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Integration of short-lived climate pollutants in World Bank activities

A Report Prepared at the Request of the G8

June 2013

THE WORLD BANK

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Abbreviations and Acronyms

AAA	Analytic and Advisory Activities
AFR	(Sub-Saharan) Africa
BAU	business as usual
BC	black carbon
BRT	bus rapid transit
CCAC	Climate and Clean Air Coalition
CFC	chlorofluorocarbon
CIF	Climate Investment Funds
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CTF	Clean Technology Fund
DPL/DPO	Development Policy Lending/Operations
EAP	East Asia and Pacific
EBRD	European Bank for Reconstruction and Development
ECA	Europe and Central Asia
FIP	Forest Investment Program
FY	Fiscal Year
GAA	Global Agenda for Action
GEF	Global Environment Facility
GGFR	Global Gas Flaring Reduction
GHG	greenhouse gas
GWP	global warming potential
HDV	heavy-duty vehicles
HFC	hydrofluorocarbons
IBRD	International Bank for Reconstruction and Development
IDA	International Development Assistance
IEG	Independent Evaluation Group
IPCC	Intergovernmental Panel on Climate Change
LAC	Latin America and Caribbean
LOSA	Line-Of-Sight Attenuation
LPG	liquefied petroleum gas
MDB	Multilateral Development Bank
MNA	Middle East and North Africa
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MP	Montreal Protocol
MRT	metro rail transit
MSW	municipal solid waste
MT	metric tonnes
OC	organic carbon
ODS	ozone depleting substances
OORG	Ozone Operations Research Group
PM	particulate matter
PMR	Partnership for Market Readiness
PPCR	Pilot Program for Climate Resilience
REDD	Reducing Emissions from Deforestation and Forest Degradation
SAR	South Asia Region
SLCP	short-lived climate pollutants
SREP	Scaling Up Renewable Energy Program in low income countries
TWC	three-way catalysts
USEPA	U. S. Environmental Protection Agency

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Executive Summary

1. As a development institution focused on reducing poverty and boosting shared prosperity, the World Bank is working in many countries that suffer from a lack of basic services such as waste management, transportation, and access to modern energy. Addressing these development challenges often has an impact on the emission of short-lived climate pollutants (SLCPs)—among them methane and tropospheric ozone, black carbon (BC), and hydrofluorocarbons (HFCs). While the development benefits are the primary focus of the World Bank's support to these projects, they also provide an opportunity to realize climate benefits as well as air quality, health, and agricultural co-benefits, by reducing SLCP emissions.
2. The World Bank report *Turn Down The Heat* presents evidence that the world could be 4°C warmer this century with catastrophic consequences, especially for the poor and most vulnerable. Recent scientific evidence suggests that reducing the emissions of SLCPs in tandem with efforts to reduce carbon dioxide emissions is likely to slow the rate of global warming over the next two to four decades.
3. Apart from the potential global benefit of changing the trajectory of surface warming, addressing SLCPs offers several tangible local benefits. The United Nations Environment Programme (UNEP) estimates that fast action to reduce SLCP emissions could avoid an estimated 2.4 million premature deaths from outdoor air pollution annually by 2030 and avoid over 30 million tonnes of crop loss per year (UNEP 2011a). The recent *Global Burden of Disease* report estimates that in 2010 there were 4 million premature deaths from indoor smoke from solid fuels and another 3 million deaths from urban air pollution (Lim et al. 2012). Both forms of air pollution include black carbon as one of the pollutants.
4. Depending on the relative cost-effectiveness compared to other measures, actions to reduce SLCPs may bring additional development gains for the World Bank's clients while delivering global climate benefits at the same time. For example, the concentrations of black carbon on Tibetan glaciers have increased two- to three-fold relative to the concentrations in 1975, suggesting a role in the acceleration in glacial melt in that region (Xu et al. 2009), which presents challenges to water resources management.
5. A 2011 synthesis report by UNEP identified a suite of 16 measures that reduce methane and black carbon emissions and that could deliver more than 90 percent of the global benefit of about 2,000 measures modeled. The 16 measures were estimated to lead to global cooling of approximately 0.4–0.5°C by 2040–2050. Of this range, about 0.2-0.3°C is due to methane emission reduction[1] (UNEP/WMO 2011a; Shindell et al. 2012). These measures and additional approaches to HFC reduction served as the starting point for a review of the World Bank's portfolio to identify and highlight potential opportunities and activities that could reduce SLCP emissions.
6. This review of the World Bank's portfolio highlights the efficacy of integrating SLCP mitigation in development projects. Over the six-year period of the review (FY2007–2012), 7.7 percent of IBRD/IDA[2] commitments (approximately US$18 billion[3]) were on SLCP-relevant[4] activities in energy, transport, roads, agriculture, forestry, and urban waste and wastewater. Going forward, the goal will be to transform as much of the SLCP-relevant activities as possible into SLCP-reducing activities. Specific commitments for the World Bank on SLCP-reducing activities will be articulated

[1] While methane represents 60% of the climate benefit, as calculated in Shindell et al. (2012), BC represents 98% of the human health benefits and 92% of the monetized value.

[2] This stands for International Bank for Reconstruction and Development/ International Development Agency, which are part of the World Bank Group.

[3] All dollar amounts are U.S. dollars unless otherwise indicated.

[4] SLCP-relevant activities are defined as those World Bank activities with the potential to reduce emissions. For example, in the energy sector, a gas flare reduction project is SLCP relevant while a power transmission project is not considered SLCP relevant.

as part of the climate action planning process which is expected to conclude in 2014.

7. SLCP-relevant activities vary across the World Bank's six regions, driven by development priorities of the Bank's operational regions and client countries. Activities relevant to rural development, such as rice irrigation, are more prominent in Sub-Saharan Africa and South Asia. In contrast, activities aimed at urban settlements, such as wastewater treatment and transport systems, are more common in the Latin America and the Caribbean region and the Europe and Central Asia region. The East Asia and Pacific region, which has a mix of countries of varying income levels, shows a blend of rural and urban activities.
8. Based on the volume of lending, the World Bank's portfolio review shows SLCP reduction potential in investments across a range of activities such as bus and rail-based transport systems (which reduce BC emissions and have strong, local public health co-benefits), solid waste collection and disposal (which reduce methane emissions), cookstoves and kilns (which reduce black carbon), and rice irrigation and wastewater management (which impact methane emissions and have global benefits to agricultural productivity and health). Realizing the full potential for SLCP reduction will require addressing a number of barriers, and mainstreaming at all levels of engagement—from strategies (for example, Country Partnership Strategies) to policy support (for example, Development Policy Operations) and in investment lending operations.
9. In selecting which of the opportunities represent optimal mitigation strategies, it is critical to consider the full suite of factors that determine the extent of service delivery, health, climate, and other development benefits for a given investment in the context of the World Bank's overarching objective of reducing poverty and boosting shared prosperity. There could be trade-offs among these different objectives and a number of factors need to be considered when taking development decisions, including

Sixteen measures that reduce methane and black carbon emissions could:

0.4

Degrees Celsius

*…**reduce** global warming by approximately 0.4-0.5°C by 2040-50.*

2.4

Million Premature Deaths

*…**avoid** an estimated 2.4 million premature deaths from outdoor air pollution annually by 2030.*

30

Million Metric Tonnes of Crop Losses

*…**avoid** annual losses from four major crops of more than 30 million metric tonnes.*

Source: UNEP 2011a and b

the opportunity cost of proposed interventions, the financial and institutional capacity of the stakeholders affected, and the location of emissions.

