDM projects in a systematic manner, to assess and remove barriers to implementation and to market project opportunities effectively is critical for host countries. In order to achieve this capacity, many countries rely on official development assistance (ODA) to fund capacity-building activities.

A number of donor countries are using ODA to assist countries in creation of good governance and capacity for acceptance and facilitation of CDM projects within host countries. These funds have been put toward creation of National Authority offices (including input into development of sustainable development guidelines), exploration of market opportunities and development of pre-feasibility studies. This on-the-ground knowledge can contribute greatly to the attractiveness of a particular country for CDM investment. For example, a clear and efficient process of approval and facilitation of CDM initiatives stands to influence the quality and number of projects that take place in a given country.

While Marrakech lays out the regulations regarding use of ODA, in practice the interpretation of these regulations is in question. After lengthy discussion in this and other fora, the chair of the Development Assistance Committee (DAC) of the OECD tabled a proposal in April 2004 to provide additional guidance to members. The DAC Network on Environment and Development Co-operation (ENVIRONET), in col-

192 Canada's CDM & JI Office (Robertson, L.), "Transaction Costs Associated with CDM Projects," submission to the Working Group on Offsets (WGO), September 2003. In summary: Proposal development (US$20–50,000); project evaluation (US$25–40,000); legal (US$100,000); monitoring and quantification (US$10–25,000 for first year).

193 Transaction Costs (references to CDM projects), Environment Canada accessed March 25, 2005. http://www.climatechange.gc.ca/english/publications/offset_costs/trans.asp

laboration with the Working Party on Statistics, proposed "the DAC should agree that the value of any CERs received in connection with an ODA-financed CDM project should lead to a deduction of the equivalent value from ODA." This proposal could have a number of implications. One outcome could be to discourage the use of ODA to any extent in CDM projects, (i.e., to limit involvement of donors to capacity building activities) due to the limited benefits developing countries would gain from turning development projects into CDM projects, as well as the additional costs to development agencies for incorporation of CDM structures and regulations into project development. Agencies are concerned with the perception of diversion of ODA to CDM, either by developing countries or critics within Canada. Another end result might be to foster the integration of additional development benefits into CDM projects, without increasing the price paid per tonne of carbon reduced (the DAC suggests the use of an established "reference price" for valuing CERs, however specifics of the application of this suggestion have yet to be fully elaborated). Some argue these additional SD benefits may contribute to the long-term "sustainability" of such initiatives, and as such increase the likelihood that projects result in measurable credits in the long term.[194]

In transportation, the high costs of infrastructure are one of the barriers to feasibility as a CDM project. In this sector, ODA could be used to reduce the cost of the project without going so far as to purchase the credits. Using ODA to fund portions of transportation projects or infrastructure improvements such as bus rapid transit or bikeways could reduce the overall cost and increase the feasibility of incorporating the CDM.

Projects initiated under the Global Environment Fund (GEF) through its implementing agencies (World Bank, United Nations Environment Program (UNEP) and the United Nations Development Program (UNDP) can contribute toward sustainable transportation development and could lead to development of PDDs, creating an environment suitable for investment by building capacity and assisting to define baseline scenarios.

Additional incentives, support from donor governments, valuation of co-benefits, and use of ODA to cover the incremental development benefits are all necessary steps to increase the financial viability of these projects. Climate change (both mitigation and adaptation) should be more fully integrated into the funding frameworks of the IMF, the World Bank, Regional Development banks and Poverty Reduction Strategic Papers (necessary for accessing development aid).

Perverse Incentives

Due to the project-driven nature of the CDM, some concern has developed that host country governments may delay or discourage development of policies aimed at reducing greenhouse gas emissions due to the perception they may lose investment and development of CDM projects. This possible impact on host country sustainable policy development has been labelled a "*perverse incentive*" of the CDM.

The Executive Board recently provided clarification on the issue by agreeing on guidelines for the treatment of national or sectoral policies in determining baseline scenarios.[195] This allows for consideration of local or national level policies that lead to market distortions or competitive advantages (or disadvantages) for proposed CDM projects, and permits adjustments in the baseline scenario as a result. The EB continues to explore the implications of sectoral level legislations.

Induced Demand and Boundaries

In many developing countries, demand for transportation has not been met. Expansion of supply is obviously needed simply to match un-met demand. However, there is a risk that development of additional infrastructure will further spur demand—a phenomenon known as "*induced demand*." In the short term, the increase in demand is referred to as induced (or generated) traffic—an increase in traffic on the affected facilities.[196] This is comprised essentially of traffic diverted from other routes, other destinations, or trips made by people that were previously in the "market" for travel but chose not to do so in the

194 Venema, H and M. Cisse (eds.), *Seeing the Light: Adapting to climate change with decentralized renewable energy in developing countries*. IISD, 2004.

195 CDM Executive Board, Meeting report from the 16th meeting of the EB, Annex 3, p. 1 available at: http://cdm.unfccc.int/EB/Meetings/016/eb16repan3.pdf

196 Lee, D., L. Klein and G. Camus, "Modeling Induced Highway Travel vs. Induced Demand" paper (#971004) presented at the Transportation Research Board Annual Meeting, January 1997, p. 7.

pre-build situation. In the medium to long term, the improvement in trip conditions produce an overall increase in demand—generated or induced demand.[197] This induced demand represents an increase in the total number of trips—trips which would not have occurred without the supply expansion. Additional long-term effects occur in the form of induced changes in urban development patterns which might further entrench auto-dependency.

The failure to account for generated demand within the many infrastructure expansion plans poses a risk to satisfying long-term air quality and mobility goals. When congestion is severe, induced demand can quickly undo any effort to improve congestion, particularly in areas of rapid growth. Although the ultimate impacts depend on the specific context, almost all empirical studies confirm the phenomena.[198] A U.S. example indicates between 60 per cent and 90 per cent of expanded road capacity is filled within the first five years with trips that otherwise *would not have occurred*.[199] A review of evidence compiled in the United Kingdom concludes that road expansion, in the short term, produces 50 per cent more trips and in the long term 100 per cent more trips.[200] In Mexico, estimates indicate that gasoline consumption per car is positively correlated with miles of highway per car: "thus, new highway construction increases car utilization more than it improves fuel efficiency via better roads and less congestion."[201] Such results offer strong caution regarding the effects of road infrastructure expansion on vehicle distances travelled and pollution, and further complicate the case for CDM in transportation. Ultimately, teasing out the potential for induced demand requires local-specific analyses; furthermore, more advanced travel forecasting techniques (e.g., in which network performance is linked back to trip generation) and, in particular, integrated land use transportation models can more effectively account for potential long-term induced demand effects.

One criticism of the recently submitted PDD for the TransMilennio project in Bogotá centred on concern over the project inducing auto demand by freeing up road space; however, survey data later was used to refute the charge that the project would induce travel demand. This is not an isolated problem in the transportation sector; many examples of energy sector reform also entail increases in demand for power from system upgrades. In locations where services are not met, improvements in access to transportation amenities can be expected as part of a "normal" development process.[202] While increasing emissions appears contrary to the aims of the mechanism, influencing the development pattern of transportation in a more sustainably oriented direction is a key potential benefit of such projects, but one that may be lost if they do not receive equitable treatment.

Standardized baselines for the sector as a whole have been suggested as one solution to the issue of latent demand. Measurements of intensity of CO_2 emissions per person km (for the country as a whole, or specific regions) could serve as a baseline. A 1999 report on transportation baselines suggests that a standardized approach be developed to account for secondary effects of transport projects.[203] Such an approach could keep evaluation simple and data requirements low, therefore, lowering costs. Further work is necessary to explore how to fairly treat these projects under the CDM.

The discussion of induced demand is closely tied to the issue of project *boundary*. Additionality—as well as the overarching sustainable development impacts of projects—stands to be greatly influenced by how and where project boundaries are drawn, This is in part due to the "enabling" influence of transportation. For example, transport services and systems at the international level allow for individuals to consume on a larger scale, and to undertake activities which could be considered, on a larger scale, "unsustainable."[204] The

197 Lee *et al.*, 1997, *ibid.*

198 See SACTRA (the Standing Advisory Committee on Trunk Road Assessment), Trunk Roads and the Generation of Traffic, U.K. Department of Transportation and HMSO (London) 1994, p. 205; Transportation Research Board (TRB), Expanding Metropolitan Highways: Implications for Air Quality and Energy Use, Special Report 245, National Research Council, Washington, DC 1995, p. 155.

199 Hanson, M. and Y. Huang, "Road supply and traffic in California urban areas," Transportation Research Board, A31, 1997.

200 SACTRA, 1995, pp. 47–48.

201 Eskeland, G. and T. Feyzioglu, "Is Demand for Polluting Goods Manageable? An Econometric Study of Car Ownership and Use in Mexico" *Journal of Development Economics*, Vol. 53, 1997, p. 435.

202 Salon, Deborah, "An Initial View on Methodologies for Emission Baselines: Transport Case Study" Information paper, OECD, 2001 http://www.oecd.org/dataoecd/50/21/2468491.pdf

203 Salon, D., 2001, *ibid.*

204 E.g., See Hall, 2002.

link with transportation points to broader issues of sustainability of global economic growth, and responsibility to future generations.[205] Research examining the connection between transportation and fossil fuel usage suggests that at a national or global level, efforts to achieve sustainability will require decoupling of transport growth from economic growth.[206] Similarly, the relationships between transportation planning and land use change at the metropolitan level are tied directly to sustainable development.

Unilateral projects

The traditionally envisioned structure of CDM projects involves investors from Annex 1 parties developing and implementing projects in host countries. It is also possible for host country governments or private entities to develop CDM activities as "*unilateral*" projects. While there are several unilateral projects under development, the first such unilateral PDD was only recently submitted to the Executive Board for approval in November 2004.[207]

Unilateral projects are characterized by involving no "up front" foreign direct investment, having only the approval of the host country prior to registration, and selling CERs through a Direct Purchase Agreement (DPA) or not selling them at all. In some cases, this can lead to reduced transaction costs and wider access to project capital at lower rates. Unilateral projects may also avoid some slow downs due to bureaucratic hurdles. Particularly during the first commitment period, hesitation of foreign investors to finance projects in countries with high perceived risk will tend to limit participation in the CDM to a handful of "safer" countries. This trend is already being observed as a number of key countries represent the bulk of CER supply. Local development of projects provides an opportunity for increased participation in the CDM, and a widening of international distribution of projects.[208] It also may provide a space for projects more aligned with the sustainable development priorities of host countries to take place, particularly those with lesser appeal to outside project developers.

Transportation projects fall into this constrained category and, as such, hold lower appeal to independent project developers for a number of reasons. First, projects in the transportation sector, in part because of the large numbers of individual travelers, entail a high degree of complication. Definition of project boundaries and clear identification of impacts are challenging activities. Second, transportation is an issue that spans numerous levels of jurisdiction. It is multi-jurisdictional (local/multi-local, regional/state to national), multi-sectoral (infrastructure, services/operations, environmental, land planning/development) and multi-agent (private sector, individuals, government). In the case of Chile (and Santiago), the institutions involved span the range of transportation, public works, environment and land planning at national, regional and municipal government levels (Chapter 3, Figure 10 that outlines relevant institutions). Working with multiple parties who all have their own perspectives, priorities and schedules can inevitably lead to lengthy time lags and considerable bureaucracy, in particular for outside actors who may not be familiar with the systems and services in place. Finally, creating change in transportation patterns and navigating projects through numerous layers of complicated jurisdiction involves long time horizons. The Transantiago project currently under development in Santiago has been in planning stages for eight years[209] and is still undergoing modification as it works towards meeting the needs of all parties involved in the process of redesigning Santiago's public transportation services. The government of Chile has committed funding to develop a (unilateral) CDM component to this initiative.

Some of these barriers to project development could be overcome by a unilateral approach. Provided that sufficient capacity exists at the local level, transportation agencies in host countries could (and should) be

205 Zegras, C., I. Poduje, W. Foutz, E. Ben-Joseph, O. Figueroa. 2004. "Indicators for Sustainable Urban Development." Chapter 7 in *From Understanding to Action: Sustainable Urban Development in Medium-Sized Cities in Africa and Latin America*. Dordrecht: Springer.

206 Peake, S. and S. Hope. 1994. Sustainable mobility in context: Three transport scenarios for the U.K. *Transport Policy*, Vol. 1, No. 3, pp. 195–207.

207 The first unilateral project is located in Cuyamapa, Honduras. The small-scale hydropower project is set to reduce some 38,552 tonnes of CO_2 equivalents per year over a ten-year period (*Point Carbon News*, November 9, 2004).

208 Jahn, Michael, A. Michaelowa, S. Raubenheimer and H. Liptow, "Unilateral CDM – Chances and Pitfalls," Climate Protection Programme, November 2003. http://regserver.unfccc.int/SEORS/cop9events/FileStorage/FS_442592919

209 Transantiago emerged from the Transpor Plan for Santiago (PTUS), as first announced by Frei in 1996.

developing initiatives additional and complementary to their planned activities for consideration as CDM projects. Local agencies are in the best position to know the sustainable development priorities of their respective sectors and what may or may not be possible to undertake as part of a project. In parallel with long-term planning, local agencies are also well equipped to determine additionality of prospective CDM projects and may be best suited to secure investment funding from government or external sources. A unilateral approach could lead to diversification in the variety of projects developed as CDM, by providing opportunities for non-traditional projects such as bikeways or "public" transport projects, likely to be sidestepped by private (external) investors.

Pursuit of more unilateral projects will open a need for further capacity building and greater access to project development funds. Part of this capacity building should entail increasing the understanding and awareness of host countries about the opportunities for project development and how the mechanism could be utilized to assist projects to reach beyond their plans to reach greater sustainable development benefits through GHG reductions. Also, this should include increasing awareness among institutions within the host country financial sector as to the mechanism, the carbon market, and the lessons learned by other countries and players in the market to date. This type of capacity building is ODA-eligible, and likely fits well with many donor countries who are interested in the expansion of the carbon market and the increase in availability of CERs.

Policy-based and Sectoral Approaches

An exploration of the barriers to transportation activities reveals the challenges associated with the project-focussed nature of the CDM for this sector. The current modalities and procedures for the CDM establish provisions for a project-based mechanism. Central to these provisions is the requirement of quantifying and verifying GHG reductions attributable to proposed projects. Yet, this project-based approach may miss many important transportation emissions reductions opportunities. For example, vehicle emissions standards can be a very efficient way to address a major portion of the passenger vehicle fleet. Similarly, renewable fuel standards (e.g., requiring a certain percentage of biofuels to be blended with gasoline or diesel) can be an efficient way to address emissions from all transportation fuels. Finally, comprehensive land use policies and transit initiatives can be effective at slowing growth in travel demand and reducing associated motor vehicle emissions. However, given the current rules, none of these three examples would fit easily into an individual CDM *project*. Instead, they each operate at the broader policy level. The advantage to working at that scale is that the policies can have a major impact on emissions. The disadvantage is that a *policy-based approach* has the potential to introduce additional uncertainty, especially in forecasting GHG reductions. While the difficulties of double counting and measurement certainly would need to be addressed, a policy-based approach to CDM projects could conceivably facilitate much greater reductions by spanning an entire sector.

There have been a number of proposals for designing policy-based and *sectoral approaches* to GHG reductions.[210, 211, 212] For example, a recent working paper from the Center for Clean Air Policy explores five sectoral-based approaches (Fixed Emissions Limits, Dynamic Limits, Benchmark Based, Sector Policy-Based Credit Generation, and Harmonized Policies and Measures) and applies them to the electricity and cement sectors. Further work is underway exploring sectoral approaches to reducing transportation GHG emissions.[213] One option under consideration is referred to as the Sector Policy-Based Credit Generation approach (a number of the same issues arise when looking at the other four options), in which:

> a specific policy in a developing country would be eligible to generate emissions reduction units. The approach would address the same set of issues as under project-based CDM—additionality, baseline and leakage—with slight modification, given the nature of the program. The boundary for the

210 Sussman, F., N. Helme and E. Williams, "Hybrid Policy Options: Carbon Intensity Targets Combined With Policy-Based CDM." Center for Clean Air Policy Working Paper, May 2004.