10. These observations call for strengthening the analytical basis for action on SLCPs. For methane and HFCs, the Bank will introduce emissions accounting over FY14–15. Assuming that adequate budget will be allocated, the Bank will also initiate work on developing and piloting methodologies to account for BC emissions. To better integrate actions that address SLCP emissions and climate benefits at the project level, it is proposed that a comprehensive economic analysis framework be developed that accounts for all the local and global benefits that projects provide due to SLCP emission reductions. Subject to funding, this would be undertaken in tandem with methodology development for BC emissions accounting, since the local benefits for health are driven by reducing BC emissions. Furthermore, it is proposed that the World Bank develop methodologies and train staff in the use of tools for SLCP accounting and economic evaluation that incorporate local and global externalities (health impacts in particular), and multiple-development benefits into the economic analysis of projects to facilitate the integration of SLCP reduction in the World Bank's portfolio.

11. The forthcoming World Bank Climate Action Plan is expected to provide a timetable for implementation of full SLCP accounting and economic evaluation with a focus on multiple development and climate benefits. It is also expected to provide a timeline to track the financing of SLCP-reducing activities at the World Bank. Under the umbrella of the Climate Action Plan, the World Bank proposes to work with multilateral development banks (MDBs) to explore options to extend the harmonized systems for climate finance tracking and GHG accounting to include SLCP reduction (based on the interest of other MDBs).

12. SLCP-reducing activities could also be scaled up in the World Bank's portfolio by raising client and staff awareness of SLCPs and their reduction benefits. Innovative instruments to finance the incremental costs of SLCP mitigation activities could be developed by the World Bank to provide the necessary impetus for action.

13. While SLCP reduction could reduce the rate of warming in the coming decades, over the long run, it makes only a modest contribution to climate change mitigation. As UNEP (2011a) underscores, immediate and substantial reductions of CO_2 and other long-lived GHGs are needed to avoid a 4°C warmer world. However, SLCP reduction can deliver significant local development benefits, particularly for human health, which provides a strong impetus for taking early action.

1 Introduction

1.1 Background

1. In May 2012, the Group of Eight (G8) industrialized member nations commissioned the World Bank "...to prepare a report on ways to integrate reduction of near-term climate pollution into their activities and ask the World Bank to bring together experts from interested countries to evaluate new approaches to financing projects to reduce methane, including through pay-for-performance mechanisms."
2. World Bank lending operations actively contribute to the sustainable development priorities of countries and advance the institution's mission of poverty reduction. Many of the activities associated with these operations also reduce short-lived climate pollutants (SLCPs), including methane (as both a direct climate forcing agent and as a precursor to tropospheric ozone), black carbon (BC), and hydrofluorocarbons (HFCs). Reductions of SLCPs can improve air quality and public health, achieve energy savings, and strengthen food security. The range of benefits associated with SLCP reduction provides a strong link with the World Bank's mandate of reducing poverty and boosting shared prosperity, as well as with the emerging focus on green growth.
3. Activities that reduce SLCPs can also yield significant climate benefits (see Box 1). As society's scientific understanding of global climate change evolves, it has come to understand that emissions of these SLCPs may be responsible for more than 30 percent of current global warming (Intergovernmental Panel on Climate Change [IPCC] 2007). Hence, their reduction could slow the rate of global warming over the next two to four decades as the world addresses the longer-term problem of carbon dioxide (CO_2) emissions and transitions to a low-carbon economy (UNEP 2011; Shindell et al. 2012).

1.2 Objective

4. The primary focus of this assessment is to respond to the first part of the G8 request and consider ways to integrate reduction of SLCPs into World Bank activities.[5] To that end, this report examines the Bank's portfolio to assess the scale of SLCP-relevant activities—activities in which SLCPs can potentially be reduced—and opportunities to deliver those reductions and their climate benefits based on analysis of six years of lending activities. This analysis is meant to inform where SLCP reduction should be made an integral part of project planning and decision making going forward, to systematically explore emission reduction opportunities with the objective to turn emission savings into expected project benefits. The World Bank will be consulting client countries on these issues and continue engaging in outreach efforts to elevate awareness on the impacts of SLCPs. Client engagement and consultation is an important step in exploring the relationship between SLCP-relevant activities and various benefits.

Box 1: Key Messages from UNEP Assessments

Recent synthesis reports from the United Nations Environment Programme (UNEP) looked at the full range of potential benefits of reducing four main SLCPs—methane, BC, tropospheric ozone, and HFCs—and identified measures that offer a realistic opportunity to significantly reduce the rate of global warming over the next two to four decades. If fully implemented by 2030, just 16 measures that reduce methane, BC, and tropospheric ozone are estimated to do the following:

- Reduce global warming by about 0.4°C by 2040–2050.
- Avoid an estimated 2.4 million premature deaths annually from outdoor air pollution and greatly reduce impacts on health from indoor exposure.
- Avoid annual losses from four major crops of more than 30 million metric tons.

Additional measures for reducing HFC emissions are estimated to do the following:

- Avoid, by 2050, an increase of one-fifth to one-fourth of the increased radiative forcing resulting from CO_2 buildup since 2000 levels.
- Avoid locking in technologies that slowly release super greenhouse gases over time.

Sources: UNEP 2011a and b.

Note: The UNEP synthesis report was in part based on prior work (Shindell et al. 2012; UNEP/WMO 2011) that found a 0.5°C reduction by 2050.

[5] To respond to the second part of the G8 request, the World Bank is convening an expert group to review methane finance opportunities as a separate exercise.