211 Samaniego, J and C Figueres, "Evolving to a sector-based clean development Mechanism." In K Baumert (ed.), *Building on the Kyoto Protocol: Options for Protecting the Climate*. World Resources Institute: Washington, DC, October 2002.

212 Schmidt, J., K. Lawson and J. Lee, "Sector-Based Greenhouse Gas Emissions Reduction Approach for Developing Countries: Some Options." Center for Clean Air Policy Working paper, November 2004.

213 A discussion draft of a paper on sectoral approaches to reduction of transport related GHGs is planned by CCAP for Fall 2005.

activity would be the entire sector. The level of emissions reduction credits generated would be calculated as the difference between the sector's business-as-usual (BAU) level—determined as the level of emissions from the sector that would have arisen if not for the introduction of the policy—and the actual levels.[214]

In the case of the transportation sector, policies could address technological and demand-side efforts, including fuel economy programs, renewable fuel standards, and "smart growth" initiatives (i.e., location efficiency, plus transit expansion and bicycle improvements). Policy goals could be expressed as technology standards, or metrics such as CO_2 per vehicle kilometre travelled, CO_2 per passenger kilometre travelled, or transport CO_2 per capita (against a hard baseline or intensity target).

An important consideration is how the sector (or policy boundaries) and related emissions are defined, which would vary with the type of policy pursued. Conceivably, a sectoral approach could be segregated to focus on different aspects of the sector (passenger transportation, freight, etc.) or could focus on specific metropolitan regions. For fuel economy programs, an appropriate sector definition could be emissions from new passenger vehicles at the national level. For renewable fuel programs, the sector could be defined as national emissions from total gasoline and diesel sold for transportation use. For smart growth efforts, an appropriate scale would likely be emissions from passenger travel in a specific metropolitan region, which would include all modes (cars, public transit, taxis, etc.).

As in the cases of bicycle initiatives and location efficiency, such policy approaches would be undertaken by the public sector, most likely national governments or regional bodies (similar to the suggestions for transport under the Green Investment Scheme discussed in Chapter 2). Thus, there would be significant flexibility on how the measures were actually implemented and how CER revenues would be used. For example, project developers could be eligible for tax credits for urban development located central to the city core, or industries purchasing fleets of vehicles could be eligible for subsidies for voluntary measures such as upgrading to less GHG emitting technology. In each of these cases, CERs would help cover policy implementation costs (for example to cover incentives or replenish lost tax revenues), potentially through use of a revolving fund. A reverse of the "perverse incentive" concern, allowing such a system creates incentives for developing country policies and measures to reduce GHGs.

A sectoral approach would involve establishment of comprehensive baselines for the sector, potentially by using IPCC methodologies currently employed for national communications as a starting point. It would be necessary to develop a more detailed methodology (e.g., including vehicle sales, VKT and fuel use) for Methodology Panel approval. Depending on the nature of the sectoral approach, it may be necessary to further elaborate these methodologies since they are primarily utilized for developing national GHG inventories and do not necessarily provide the level of disaggregation necessary for employing a sectoral approach.

The quality of baseline data, and the success of monitoring efforts, would depend on accuracy and thoroughness of national data on vehicle sales, fuel use and regional travel surveys. Given the comprehensive scale of sectoral approaches, dynamic baselines might be particularly appropriate (e.g., incorporating the relationship between GDP and vehicle sales into the forecast). One of the key questions for sector-based programs is defining the baseline appropriately so that the new policy would be additional. Additional reductions would be reported against baselines and credits could be sold unilaterally or through MOUs to countries that have provided capital investments.

The CCAP working paper raises the question of whether the full emission reductions generated should be available for sale, or whether a portion should be retired as a "benefit to the atmosphere." If a sectoral approach was pursued in the context of national GHG reduction commitments, the implementing country could commit to reducing emissions by a certain amount and treating anything beyond that level as saleable. Also, international air and marine transportation are not addressed in the Kyoto Protocol, but are an increasingly important component of global GHG emissions. A future sectoral approach could potentially incorporate these substantial sources of emissions.

While significant technical and procedural complications remain to be clarified, there is considerable interest in, and opportunity for sectoral approaches for CDM to reduce GHGs. The policy-based sectoral

214 Schmidt, J. *et al.*, 2004, pp. 16–17.

approach mentioned above is just one of several under consideration. Final determination of which approach is most compelling will depend on how well it addresses local needs and its compatibility with the evolving international policy framework for GHG reduction.

Transport and Climate Change: Beyond CDM

Promising opportunities for emission reduction projects in the transportation sector exist, however, as we have seen from the case studies there are also many challenges in the fit with the CDM. Current experience and future forecasts show that travel activity is growing much faster than can be offset by vehicle efficiency improvements expected over at least the next 30 to 50 years. Progress will be required on all three key variables that drive transportation CO_2 emissions—travel activity (VKT), vehicle energy intensity and fuel carbon content—in order to achieve long-term reductions. Importantly, projects and policies that address travel demand do not appear to be a good fit with the CDM under its current formulation. Therefore, other policy mechanisms will be necessary to reduce transportation sector emissions.

In this section, we take a longer-term view of the sector in order to identify opportunities and constraints for policy interventions to reduce transportation greenhouse gas (GHG) emissions.

Opportunities for International Assistance: The Kyoto Protocol is an important, but small step toward mitigation of anthropogenic influence on the climate. The CDM was never intended to stabilize developing country GHG emissions, nor was it envisioned as the single tool for advancing sustainable development. That is clearly a larger task for developing countries, one that can be supported by industrialized countries through a variety of avenues. Below, we present several opportunities for such support in the transportation sector specifically.

Financial Assistance

The international community already contributes to sustainable transportation projects through loans and various bilateral initiatives. In addition, the GEF provides financial support for the planning and development of sustainable transportation projects such as Transantiago in Chile and the EMBARQ project in Mexico City. GEF funding can in some cases lay the groundwork for project financing from the World Bank. Continued and increased financial support for sustainable transportation and land use projects and policies will be critical in addressing VKT growth.

It is also important to consider where development bank funding supports works counter to the goals of the Kyoto Protocol and climate protection, such as road capacity expansion projects, or economic development projects in locations without good transit or pedestrian access, or continued dependence on fossil fuel imports for some countries. In addition, "one-off" transportation projects that are not integrated into broader local transportation and land use plans will not achieve optimal GHG results. It would be useful for the development banks to review the VKT and GHG impacts of the transportation and infrastructure projects they fund, with an aim to a strategic and comprehensive approach at carbon management.

Fostering Local Leadership

It is important to note that one of the most successful and frequently imitated Bus Rapid Transit systems, TransMilenio in Bogotá, Columbia, was funded entirely with public funds: 70 per cent from the central government, 30 per cent from a fuel surcharge. The Bogotá case underscores the earlier point about the importance of local leadership. The city's former mayor, Enrique Peñalosa, was not only instrumental in building TransMilenio, but also lead efforts to construct 250 km of bikeways, hundreds of kilometres of sidewalks, pedestrian streets and a 40 per cent private car restriction during peak hours.[215]

Support for Metropolitan Visioning Efforts

International assistance can provide impetus and funding, but cannot force local change. Long-term sustainability solutions will only be politically viable if there are clear connections to tangible short-term benefits (e.g., health, congestion relief). Political leaders are challenged in promoting projects or capital plans that offer benefits long after their term in office expires. This is an issue for developed countries as well, who also struggle with the challenges of long-term sustainable transportation planning and implementation. Knowledge about the GHG impacts and economic risks of current policies and trends can help form educated decisions. Comprehensive regional

215 For more information, see http://www.itdp.org.

planning can be a crucial first step for improving transportation system sustainability.

A metropolitan "visioning" process can engage community members in developing alternative growth scenarios with different land use allocations and transportation options, and can be a powerful tool to educate political leaders and arm them with the information they need to champion implementation. Participants develop a vision of where in the region to locate new housing and employment, which areas to protect from development, which areas to promote, what densities are appropriate for different areas, what kinds of transportation choices should be available, etc. These data are then run through transportation models to determine the traffic, environmental and economic impacts of each scenario. Such outputs allow policy-makers to assess and communicate long-term impacts and risks of business-as-usual policies, and the benefits of more integrated transportation and land use. A visioning process can help political leaders decide whether to continue to build new roads and subsidize sprawling development patterns with supportive infrastructure (roads, schools, utilities), or decide to focus development in efficient locations and provide people with high-quality, affordable alternatives to driving. Visioning processes are unique among the various factors influencing policy decisions in their ability to provide images of long-term regional changes and quantify relevant impacts (congestion, emissions, health and costs).

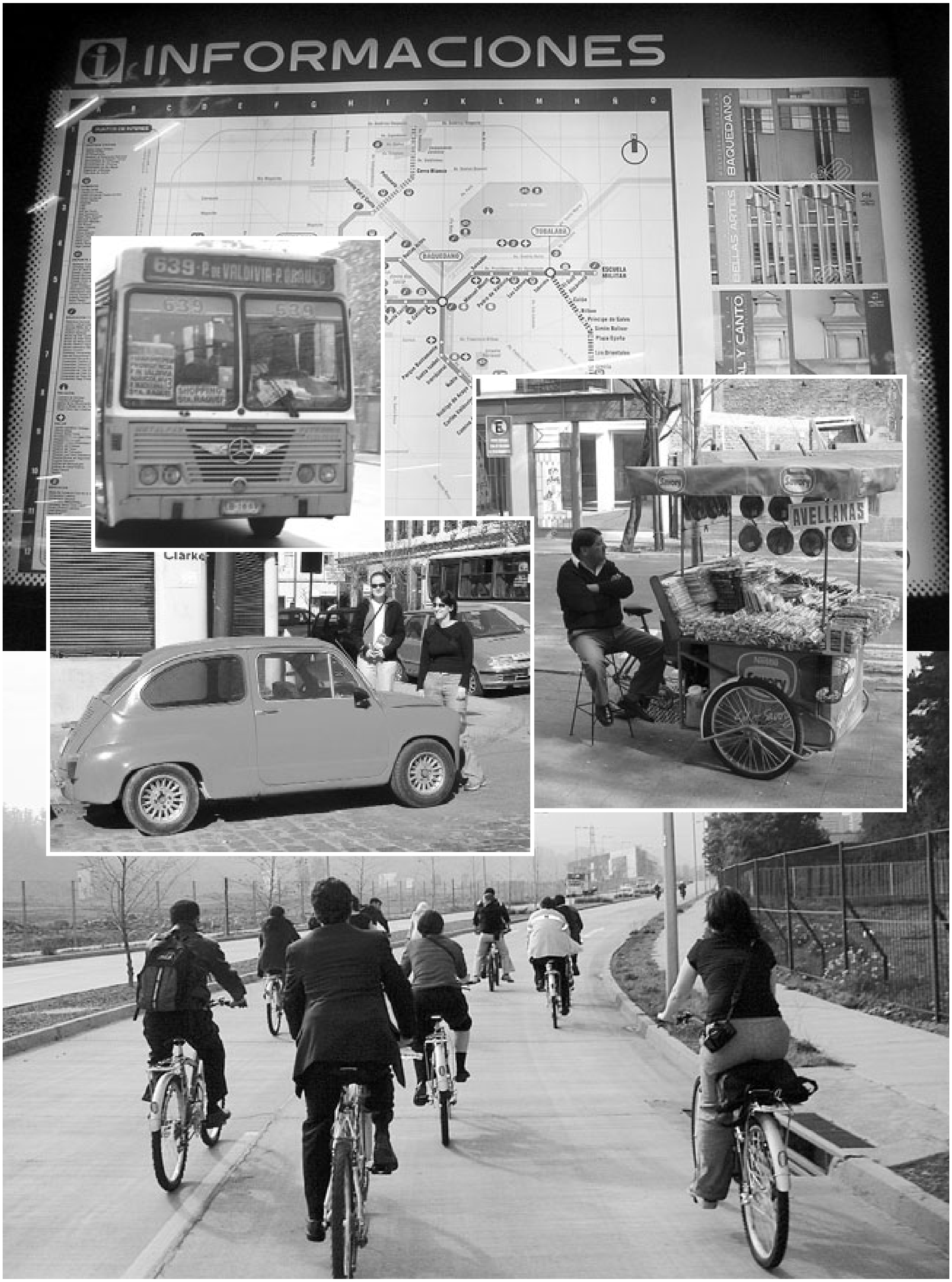
Successful implementation of visioning is unlikely without two key elements: political leadership and funding (for transit, design changes, development incentives, bike infrastructure, etc.). Many other factors are necessary to meet planning goals (new policies and incentives, coordination among local governments, zoning changes, other legislative and regulatory changes), however, political leadership and funding support are key. As such, financial and technical support is needed for areas such as visioning process implementation, staff training, model development and calibration, and data collection and improvement.

Technical Support and Cooperative Efforts for Exploring Sectoral or Regional Targets

As part of, or separate from, the CDM, support is needed for the analysis and development of sectoral or regional emission targets in developing countries. Such targets could be based on VKT growth, mode split, vehicle emission rates and fuel carbon content. Developing and industrialized countries face the same set of transport challenges, even if they are at different places on the motorization and emissions curve. Thus, this area is ripe for a cooperative approach among developing and industrialized countries for sharing methodological and analytical experiences.

Coordinated Policies and Measures

Where direct assistance may be too expensive and information sharing may be insufficient, it is worth considering areas in which more formal collaboration be appropriate and effective. For example, multiple countries could potentially coordinate on international GHG emission standards for passenger vehicles. Industrialized and developing countries could pool resources for research and development into cellulosic ethanol and hydrogen fuel cells. Countries could certainly share best practices on finding sustainable funding for sustainable transportation, integrated land use planning, intermodal freight alternatives and high-speed passenger rail networks.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Chapter Six
Conclusions and Recommendations

Introduction

In considering the potential for transportation projects under the CDM, it is important to recall the dual purpose of the CDM: providing a cost effective emission reduction option for Annex 1 countries while contributing to sustainable development in host countries.[216] Research for this project and input from participants at the international workshop in August confirmed the central role transportation systems play in urban sustainability and development. A working transportation system is crucial for economic development as it provides access to jobs and recreation, enables the efficient functioning of day-to-day services of goods delivery, waste removal and emergency services. An efficient transportation system that is integrated with sustainable land use development can help to abate ongoing growth in motor vehicle travel, thereby reducing air pollution and run-off, lowering health care costs and can help optimize infrastructure expenditures.

Moving forward, careful thought and consideration are needed on whether or how the CDM can better recognize and emphasize these broader sustainability considerations, particularly those correlated with slowing growth in travel demand. The conclusions and recommendations from the case studies are presented below as a contribution toward this broader dialogue.

Bus Technology Switch Case Study

The bus case study assessed the GHG reduction potential for a technological switch from diesel to hybrid diesel-electric fuel for the feeder areas within the Transantiago plan. As discussed previously, the results of this analysis show a decrease in emissions with the technological improvements. The results also demonstrated that *as much as nine per cent of the costs associated with this technological switch could be covered by revenue from CERs*. The case study demonstrates that *it is possible to establish an acceptable methodological framework for a technical fuel switch bus project under the CDM*. It should be noted that although this technology has been tested, the literature reveals a wide range of data on performance variables. Assumptions about successful penetration of technology, technology performance and local driving conditions (drive cycle) can greatly impact the economic feasibility of undertaking a fuel switch bus project through the CDM.

The bus technology switch case study pointed to some issues that are similar to other projects in the transportation sector. Development of CDM baselines and monitoring protocol depend highly on the availability and quality of data, as well as the clarity of future planning, in any sector. In the transportation sector, a mixture of private and public data contributes to the complexity of the situation. Transportation planning takes place over multi-year time frames and often crosses numerous jurisdictions and political cycles. Strong connections between these processes and CDM project developers are necessary to develop defensible PDDs in the transportation sector. It is, therefore, possible to conclude that *large-scale, comprehensive transportation plans and data collection can contribute to baseline development and monitoring efforts*. Projects like Transantiago define the future for

216 Kyoto Protocol, Article 12.2: "The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3."

public transportation, including assumptions about penetration of new technology and municipal expansion. Working from a clear picture of what is planned in a business-as-usual scenario for transportation aids greatly in building a case for additional components that may be CDM-eligible. Flowing from this conclusion, it is recommended that the measurement of transportation use and data collection, for the purposes of CDM as well as for a host of other reasons, should be expanded and promoted.