1.3 Structure of the Report

5. This report focuses on three principal analyses and focuses on methane, BC, and HFCs, without a separate analysis of precursors for ozone other than methane. It is structured as follows:
6. **Chapter 2**—scientific and technical context for World Bank action—considers the net benefits of focusing on reductions of SLCPs from the perspective of their contribution to global climate change. This chapter highlights the multiple benefits of SLCP reduction and discusses the relevance of SLCPs from a global, regional, and local perspective. It also discusses sectors that contribute to the emissions of SLCPs and their precursors highlighting the projects that typically relate to SLCP emission sources and potential interventions that can deliver SLCP reduction and climate benefits.
7. **Chapter 3**—nexus of World Bank activities and SLCP emissions—assesses World Bank lending commitments in fiscal years 2007–2012 that offer SLCP reduction opportunities. The chapter describes the methodology and database used for the analysis, identifies the major sectors, project types, and project components associated with SLCP emissions, and lists the major SLCP-relevant activities and opportunities to reduce SLCP emissions and deliver multiple benefits within the World Bank's portfolio.
8. **Chapter 4**—roadmap for integration—presents the key steps that the World Bank could take to maximize the multiple benefits of SLCP reductions in its lending operations. The chapter discusses the economic evaluation framework and how it could be used in decision-making processes. The chapter identifies actions that may help overcome barriers to the uptake of SLCP reduction opportunities.
9. **Chapter 5**—draws on the preceding analytical discussion to summarize the findings and highlight practical next steps for harnessing the multiple benefits of SLCP reduction in World Bank activities. This chapter also includes plans for strengthening systems for accounting for SLCP emissions and using that information in economic evaluation of SLCP-relevant activities.

This analysis examines the World Bank's portfolio to assess the scale of SLCP relevant activities to inform where SLCP reduction should be made an integral part of project planning and decision making going forward.

2 Scientific and Technical Context for Action on SLCPs

10. Reducing SLCPs can help address global warming and improve development outcomes, especially human health. Climate change impacts, including the increased frequency and intensity of extreme weather events, threaten not only future poverty reduction but also the sustainability of past gains, with potentially catastrophic consequences in the long-run. In the short-run, local health costs can have even greater importance, when dense populations are exposed to high local concentrations of SLCPs. This chapter considers the net benefits of focusing on reductions of SLCPs.

2.1 Development Benefits and Costs of SLCP Reduction

11. SLCPs have shorter lifetimes in the atmosphere than CO_2. From a development perspective, the local benefits of reducing incomplete combustion of biomass and fossil fuels generally far exceeds the potential climate benefits of reducing their emissions. For example, BC from incomplete combustion of diesel in vehicles is a toxic air pollutant. Diesel exhaust is a risk factor for cardiopulmonary disease and can trigger asthma or heart attack, leading to increased hospital visits and risk of premature death (World Bank 2011a).

12. Methane is released as a fugitive emission from oil and gas production and distribution and biogas production; from agriculture including livestock and rice farming; from decomposition of municipal solid waste; and other sources like coal mines. In the atmosphere, methane leads to the formation of tropospheric ozone or smog. These pollutants can cause significant crop damage, affecting agricultural yields (UNEP 2011a).[6] HFCs are valuable synthetic chemicals for heating and cooling systems under the roughest operating conditions given their low combustion and explosive properties, but these same properties increase the global warming potential of emissions. A full list of the range of environmental, agricultural, air quality, and public health benefits associated with SLCP reduction is provided in Annex 1.

13. It should be noted—consistent with the World Bank Environment Strategy and OECD policy (World Bank 2010a; OECD 2009)—that SLCP reduction strategies and opportunities with the greatest overall benefits may not be the cheapest options. Box 2 contains information on abatement cost estimates for methane and BC, along with other non-CO_2 climate pollutants (ClimateWorks Foundation 2011). New tools are needed to comprehensively evaluate the co-benefits and additional costs to achieve the greatest overall benefit. USEPA's (2012b) *Report to Congress on Black Carbon* suggests, "selecting optimal BC mitigation measures requires taking into account the full suite of impacts and attempting to maximize co-benefits and minimize unintended consequences across all objectives (health, climate, and environment)."

2.2 Short-Lived Climate Pollution and Global Warming

14. *"The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things."*

IPCC, Fourth Assessment Report, 2007

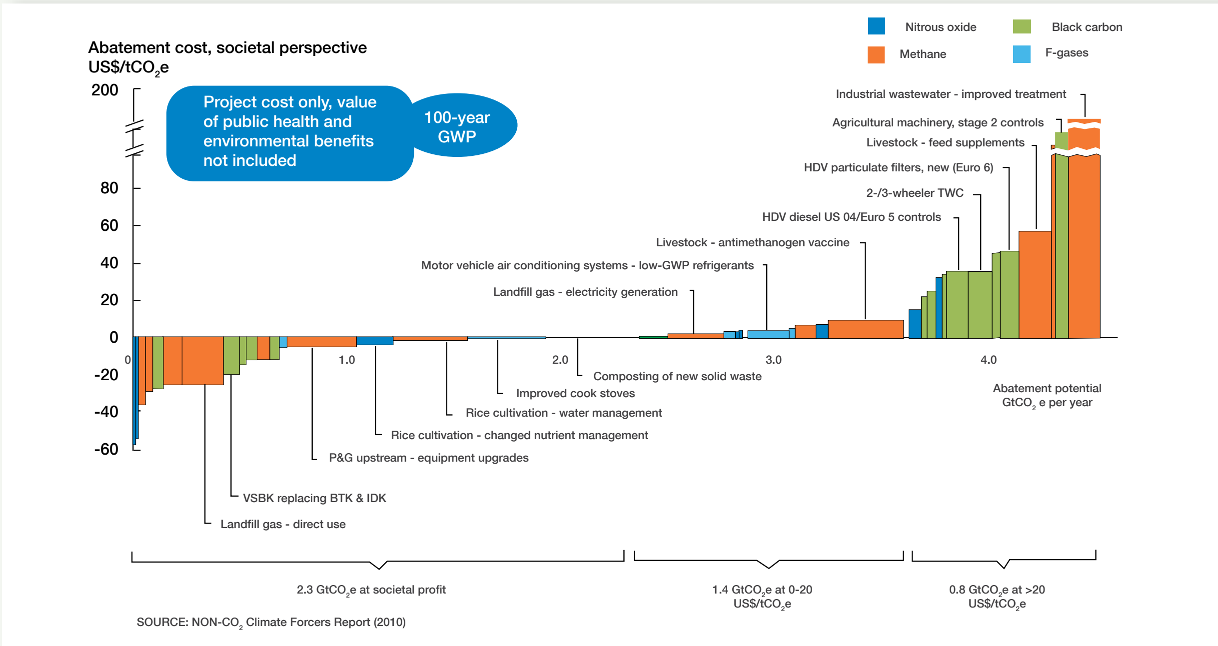
15. Despite the climate system's complexity, the scientific establishment has developed a firm understanding of the major processes operating within each component of that system. Sophisticated climate models are now able to replicate past climate trends and project interactions of the various climatic effects to yield increasingly accurate climate simulations for the future at a global and regional scale. As scientific understanding of the myriad effects of specific pollutants on climate improves, the large and dominant role played by long-lived greenhouse gas (GHG) emissions in raising global average temperature remains unchanged.

16. SLCPs—including methane,[7] BC, and some HFCs—are potent in terms of their radiative properties. However, because of their short lifetime, they have received less attention than their long-lived counterparts, which continue to warm the planet for centuries after their release. When grouped together, the Intergovernmental

[6] There is still significant uncertainty about the magnitude of crop losses based on geographical and temporal settings. For example, greater benefits will accrue in locations where more crops are grown and where ozone is reduced during transpiration. Research continues to improve atmospheric modeling of ozone concentrations and the understanding of plant exposure.

[7] While tropospheric ozone contributes to radiative forcing and is short-lived, global measures to address this pollutant are restricted to those measures that reduce methane given its dual role as both a SLCP and as the major cause of observed increases in global background levels of tropospheric ozone. Addressing tropospheric ozone in local, urban contexts often involves more complicated local chemistry and meteorology and is best dealt with through local control programs. Hence, this report follows the convention of associating global ozone measures with the SLCP methane.

Box 2: Abatement Costs for SLCP Reduction



Estimating abatement costs for measures to mitigate SLCPs requires data on project costs, economic factors, and emission reductions potential. In this portfolio review, we did not have adequate data from World Bank SLCP-relevant projects to establish abatement costs, with the exception of carbon finance operations that reduce methane. However, information on the cost-effectiveness of individual measures is available in the literature, including the UNEP synthesis report (2011a, Table 4.1), new studies such as Höglund-Isaksson (2012), and a report from the ClimateWorks Foundation (2011), which considered all non-CO_2 climate pollutants, including nitrous oxide and some longer-lived fluorinated gases.

The figure above from ClimateWorks (2011) shows that about half the interventions considered for SLCP reduction at that time could be achieved at low or no cost when taking account of only project costs (not co-benefits of lives saved or crop losses prevented) and assuming a social discount rate of 4 percent. Generally methane measures can be achieved at negative costs, while BC measures are more expensive. However, BC measures may deliver a larger short-term climate benefit and important local health and other environmental benefits.

Source: Non-CO_2 Climate Forcers Report (2010).

Panel on Climate Change (IPCC 2007) estimated that SLCPs may be responsible for more than 30 percent of overall global warming. Recent estimates put this number higher at between 40 and 45 percent of the total or higher (Molina et al. 2009; Bond et al. 2013).

17. New analyses indicate that SLCP reduction could reduce the rate of global warming over the next two to four decades as the world addresses the longer-term problem of CO_2 emission reduction and transitions to a low-carbon economy (UNEP 2011a; Shindell et al. 2012).[8] A slowdown in the rate of warming—achieved by rapid reductions of SLCPs with substantial action on CO_2 emissions—could reduce the projected global temperature increase and avoid potentially dangerous "tipping points" in important climatic systems (Molina et al. 2009). Note that there is considerable uncertainty associated with the net global climate impact of BC

[8] The Shindell et al. (2012) analysis indicates that global implementation of 14 key measures to reduce BC and methane would result in reduced warming of approximately 0.5°C by 2050.

emissions (UNEP 2011a; Shindell et al. 2012; Bond et al. 2013).

18. It is important to highlight that the near-term temperature reduction that SLCP mitigation may provide does not diminish the urgency of reducing CO_2 emissions. While SLCP reduction could slow the rate of warming in the coming decades, over the long run, it makes only a modest contribution to climate change mitigation. As UNEP (2011a) underscores, immediate and substantial reductions of CO_2 and other long-lived GHGs are needed to avoid a 4°C warmer world.

19. A detailed description of the key SLCPs (methane, BC, and HFCs), their primary climate effects, and estimates of their warming potential are provided in Annex 2.

2.3 Measures to Reduce Short-Lived Climate Pollutants

20. Some SLCP emission reduction measures have large local development benefits (such as human health and agriculture) and also deliver near-term climate benefits. These benefits—both for development goals and for the climate system—vary strongly by measure and across regions (Shindell et al. 2012).

21. SLCP reduction opportunities span the energy sector (for example, oil and gas extraction and transportation, fuel choices including biogas and biomass, supply-side and demand-side energy efficiency, cooking and heating facilities, refrigeration), agriculture (for example, agricultural and burning practices), transportation (for example, public transit, rail, freight, vehicle exhaust emissions control, and vehicle cooling), buildings (for example cooling systems, building construction and insulating materials), and waste and wastewater management (for example, solid waste and wastewater treatment).

22. UNEP's 2011 assessment of SLCP emissions analyzed the cost and technical potential of more than 2,000 control measures that reduce methane and BC emissions (UNEP 2011a).[9] Tables 1 and 2 list the key measures with the greatest reduction potential. The measures in Tables 1 and 2 may or may not be the most relevant interventions from a development perspective and thus may not be within the purview of the World Bank. As with the UNEP synthesis report, these measures serve as an appropriate basis for beginning a review of the World Bank's lending portfolio.

23. Methane abatement opportunities occur in the energy, waste management, and agriculture sectors. Black carbon emission reduction opportunities can be found in the transport, residential, industry, and agriculture sectors. A recent assessment by the USEPA (2012b) confirmed the control opportunities for BC (including those identified in UNEP 2011a). A 2013 scientific assessment of BC sources and impacts also confirms the key mitigation options (Bond et al. 2013).[10]

24. A separate UNEP assessment (UNEP 2011b) reviewed short-lived HFCs, which are considered in this report (a typology of HFC abatement options is presented in Chapter 3). International efforts to address HFC growth are gaining momentum in part because alternative technologies do, or will, exist for a number of applications. However, technically proven, commercially viable, safe, and affordable alternative technologies with low to no global warming potential (GWP) are not available in all sectors. This is particularly so for residential air conditioning which has high growth rates in developing countries.[11] The World Bank, as an implementing agency to the Multilateral Fund for the Implementation of the Montreal Protocol and for the Global Environment Facility (GEF), promotes adoption of low to no GWP, energy efficient technologies where possible as an alternative to hydrochlorofluorocarbons actively being phased out. This work seeks to help countries and industry transition to systems using HFCs with lower GWP where low to no GWP technologies are not available. These activities are carried out in combination with other program elements, such as investments in greater energy efficiency (see Box 3). The Bank is currently identifying ways to pair sound alternative technology choice with energy efficiency improvements beyond direct energy efficiency investments, to inform the design, procurement and implementation of Bank investments.