The bus technology switch case study also highlighted another issue that is consistent among the three case studies, namely the lack of information and examples of prior methodologies in the transportation sector. It is, therefore, the recommendation of the project that further examination and development is needed for transportation methodologies in general. This point was recently supported by an input made by Mexico (with support from other countries) to a decision approved at the 10th Conference of the Parties to the UNFCCC in Buenos Aires, Argentina. The related (draft) decision calls for project participants to make proposals for new baseline and monitoring methodologies for project activities in sectors not yet covered by approved methodologies, such as *transportation*, energy efficiency and district heating. It also called for the Executive Board to "consider such proposals with priority and continue its work on elaborating consolidated methodologies for new sectors."[217]

With a number of data modifications, the methodology developed to assess emission reduction possibilities and costs for the bus case study could be used to analyze alternative technologies or other components of Transantiago. This could include different modes (e.g., taxi, local freight), geographical areas or fuels. In fact, the bus case study concludes by stating that *re-analysis using a different fuel source (other than diesel hybrid-electric), or different modes (e.g., taxis), could bring even better CO_2 reductions* than those outlined in Chapter 4a. The Transantiago program is currently exploring opportunities for expansion, while at the same time looking to build on their plan to incorporate additional CDM eligible projects. Given this, we recommend that Transantiago assess GHG reduction opportunities and CDM potential for the taxi program currently under development, as well as an additional program or regulation targeted at trucks entering the downtown core.

Recommendations:

- Measurement of transportation use and data collection, for the purposes of CDM as well as for a host of other reasons, should be expanded and promoted.
- Further examination and development is needed for transportation methodologies in general.
- Efforts to develop and strengthen transportation methodologies place emphasis on those initiatives that moderate the growth in demand for motorized travel.
- Transantiago should assess GHG reduction opportunities and CDM potential for the taxi program currently under development, as well as an additional program or regulation targeted at trucks entering the downtown core.

Bicycle Initiatives Case Study

The metropolitan region of Santiago recognizes the importance of bicycles in the development of an overall transportation plan, and is promoting this mode through the development of a new network of bicycle lanes. Two options for emissions reductions were examined through this case study: an individual bikeway and a comprehensive bicycle network.

Overall, the conclusion of the project is that *bicycle projects and policies can play an important role in advancing sustainability in Chile*. In addition to the infrastructures initiatives already underway in Santiago, it is recommended that Transantiago, CONASET and other municipal actors consider implementing a number of comprehensive policies and funding partnerships that can contribute to increasing non-motorized trips and reduce overall emissions. These include: a) promotional campaigns to improve the image of cyclists, b) land use policies to enable shorter trips suitable for bicycles, and c) adequate, secure parking facilities at inter-modal transfer points.

The second key conclusion of the project is that *bicycle projects face serious barriers to successful CDM participation*. Reasons for this include imprecise forecasting capacity for ridership and high costs involved in monitoring bicycle usage. In addition, once an accu-

217 Decision -/CP.10, para 15. "Guidance Relating to the Clean Development Mechanism."

rate number of trips is determined, assumptions about what alternative modes these trips displace (if any) and subsequent emission quantifications are uncertain at best. Although small-scale CDM rules allow for a simplified approach, the project found revenue estimates too low to make such initiatives attractive.

Given all these barriers along with the low tonnage associated with NMT projects, the third conclusion is two-part. *First, individual bikeways do not make for attractive CDM projects. Second, a comprehensive network of segregated bikeways and bike lanes may be more attractive as a CDM project* given the larger scale of the impacts and potential reduction in monitoring costs at the regional level. Based on this conclusion, it is recommended that local government conduct a feasibility assessment of the Santiago bicycle master plan as a CDM initiative. Further to this, and given the fact that only a very small portion of overall project finance will be provided through CERs, a comprehensive bike network is likely more feasible as a "unilateral" initiative. Co-financing sources (from ODA and other programming) beyond CDM that can be targeted to cover the costs of the incremental benefits gained from bicycle initiatives (e.g., health, air quality, transportation) may increase the feasibility of such a venture.

This third conclusion comes with an important caveat. *Comprehensive bicycle networks and complementary efforts such as promotional campaigns operate at the policy level, and thus may require changes to the project-oriented CDM modalities and procedures*. Therefore, the findings of the bicycle case study support those outlined in the bus study above, by recommending Parties to explore a revised version of the CDM in the second commitment period that allows for incorporation of policies, sectoral approaches, or both.

Further, this research finds that *Parties to the UNFCCC process should work to incorporate consideration of non-motorized sources of transportation, as well as efforts to reduce motorized transportation demand, in development of a future CDM-type mechanism post-2012*. Improved non-motorized travel data could contribute to strengthening this conclusion by reducing monitoring costs and assisting with baseline development. Data enhancements could also improve planning and implementation of NMT policies independent of CDM.

Recommendations

- Host country transportation authorities should explore co-financing sources and build capacity for unilateral projects.
- Transantiago, CONASET and other municipal actors should continue pursuing comprehensive policies to increase non-motorized trips and reduce overall emissions (e.g., promotion, parking, land use).
- NMT data collection should be improved with assistance from international funding in order to foster sustainable transportation solutions and strengthen monitoring potential for involvement in CDM.
- Santiago should conduct a feasibility assessment of the Santiago master bicycle plan as a potential CDM initiative.
- Parties (to the UNFCCC) should incorporate consideration of non-motorized sources of transportation, as well as efforts to reduce transportation demand, in development of a future CDM-type mechanism post-2012.
- Parties should explore a revised version of the CDM in the second commitment period that allows for policy or sectoral approaches, or both.

Location Efficiency Case Study

The rapid urban expansion currently taking place in Santiago and other developing country urban centres has important implications for transportation infrastructure provision and air quality. The "location efficiency" concept rests on the premise that *influencing urban growth patterns will have an important long-term impact on travel demand and GHG emissions*.

Research undertaken through this and other projects have concluded that *land use plays a fundamental role in influencing travel behaviour* (particularly trip distances and mode choice), by determining the relative distribution of trip origins and destinations as well as influencing the relative attractiveness of different modes. Land use patterns and urban form influence travel demand at three different spatial scales: the metropolitan (city size), the intra-metropolitan (relative location), and local/neighbourhood (urban design). The first two levels of effects can be more easily detected than the third. At all levels, considerable uncertainty exists in predicting the ultimate potential influence of land use changes on travel behaviour and GHG emissions.

Given the relationship between land use, travel behaviour and ultimately GHG emissions, it should follow that international agencies, CDM project developers, or others interested in GHG emissions reductions would benefit from a thorough assessment of the true potential of changes in land development patterns to influence travel demand, GHG emissions and local quality-of-life concerns in the developing world. The long history of experiences in the industrialized world (e.g., Netherlands, Japan, U.S.) and some developing countries offers room for both hope and scepticism, not only in terms of the total degree of influence, but whether or not viable policy mechanisms exist.

More work is needed as well in determining what types of analytical tools are acceptable for predicting effects, how project "boundaries" can be adequately defined, and whether alternatives to large-scale integrated models might be appropriate (particularly in places with little available data).

In the case of Santiago, fairly detailed and updated travel survey and land use data exist. Nonetheless, we conclude that *estimating a fully integrated land use and transportation model remains constrained by lack of information* on future transportation projects and their relevant behavioural influences.

The initial analysis for the Santiago case suggests large-scale GHG reductions may be possible through changes in land use patterns, but the scale of the interventions in some of the scenarios are unrealistic. At least one scenario *appears to achieve results compatible with implementation at current CER market rates, although more detailed modelling would likely be required.*

Findings from the project conclude that *specifying and estimating a theoretically consistent model is possible, but it is not clear how much time and resources would be required to develop a comprehensive model* that accounts for all the influencing factors (e.g., trip chaining, off-peak and weekend travel) and entire system (e.g., commercial/freight travel). It might be possible to forego some of the detailed modelling if broad-brush strategies can be mapped out and sectoral-type commitments made, with detailed monitoring and verification.