25. The location and timing of BC reduction opportunities is important (USEPA 2012b). For example, BC reduction measures may be most effective near the

[9] This assessment was based on information in the GAINS integrated assessment model (Amann et al. 2011) and accounts for the positive and negative climate forcing of BC and methane as well as co-emitted species for each measure. The model, therefore, can estimate the integrated climate benefit of each of the 2,000 measures considered to develop a ranking. The 16 measures identified account for 90 percent of the maximum reduction potential in CO_2e terms through 2030 (UNEP 2011a).

[10] The measures listed in Table 1 and 2 were selected with consideration to co-emitted species and location of emissions.

[11] Although a couple of companies have already developed HFC-free room air conditioners and started serial production, regulatory issues and charge size restrictions (limiting prototype capacities) prevents widespread deployment.

Table 1: Methane Abatement Opportunities with Climate and Air Quality Benefits by 2030

Measure	Sector
Extended premine degasification and recovery and oxidation of methane from ventilation air from coal mines	Fossil fuel production and transport
Extended recovery and utilization, rather than venting, of associated gas and improved control of unintended fugitive emission from the production of oil and natural gas	
Reduced gas leakage from long-distance transmission pipelines	
Separation and treatment of biodegradable municipal waste through recycling, composting, and anaerobic digestion as well as landfill gas collection with combustion/utilization	Waste Management
Upgrading primary wastewater treatment to secondary/tertiary treatment with gas recovery and overflow control	
Control of methane/emissions from livestock, mainly through farm-scale anaerobic digestion of manure from cattle and pigs	Agriculture
Intermittent aeration of continuously flooded rice paddies	

Source: UNEP 2011a.

Table 2: Black Carbon Abatement Opportunities with Climate and Air Quality Benefits by 2030

Measure	Sector
Standards for the reduction of pollutants from vehicles (including diesel particle filters), equivalent to those included in Euro-6/VI standards, for road and off-road vehicles	Transport
Elimination of high-emitting vehicles in road and off-road transport	
Replacing lump coal by coal briquettes in cooking and heating stoves	Residential
Pellet stoves and boilers, using fuel made from recycled wood waste or sawdust, to replace current wood burning technologies in the residential sector in industrialized countries	
Introduction of clean-burning (fan-assisted) biomass stoves for cooking and heating in developing countries	
Substitution of traditional biomass cookstoves with stoves using clean-burning fuels (liquefied petroleum gas (LPG) or biogas)[1,2]	
Replacing traditional brick kilns with vertical shaft brick kilns[3]	Industry
Replacing traditional coke ovens with modern recovery ovens	
Ban on open burning of agricultural waste[1]	Agriculture

1. Motivated in part by its effect on health and regional climate, including its impact on areas of ice and snow
2. For cookstoves, given their importance for black carbon emissions, two alternative measures are included
3. Zig-zag brick kilns would achieve comparable emission reductions to vertical-shaft brick kilns

Source: UNEP 2011a.

Himalayas, the Arctic, and other snow- and ice-covered regions.[12] The pursuit of some diesel-reduction strategies such as a focus on regulatory measures aimed at SLCP reduction could have potential trade-offs with a focus on transport investment that are beneficial for poverty reduction and growth. HFC reduction opportunities may be limited geographically by technical capacity and professional knowledge, by regulatory and enforcement systems (such as building codes), and by safety considerations or public and industry acceptance. Brick-kiln and cook stove programs are particularly relevant in Sub-Saharan Africa and Asia. Methane emissions tend to increase the hemispheric burden of background tropospheric ozone and thus do not have region-specific concerns. However, both BC and ozone have region-specific health and agricultural benefits regardless of where the reductions occur.

2.4 Uncertainty of Climate Impacts

26. All SLCPs have global warming effects, but they are seldom emitted alone, and some of the co-emitted species may have global cooling effects. This area of uncertainty is an issue primarily with BC emissions from combustion of biomass and of fossil fuels with high sulfur content. The net global warming effect of these BC emissions may be positive or negative depending on the source, co-emitted pollutants, and geography (see footnote 12). Hence, while it is easier to link BC emissions reduction to local benefits (such as reduced health impacts), in assessing climate impacts it is important to consider whether reducing SLCP emissions is expected to lead to net cooling.

27. While these scientific uncertainties present challenges to the development of a set of optimal measures to address global warming from SLCPs, tools are being developed that can estimate the multiple benefits (such as for health and agriculture) of SLCP reductions while accounting for trade-offs and synergies between co-pollutants. These tools and implementation strategies are discussed further in Chapter 4.

Box 3: Safeguarding the Ozone Layer and the Climate: the World Bank's Montreal Protocol Portfolio

The World Bank has served as an implementing agency for the Multilateral Fund for the Implementation of the Montreal Protocol (MLF) and GEF since the early 1990s. Under the MLF, over US$1 billion was approved for projects in more than 25 countries. This has resulted in the elimination of over 300,000 ODP-tons of ozone depleting substances (ODS)—more than two-thirds of the total phase-out achieved by the MLF. Through World Bank-GEF supported projects, valued at US$93 million, another 230,000 ODP-tons of ODS were eliminated from countries with economies in transition. Since ODS are also high-GWP substances, the MLF portfolio has resulted in avoided emissions of more than 1.2 GT (billion tons) of CO_2-equivalent (CO_2e) (discounting the GWP of alternatives that were introduced).

Projects approved since 2011 are also designed to avoid the introduction of HFCs where feasible. Where not feasible, less potent HFC-based formulations, HFCs with lower GWP values, or other measures are introduced to offset the impact of the gas (such as energy efficiency measures or smaller charge amounts). Through five of the six HCFC phase-out projects, it is estimated that nearly 27 million tons of CO_2e from HFCs will have been avoided annually through alternative technology choices. Two of these projects became effective in 2012 and three will become effective in 2013. In the only case where high-GWP HFCs could not be avoided, the project aims to generate a net benefit to the climate by increasing the average energy efficiency ratio of new air-conditioning units.

Note: ODP-tons = tonnes weighted by a chemical's ozone-depletion potential.

[12] The reflectivity of the surface is important because the benefit of reducing black carbon (which absorbs light and heat) can be offset by co-emitted sulfate and organic carbon (which reflects light back to space). Over bright surfaces the effect of sulfate and/or organic carbon is minimized as reflective aerosols have a similar albedo to the surface, while the effect of absorbing BC is enhanced as its contrast with the surface is larger than elsewhere.

27 Million

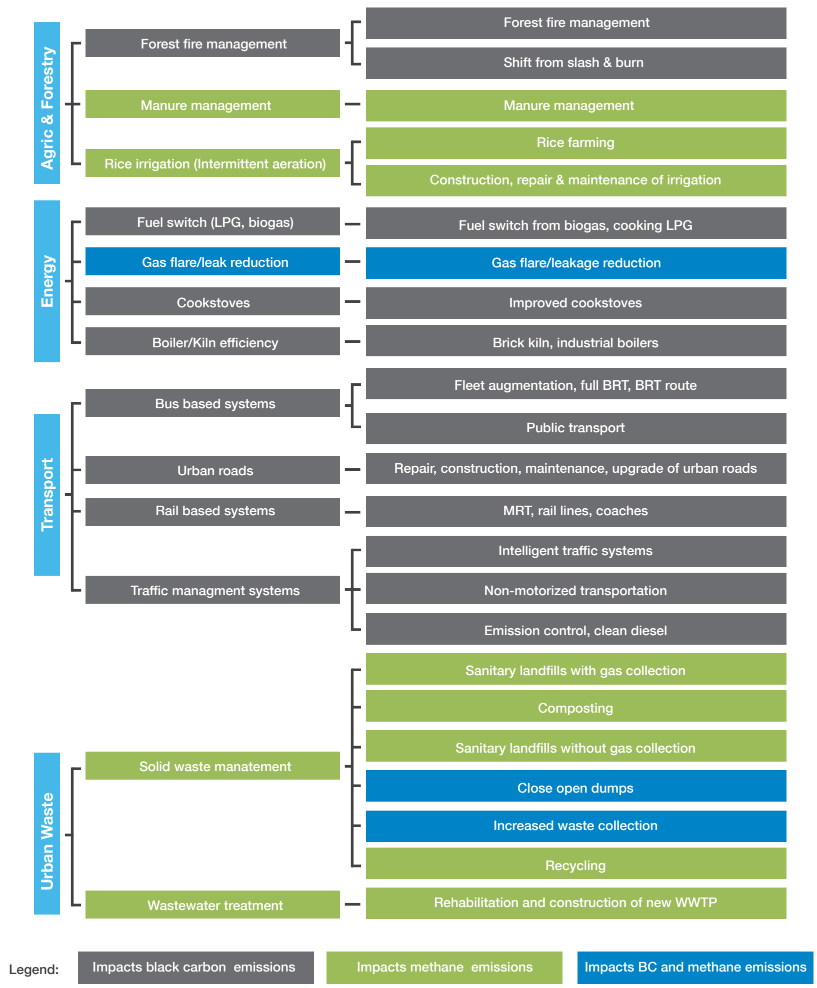
Five HCFC phase-out projects approved by the World Bank since 2011 are estimated to avoid nearly 27 million tonnes of CO_2e annually through alternative technology choices.

3 Nexus of SLCP Emissions and World Bank Activities

28. The World Bank works in many of the key activity areas that affect SLCP emissions. It provides financial support to client countries through IBRD/IDA loans, development policy operations, and dedicated climate-financing instruments, such as carbon finance, the GEF, and Climate Investment Funds (CIF).

29. As a development institution focused on reducing poverty and boosting shared prosperity, the World Bank provides assistance to countries that have not been primarily driven by SLCP concerns, except in the case of dedicated climate finance instruments (such as carbon finance for methane) or where elevated fine particulate concentrations from BC emissions pose a serious threat to public health and even economic productivity. There is, however, significant opportunity to reduce SLCPs in World Bank projects. This chapter highlights these opportunities through a portfolio review of SLCP-relevant activities over six fiscal years (FY07–12, that is, July 2006 through June 2012). It presents activities where the World Bank's IBRD/IDA portfolio has potential to contribute to SLCP emission reductions. It also presents a snapshot of the development policy support portfolio (Development Policy Operations), as well as climate finance instruments and ozone programs.

Figure 1: Aggregation of Project Activities into Typologies



3.1 Methodology and Criteria for Portfolio Selection

30. Sixteen UNEP abatement measures (Table 1 and Table 2 in Chapter 2) were used along with the known SLCP emission sources to identify sectors in the World Bank's lending portfolio that could impact SLCP emissions. Seventeen sub-sectors were identified and analyzed, covering projects in energy, agriculture and forestry, transportation, solid waste, and wastewater. The review excluded stand-alone carbon finance, Montreal Protocol, and GEF projects, but included those blended with IBRD/IDA financing. Development Policy Operations (DPOs) were included but were distinguished from investment lending projects because of their focus on policy support.

31. Based on their impact on SLCP emissions and drawing on the abatement measures in Table 1 and Table 2, initial screening identified project activities that affect SLCPs in 256 investment projects, henceforth referred to as SLCP-relevant activities.[13] During FY2007–12, the World Bank committed a total of US$233.3 billion

[13] SLCP-relevant activities are defined as those World Bank activities with the potential to reduce emissions. For example, in the energy sector, a gas flare reduction project is SLCP relevant while a power transmission project is not considered SLCP relevant.

of IBRD/IDA resources to finance 2,002 projects. The identified SLCP-relevant activities totaled approximately US$18 billion (7.7 percent of the total commitments).

Project Typology

32. The typology developed for the analysis is shown for methane and BC in Figure 1. The figure shows which activities in the transport sector can impact black carbon emissions, while activities under the wastewater and solid waste sectors have an impact on the emission of methane. The agriculture and forestry sector, together with the energy sector, impact black carbon and methane emissions.

33. A typology related to avoidance or elimination of HFCs has been developed (see Figure 2) to complement the typology of SLCP activities based on the UNEP synthesis report (2011a), which focused on methane and BC. The types of projects where HFCs can be avoided or eliminated are closely aligned with the industrial sectors traditionally covered by the Montreal Protocol, given that HFCs were developed primarily as substitutes for ozone depleting substances (ODS) in foam, refrigeration and air conditioning, fire protection, and aerosols.