Building on this conclusion, we recommend a number of actions. First, efforts must be focussed on developing enhanced analytical capacities to understand the range of relevant effects of travel. This should include detailed examinations of the possible neighbourhood-level (micro) effects of transportation options. Part of this process is better understanding the role of attitudes and people's choices in determining outcomes, and assessing whether these are fundamental drivers of change (as opposed to land use, per se). Influencing behaviour and attitudes may be as important as altering urban forms to affect a change in behaviour.

Second, the EB and the CDM community should promote dialogue with project developers to build a better understanding of what level of modelling detail/sophistication is necessary for demand-side projects. For example, do considerably more effort, resources and data significantly improve predictive power, or can a more simplified but acceptable approach be found? Practitioners will need to establish accepted approaches/protocols for monitoring and verification, such as stratified sampling. To support these activities, it is critical to establish a consistent revenue stream to fund an otherwise oft-neglected area of need: updated origin-destination surveys and related data.

Third, "CDM-friendly" sustainable transportation efforts must be put into practice at the local level. Transportation and urban planners must create an appropriate framework and techniques for identifying and quantifying co-benefits, including accessibility benefits, local pollution reduction, etc. Planners and policy-makers also need to establish a set of feasibility and policy constraints in order to produce more sustainable land use patterns. Included in these criteria should be an identification of an acceptable pace of change and a clear vision of the political and institutional implications.

Capturing long-term benefits poses an analytical challenge. The question of how far into the future can we trust forecasting techniques is a difficult one to answer. In addition, the CDM creates specific challenges in terms of limited project timeframes. The lack of centralized and coordinated transportation planning authority may be the greatest single stumbling block in the case of the CDM. Irrespective of the approach taken, (e.g., the detailed modelling approach to predict effects, or the voluntary sectoral target approach) some empowered and accountable authority (over relevant sectors such as land use, infrastructure and transportation) most likely must exist for the CDM model to function for location efficiency. Few, if any, examples of such an authority can be found today.

Broadly, there is a need to develop alternative approaches to forecast effects (from detailed integrated modelling to more broad-brush visioning and participatory exercises) across cities of different types (size, data availability, etc.) in order to gauge the differences in approaches and strengths and weaknesses.

Recommendations:

- Transportation planners and developing countries considering CDM could benefit from a thorough assessment of the true potential of changes in land development patterns to influence travel demand, GHG emissions and local quality-of-life concerns.
- More work is needed as well in determining what types of analytical tools are acceptable for predicting effects, how project "boundaries" can be adequately defined, and whether alternatives to large-scale integrated models might be appropriate.
- Capacity building is needed to develop enhanced analytical capacities to understand the range of relevant effects of travel.
- The EB and the CDM community should promote dialogue with project developers to build a better understanding of what level of modelling detail/sophistication is necessary for demand side projects.
- "CDM-friendly" sustainable transportation efforts, and coordinated planning efforts, must be put into practice at the local level.

Overall Project Conclusions

1. *Consideration should be given for how to promote measures that impact travel demand*, including non-motorized transportation. It is crucial that initiatives aimed at a fundamental shift in transportation emissions address vehicle purchases (i.e., fuel efficiency), fuel use (e.g., low carbon fuels) and travel behaviour (i.e., slowing the rate of growth of motorized trip-making). Although they have the potential to contribute positively to long-term sustainability goals such as motorized trip reduction, projects that specifically address transportation demand do not fit well into CDM as it is currently designed. This is in part due to uncertainty of projected impacts and difficulties monitoring change in travel behaviour. Moderating the growth in demand for motorized travel addresses the root of transportation problems and such initiatives should be considered, in part because of their multiple co-benefits, including air quality improvements, noise reduction, etc. As such, modalities and procedures should be expanded to better facilitate demand-side projects (e.g., land use, public transit). Given the low tonnage but many co-benefits of demand-side transportation projects, a unilateral approach may be more effective for projects such as bike initiatives, transit and land use.
2. The CDM can bring us only part of the way toward reducing greenhouse gas emissions from the transportation sector. *Political decisions to channel resources to land use planning, public transit, pedestrian and bicycle infrastructure are more important for long-term sustainability*. Planners and policy-makers must, then, take an integrated approach, including mainstreaming climate change considerations (both mitigation and adaptation) into transportation policy development and decision-making.
3. *A future CDM-type mechanism should incorporate sectoral and/or policy based approaches*. Research conducted in the three case studies of this project leads to the conclusion that, generally speaking, the rules will need to be modified before the CDM will facilitate transportation projects. This is, in part, due to the current low market value for CERs, and the project-based focus of the mechanism. Projects that we have examined that do fit under the CDM (such as technology switching) are often characterized by low tonnage and typically will not bridge the gap toward reducing long-term emissions growth. Projects that could potentially deliver substantial reductions by, for example, promoting location efficient development, are too complicated to capture into the required project-based framework required by the current CDM rules. A sectoral approach has the potential to reduce the "perverse incentive" that can dissuade developing countries from pursuing GHG reduction policies, and can address "leakage" concerns due to their comprehensive nature. Despite their potential impact, however, policy and sectoral

approaches can introduce uncertainty, particularly in forecasting reductions. Options for how to estimate for and monitor such initiatives should be part of a discussion of how to integrate these approaches into a future regime. One option may be to move from individual project tracking towards generalized estimations of reductions coupled with audits for performance. This change could lead to reduced costs and would open the door to more projects.

4. *One of the current limitations for transportation sector CDM is the additionality requirement*. Because of the high costs associated with transportation projects and the variety of co-benefits driving such investments, it is difficult to prove the CDM pushes many transportation projects over the margin into feasibility. In the transportation sector particularly, requiring project developers to concentrate on what can be confidently quantified leads to discounting benefits from projects that create the kind of long-term change in travel demand that the mechanism aims to promote. In addition, such restrictions lead to fewer projects being put forward for consideration. The project found agencies should integrate CDM into long-term transportation planning and explore early the option to use CDM. New approaches to additionality should be encouraged that make space for transportation system improvements.

5. Any project-based approach to emission reductions (and likely sectoral and policy approaches if and when they emerge in the future) necessitate measurement of indicators (emissions, trips, mode share) against a business-as-usual projection. This measurement requires a clear vision of future transportation plans and their possible related emissions. Therefore, *local processes that clarify transportation plans for the future, such as Transantiago, contribute to facilitating CDM participation*.

Closing Remarks

Policy-makers in developing countries such as Chile face the challenge of directing their country's transportation systems to meet the demand generated by population and economic growth without compromising human health and environmental quality. Achieving the ultimate goal of a sustainable transportation system will require in-depth analyses of policy options to promote technology improvements, fuel switching, development of sound transportation infrastructure, and effective land-use planning, as well as the commitment of considerable financial resources. For the CDM to meaningfully contribute to reducing global transportation sector emissions, it must effectively encompass the range of potentially viable options, including technological solutions, demand management strategies, as well as policy-based and sectoral approaches.

Slowing Growth in Travel Demand

Reducing length and number of trips is a key issue for the future relevance of the CDM. Technology projects that focus on vehicle efficiency and fuel carbon content do not address the full transportation picture —fundamental change in transportation emissions requires policies and measures to slow growth in travel demand. Enhanced public transportation and more efficient land use development patterns can have very significant implications for travel-related emissions at the regional and neighbourhood levels; this is primarily a "behavioural" change, not a technological one.

International assistance through ODA, development banks or the CDM can kick-start reform but local governments need to set overall goals for more sustainable transportation. Long-term sustainability solutions are only politically viable if they are accompanied by tangible short-term benefits. Metropolitan "visioning" processes can be a powerful tool to educate leaders and arm them with the information needed to champion implementation. Further, allowing for policy-based or sectoral CDM could better accommodate structural changes such as comprehensive transit and land use strategies, fuel economy standards and renewable fuel standards.