Figure 2: Typology of HFC Reduction Projects within the World Bank

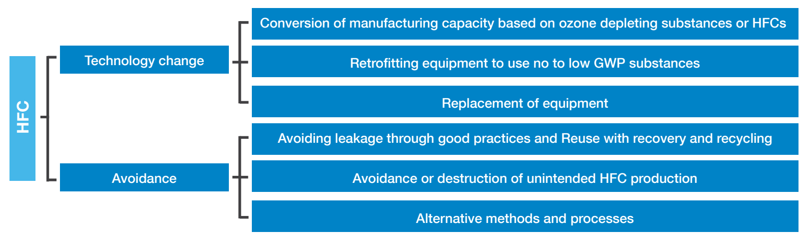


Figure 3: Regional Distribution of SLCP-relevant Projects by Typology

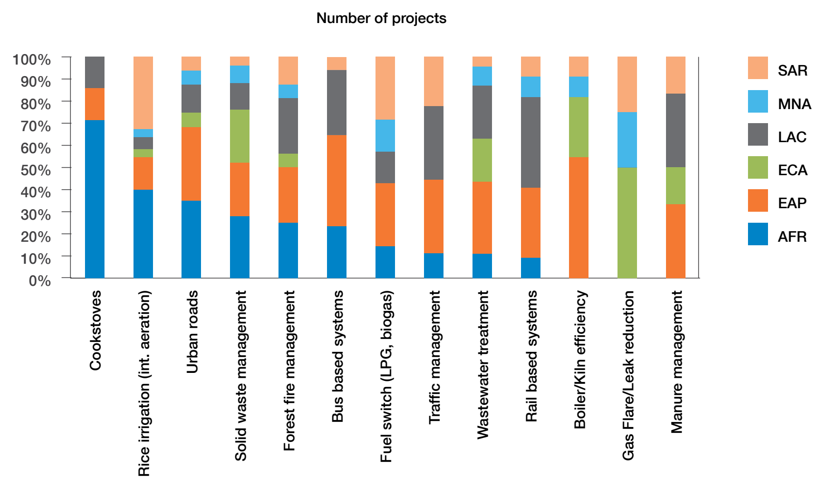
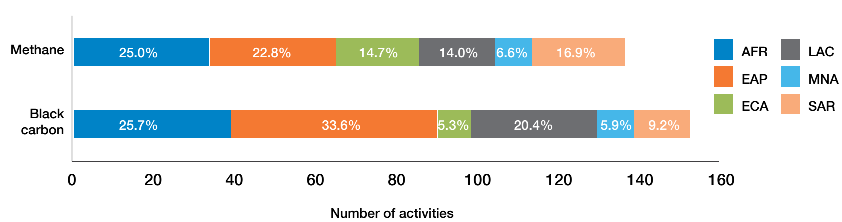


Figure 4: Regional Distribution of SLCP-relevant Potential Impacts on Methane and BC Emissions



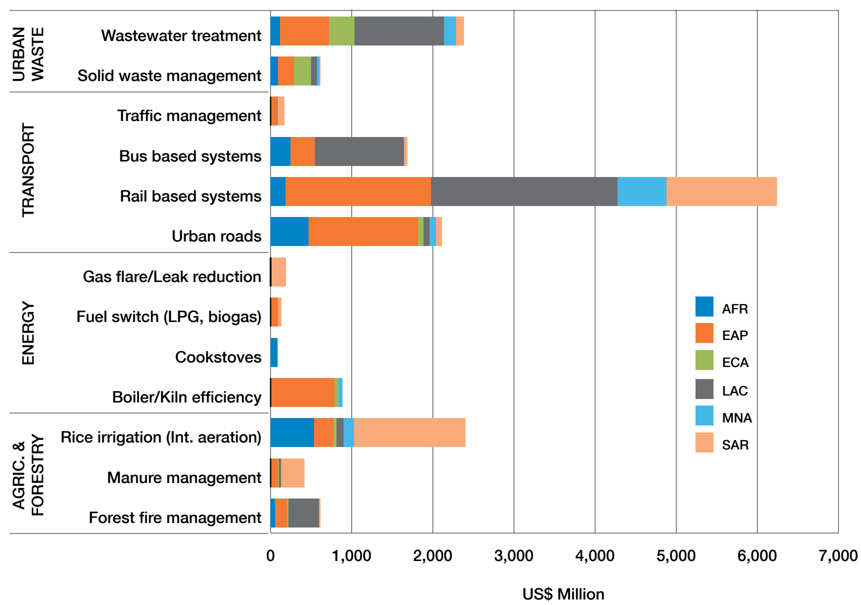
Project Portfolio

34. The regional distribution of SLCP-relevant activities tends to reflect the development needs across geographies (see Figure 3). For example, rice irrigation and cookstove projects aimed at increasing access to improved energy services are more concentrated in the Sub-Saharan Africa (AFR) and South Asia (SAR) regions. Activities aimed at improving the quality of life in urban settlements—such as wastewater treatment and rail based systems—are concentrated in the Latin America and Caribbean (LAC) and Europe and Central Asia (ECA) regions. The East Asia and Pacific (EAP) region, which has a mix of low- and middle-income countries with varying income levels, shows a blend of projects (see Annex 3).

35. Overall, there were slightly more SLCP-relevant activities with the potential to reduce black carbon than methane (Figure 4).[14] AFR and EAP together represent more than half the BC related activities, while the methane related portfolio is more evenly distributed

[14] Activities that impact both BC and methane are included under the predominant pollutant of these two.

Figure 5: Aggregation of Commitments to SLCP-relevant Project Activities Showing Regional Distribution and Number of Activities



Over six years (FY2007-12) approximately US$18 billion of IBRD/IDA commitments were on SLCP-relevant activities.

across three of the six operating regions of the World Bank (AFR, ECA, and LAC), though the majority of activities are in EAP.

36. Figure 5 shows financial commitments by project type. Rail based systems account for the largest financial commitments. LAC region has the highest commitments (US$2.3 billion) for rail based systems, followed by EAP at US$1.8 billion. Wastewater treatment projects account for major commitments in LAC and EAP. It is important to highlight that the size of financial commitments should not be considered proportional to the potential for SLCP reduction and hence should not be taken as the basis for gauging future emission reduction potential.

3.2 Potential Opportunities to Address SLCP Emissions

37. SLCP emissions are closely linked to economic development. The increase in agricultural production, in particular livestock; in oil and gas production; and in waste from households and businesses are all sources of methane emissions. Open biomass burning, residential heating and cooking, industry and transport are some of the biggest BC emitters globally. Many of these emissions tend to increase with population and income growth in the early stages of development before falling at higher income levels. Emissions from mobile sources will also rise strongly during the development process.

38. The mission of the World Bank is to reduce poverty and boost shared prosperity to further the development goals of its client countries. However, SLCP emissions can partially offset the gains in prosperity and poverty

reduction through its adverse effects on climate change and local development. SLCPs damage human health and ecosystems. Short-term and long-term exposure to particulate matter constituents such as black carbon leads to higher mortality risks, due particularly to cardiopulmonary causes, and an elevated risk of respiratory morbidity. Very high levels of exposure to fine particulate matter have led to a higher incidence of lung cancer.

39. Activities that reduce SLCP emissions in the World Bank portfolio are usually ancillary to the primary project development goals. Several case studies are used in this section to highlight the types of projects where SLCP emissions have been reduced or where there are opportunities for incremental efforts. Two case studies on non-climate benefits of SLCP emission reductions illustrate how the World Bank's core development projects can provide quantifiable multiple benefits, such as improved local air quality and public health (see Box 5).