Policy-Based and Sectoral Approaches

Transportation sector emissions come from many small sources, i.e., individual vehicles. Project impacts will be minimal unless many vehicles, litres of fuel or passengers are affected. The CDM was designed to address specific projects with quantifiable and verifiable GHG reductions. Yet, this project-based approach may miss many important transportation emissions reductions opportunities.

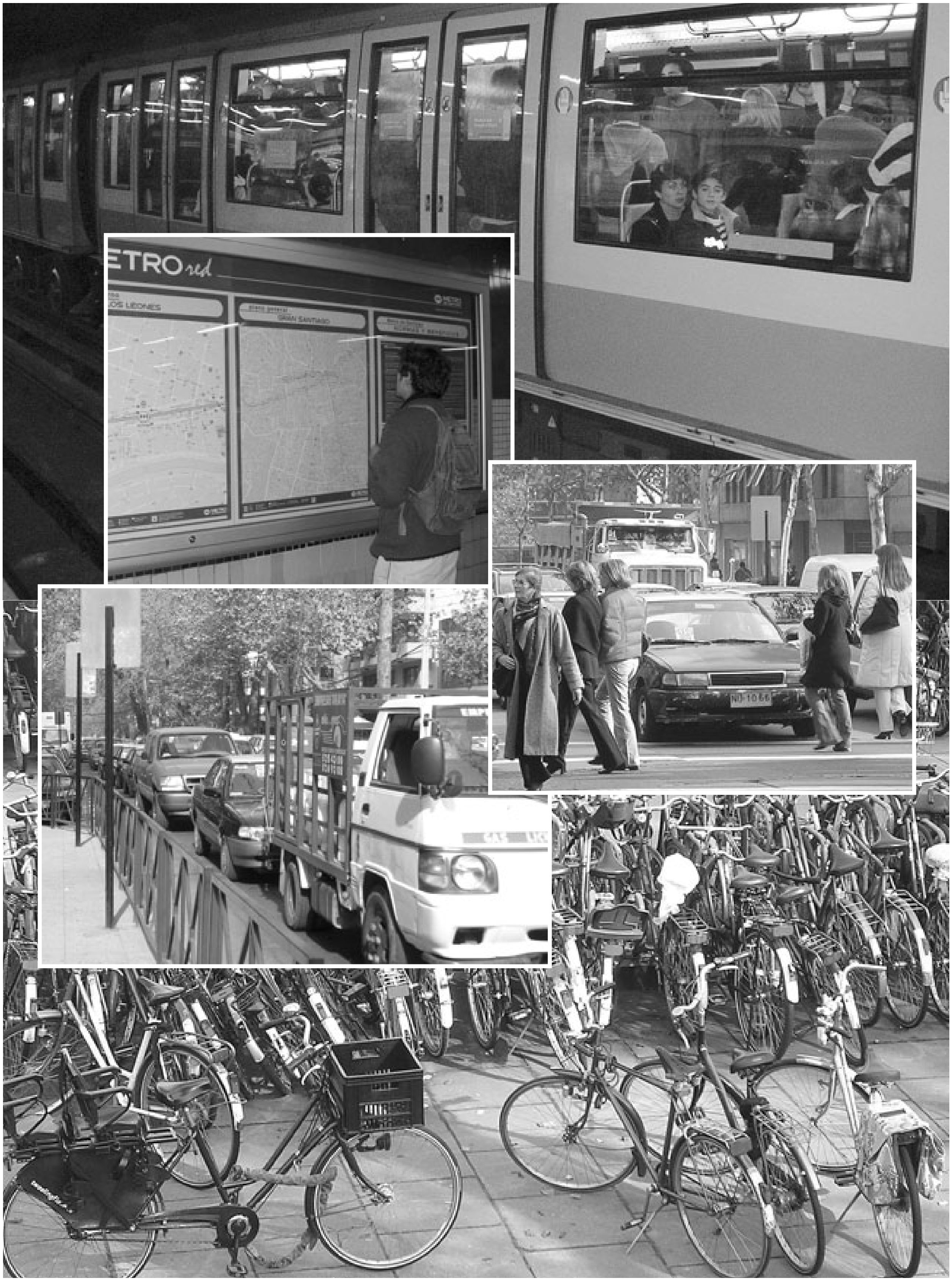
Sector-based approaches have the potential to achieve major GHG reductions and reverse the "perverse incentive" that can dissuade developing countries from pursuing GHG reduction policies. Sectoral approaches can also reduce emissions "leakage" concerns due to their comprehensive nature. For example, under the current, project-based approach, a country could generate CERs for a project that reduces emissions (e.g., bus rapid transit), while at the same time pursuing projects and policies that increase emissions (e.g., suburban road building).

Looking Forward

It is important to recognize the high opportunity costs of delayed investment in sustainable transportation. Given the rapid growth in car ownership and use, planning early for transportation alternatives is critical. Current infrastructure, investment and development decisions have a major impact on future emissions and implementing sustainable solutions now can advance multiple public goals and offer many other co-benefits including improvement in air quality, health and congestion. These changes, however, will require deliberate planning, investment, and political will; the CDM can only play a small part in a larger framework of planning for sustainable development.

Advancing local sustainable development goals while reducing global GHG emissions are the ultimate objectives of the CDM. As Annex 1 countries work toward reductions for the first commitment period, negotiations are currently underway for post-2012. The CDM framework for this period must give greater consideration to transportation sector emissions and provide sustainable development incentives for developing countries. Allowing for policy-based or sectoral CDM post-2012 will open the door to many more emission reduction opportunities. International assistance through ODA, development banks, and other funding agencies and programs, must join with local leadership to achieve this common goal.

With concerted effort to incorporate the sector-specific issues identified throughout this report, reductions in emissions from transportation have the potential to play an integral role in a comprehensive approach to climate change, in both developing and developed countries.



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Appendix A: Steering Committee

Primary Members

Transantiago

MINVU

SECTRA

CONASET

CONAMA

MOPTT

Consultative Members

Ciudad Viva

Cyclistas Furiosas

Appendix B: Initial Project Ideas and Case Study Selection

Phase One

The purpose of this phase was to develop an initial list of potential transportation sector projects that could potentially qualify under the CDM based on literature findings, an analysis of Chile's transportation sector and review of projects currently in the CDM pipeline. The project analyzed Chile's transportation sector including the current condition of the transportation infrastructure, technologies and fuels in use, governmental transportation policies, ridership behaviour and projected growth in demand. While this analysis examined country-wide conditions, it mainly focused on the Santiago Metropolitan Area. As part of this analysis, the project team applied its knowledge of key technical resources to evaluate the GHG mitigation potential, air quality and health impacts from changes in transportation technologies, fuels, policies and practices.

The list of initial project ideas included:

- airport efficiency;
- bike lane development;
- bus technology switch;
- bus upgrade fund;
- busway electrification (trolleys);
- dedicated bus transit lane;
- freight;
- light rail expansion;
- location efficient urban development;
- maintenance changes;
- Melitrén;
- passenger fuel efficiency;
- school location;
- signal control;
- surviving roads; and
- vehicle air conditioning emissions.

Below is a brief description of those dropped in the first phase.

Airport Efficiency: The project idea would have assessed GHG reduction opportunities from airport operations, ground service equipment and passenger ground transportation to/from the airport. The Steering Committee did not choose this project for further exploration.

Bus Upgrade Fund: This project concept involved developing a fund of money to fund bus retrofits or replacements with the aim of reducing GHG emissions. This fund could potentially be set up as a revolving loan, financed in part by a CDM investor or by the Chilean government directly. The Steering Committee did not select this project for further exploration, partially due to its complicated baseline and additionality issues.

Dedicated bus transit lane: Independencia – Recoletta: Given that the planned metro extension will not cover the full service area envisioned in the light rail plan, there is still need for additional transit service in the northern neighbourhoods of Santiago. This analysis examined the potential GHG reduction from establishing a segregated bus lane in a 37 km roadway being built underneath the Rio Mapocho through the *comunas* of Bella Vista and Providencia. The Steering Committee did not identify this project as a priority.

Freight: In collaboration with EFE (Empresa de los Ferrocarriles del Estado), the project examined the use of freight trains to reduce the number of trucks transporting goods from Chile to Argentina and other destinations, thereby reducing CO_2 emissions. However, after initial research and discussions the project was set aside because the Steering Committee preferred to focus on issues more directly related to Santiago. In addition, high infrastructure costs were an impediment to implementation, as considerable funding would have to be leveraged from other sources.

Light Rail Expansion: This project involved the potential GHG reduction building a light rail extension from the Metro to areas further outside the city core (Independencia and Recoletta). Metro had conducted an extensive study and plan for this project, but during the course of the project. Metro decided to pursue an extension of the existing system instead of a new light rail line. The announcement of the extension affected the additionality of the project, making it no longer feasible in the context of the current CDM rules.

Maintenance: Changes Improved vehicle maintenance practices (e.g., tire inflation, low friction oils), either in freight fleets or in individual passenger cars, reduce energy use and GHG emissions. This project explored using CERs sales to fund a maintenance program. The Steering Committee did not choose this project for further exploration.

Passenger Fuel Efficiency: This project idea involved exploring technologies and policy opportunities for improving passenger vehicle efficiency. Potential policy options included regulations or incentives that could be funded through the sale of CERs. The Steering Committee did not select this project for further exploration.

Signal Control: Changes to signal timing at intersections in Santiago could improve vehicle flow and potentially reduce energy use and GHG emissions by reducing idling and start-and-stop driving. Significant improvements have already been made in Santiago, so it is important to consider what the next level of optimitization would bring. This project was a high priority for some Steering Committee members but in the end, the Committee decided to focus limited resources on other initiatives.

"Surviving Roads": In response to plans to construct the *Costanera Norte* highway, stakeholders suggested the "surviving roads," from which traffic will be diverted once the new highway is completed, be re-developed into promenade-type streets. These streets, namely *Bella Vista* and *Conquistador*, could be transformed to include additional pedestrian-friendly aspects including segregated busways and bike lanes. This project was relegated to lower priority by the Steering Committee in place of bike lane development. Lessons learned from bike lane projects were considered more replicable in other cities.

Vehicle Air Conditioning Emissions: This project involved reduction of emissions from vehicles by encouraging limited use of air conditioning. Vehicles with air conditioning consume more fuel as the units demand considerable power to run. The Steering Committee did not select this project for further exploration.

Phase Two

In the second phase, project participants, in collaboration with the steering committee, evaluated and narrowed down the list. This evaluation process was based on a criteria matrix[218] that was developed by the project team. The criteria were based on local relevance and technical CDM considerations and were grouped into two different levels: Primary and Secondary.

Primary Criteria

The characteristics identified as primary criteria are considered the basic elements necessary to begin considering the project for further analysis. They include: 1) Sustainable Development Impact (i.e., does the project idea contribute to sustainable development priorities as defined by Chile?); 2) Cost Effectiveness (i.e., is the project idea cost effective?) and; 3) CDM Eligibility (i.e., is the project financially and environmentally additional?). For the project idea to pass to the secondary level of evaluation the answer to all three of these had to be positive.

Secondary Criteria

The secondary criteria, while not necessarily as stringent, were still important factors in the decision process. The secondary criteria included: greenhouse gas reduction potential; local benefits (positive health/environmental impacts); replicability (possibilities for local, national and international replicabil-

218 The Criteria matrix is available on the project Web site: http://www.iisd.org/climate/south/ctp.asp

ity) and finally, feasibility (in regards to ease of implementation).

Six project ideas scored the highest and were chosen for further development including:

- bike lane development;
- busway electrification (trolleys);
- bus technology switch;
- location efficient urban development;
- Melitrén; and
- school location.

Phase Three

This third phase involved drafting briefs for the six chosen project ideas. These briefs were presented to the steering committee for review and three final case study topics were selected for further development.[219] Below is a short description of the three that were not selected for further investigation.

Melitrén – This project idea explored the potential for development of the Melitrén, an inter-urban train line running 60 km from the center of Santiago to the neighbouring town of Melipilla. The light rail line would relieve congestion in the urban area by reducing car and bus trips in and out of Santiago, thereby making travel more reliable and improving the quality of life of passengers. The project plan was to assess the impacts of Melitrén service on travel behaviour in the affected corridor and estimate subsequent effects on GHG emissions. The CDM could be used to partially fund the project in order to reduce the need for public and private investment. This project idea was set aside based on initial investigations into the high infrastructure costs associated with the project development of rail. In addition, the environmental benefits were uncertain, as many new rail trips might be shifted from clean technology buses.

School Location – According to the GEF, an estimated 35 per cent of trips in Santiago are related to getting students to and from school. In fact, according to the 2001 O-D survey almost three million trips per workday can be attributed to the movement of students. The distance between popular and well respected urban schools in Santiago and the neighbourhoods of their students has increasingly contributed to on-peak traffic volume in the city. The demand for this type of transportation has been increasing substantially as Santiago expands and the need for private schooling increases. The demand for transport for children from suburban areas to central urban schools has been filled either by parents or transportation services run by private individuals. The school location project idea centered on channelling a subsidy (based on sale of CDM credits from displaced student commuters) toward development of a school or schools located in the neighbourhoods where the commuting students live. The government could offer the subsidy upfront and recover the price for the costs later. Additionally, the subsidy from the CERs could be supplemented by funds from other government departments (health, etc.) after other benefits have been measured and accounted for. This project idea was set aside based on fact that the GEF project (at the time of consideration) was undertaking an extensive study on the issue of school location and impacts on transportation demand.

Busway Electrification – At the request of the Steering Committee in November 2002, the project team studied the costs and benefits of the electrification of a busway, or “troncal” in Santiago. The goal of this study was to determine, through quantitative and qualitative analysis, whether a trolley system in Santiago would be an economically viable way for the city to not only reduce its GHG emissions but also to improve its air quality and provide an efficient means of public transportation. The study concluded that electrification of a troncal for a trolley system is not a cost-effective method to reduce GHG emissions.

Phase Four

The final phase of this process involved developing the three remaining project ideas into comprehensive case studies. The three chosen project ideas were:

> *Bus Technology Switch* – This analysis examined the potential GHG benefits that could be gained from a technological switch of buses (e.g., diesel to hybrid diesel-electric), within a newly structured bus system under development in Santiago, given current CDM guidelines. The methodologies for this study are uniquely tied to the new system-wide Transantiago plan and, with that in mind, the team worked closely with Transantiago

219 The six project idea briefs are posted on the project Web site: http://www.iisd.org/climate/global/ctp.asp

as well as the private sector, who in the end will be implementing the new technologies.

Bicycle Prioritization – This analysis examined the methodological challenges involved in baseline, measuring and monitoring emissions reductions from potential new bicycle lanes, as well as from complementary policies such as bicycle storage and encouragement of a shift from other transportation modes. For this study, the project team worked closely with both CONASET and the NGO community in Santiago.

Location Efficiency – This analysis examined the GHG impacts from particular land development strategies aimed at reducing travel demand and the potential use of the CDM to attract financial resources to this type of "location efficient" urban development. The ultimate goal of this case study was to: identify specific real estate development opportunities; quantify the travel behaviour impacts of those developments; estimate the net impacts on transportation greenhouse gas emissions of the developments if they were to be realized; and, identify potential avenues for CDM investment.

Getting on Track: Finding a Path for Transportation in the CDM

The Clean Development Mechanism (CDM) established under the Kyoto Protocol provides a unique opportunity for implementing projects in developing countries that reduce greenhouse gas emissions and promote sustainable development. As a leading source of greenhouse gas emissions, the transportation sector could play a central role in the CDM and in addressing climate change.

By delving into the key questions of the CDM within the context of the transportation sector of Chile, including project baseline, additionality, methodology, monitoring and leakage, the case studies presented in this report shed light on how a range of transportation projects fit within the current CDM. The report also examines how such projects could be better facilitated in the future, and where other policy approaches may be appropriate. Taking the lessons learned from these case studies and outcomes of an international workshop held in Chile, the report presents conclusions regarding how transportation projects currently fit into the CDM framework and potential changes for post 2012.

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