Transportation Projects

40. Transport projects include urban transport projects, urban road projects spanning their construction, rehabilitation, maintenance, upgrading, and expansion, as well as long-distance rail projects. Project activities include passenger and freight rail, bus rapid transit (BRT) systems, metro rail transit (MRT) systems, augmentation or provision of public bus fleets, and the promotion of non-motorized transportation systems, such as bicycle routes and parking facilities.

41. Urban road project activities reduce travel time or ease intra-city traffic by rerouting intercity traffic, while others recognize the synergies between roads and other sectors, such as agriculture. Facilitating freight transport across the country is often a development objective of roads projects. Road projects can contribute to the reduction of black carbon if project activities reduce congestion and with it diesel consumption per vehicle-km due to improved traffic flows.

42. Black carbon is a subset of particulate matter, a commonly regulated air pollutant to which diesel exhaust contributes disproportionately. The local benefits of reducing particle emissions in terms of better health and productivity gains can be significant in urban areas where population exposures are high.

Box 4: Emissions from Roads

In Guangdong Province in China from 2000 to 2009, the total freight tonnage increased by more than 125 percent. According to the Chinese Ministry of Transportation, the fuel efficiency of Chinese trucks is about 30 percent lower than in advanced OECD countries. The Guangzhou Green Trucks Pilot Project (2010) demonstrated that fuel costs for long-haul trucks were decreased by 6.6 percent and for garbage trucks 18.5 percent through efficiency improvements leading to reduction in operating costs and in emissions—including black carbon (see Annex 3 for details).

43. A significant opportunity for SLCP reduction is available through addressing fleets of freight transport vehicles. The World Bank is beginning to use this opportunity for example, through green freight projects that aim to improve fuel efficiency of transport fleets and provide BC reductions as a co-benefit (see Box 4). However, green freight is not a major part of the World Bank's lending portfolio.

44. Urban transportation projects including bus rapid transit (BRT) systems, metro rail transit (MRT) systems, augmentation or provision of public bus fleets, the promotion of non-motorized transportation systems to promote a modal shift from personalized modes (cars and two-wheelers) and informal transport modes (mini-buses, vans, or trucks), to transportation systems that use less fuel and take less road space per passenger or unit of freight, ease congestion, and reduce trip length and duration. Hence they can be associated with reducing emissions of particulate matter (PM) of which black carbon is a component, and improving air quality. Estimates made for select World Bank projects show potential to reduce BC emissions and deliver significant co-benefits (Box 5).

45. To identify reduction potentials, data on emission reductions are needed not only by adjusting the portfolio composition, but the emission consequences of new project designs and new project types. Furthermore, interactions of SLCP reductions with

Box 5: Emissions from Urban Transport (Bus and Rail-based Systems) Projects

SLCP emission estimates have been made for select World Bank projects where data is more readily available. For example, the Pimpri-Chinchwad BRT project in India (approved in December 2009 with GEF support) and the Cebu BRT project in Philippines (expected to be approved in July 2013[15]) are expected to reduce BC emissions over the course of their lifetime. In Cebu, this is estimated to result in monetary savings ranging from US$94 to US$135 million in direct health costs, not taking into account the additional benefits of time savings resulting from reduced congestion and a decrease in road accidents. The Pimpri project is estimated to reduce 307 tons of PM over a 20-year lifecycle. However, if scaled up to the national level, it is estimated that more than 1,000 km of new BRT corridor could be deployed in larger cities across India.

An analysis of 1,000 km of new BRT corridor deployed in 20 or more Indian cities shows that more than 300 tons of BC emissions could be avoided each year, with additional benefits (depending on deployment schedule) including the following: i) 1,100 to 1,350 reduced traffic fatalities per year; ii) US$1.6 to 1.9 billion/year in fuel savings; iii) 1.9 to 2.3 million tons/year of CO_2 emissions reduction; iv) US$6.4 to 8.1 billion in macroeconomic benefits (over 20 years); v) 50,000 to 90,000 short-term jobs rising to 128,000 permanent new jobs; vi) more than 175 avoided deaths annually in India because of improved air quality; vii) more than US$500,000 in annual avoided crop losses because of air pollution; viii) 500 million hours/year of time savings because of shortened trips.

other emissions have to be taken into account (measures to reduce diesel usage could lead to substitution by gasoline, and therefore reduced SLCP emissions but higher CO_2 emissions). The focus on regulatory measures for effective SLCP reduction from transport, for example, could have potential tradeoffs with a focus on transport investment that are beneficial for poverty reduction and growth.

46. Some urban transport projects explicitly address local air pollution and others present good practice. For example, the Haiphong Urban Transport Project in Vietnam (approved in March 2011) is supporting emission abatement through the inclusion of maintenance programs in public transportation.

47. There are further opportunities to tackle HFCs, another SLCP, in transport projects which involve new vehicle fleet and railway rake purchases. Since HFC substitutes for air conditioning in these vehicles are just becoming commercially available, procurement or project design practices could indicate a preference to purchase vehicles using non-HFC systems.

48. In general, transport projects can help improve traffic flow and offer numerous opportunities to address SLCP emissions. Interventions in urban areas provide opportunities for delivering SLCP reductions with significant local health benefits (see Box 5) given the larger population exposure. While it is approximated that 40 percent of overall transport sector lending is on activities that are SLCP relevant, more data and analysis are required to determine the fraction that may be SLCP reducing. Given the large potential in transport sector, the World Bank is committed to increasing the share of SLCP-reducing activities as a fraction of SLCP-relevant activities. This will entail providing incentives to reduce SLCP emissions in projects up to a point where emission reduction benefits balance development costs.

49. Long-distance rail projects are an increasing part of the World Bank's portfolio, offsetting traffic and freight that would otherwise be carried mainly by road transport. This has significant benefits in terms of SLCPs and GHGs. The Shi-Zheng Railway Project, for example, estimates CO_2 emissions from equivalent road freight transport to be approximately 400 percent higher than when carried by rail. Similarly, GHG analysis for the Dedicated Freight Corridor project in India showed that it emits 2.25 times less GHGs than the baseline over a 30-year time frame, where the bulk of the difference comes from the decreased use of diesel fuel, which is also responsible for BC emissions.

Energy Sector

50. The World Bank is engaged in helping developing countries deliver modern energy services that are reliable, affordable, and sustainable. Some projects involve the activities listed in Tables 1 and 2.

Cookstoves, Kilns, and Boilers

51. Combustion products of biomass and fossil fuel contain varying quantities of black carbon, depending on combustion efficiency. Project activities that involve biomass (cookstoves, sustainable charcoal production) are typically aimed at improving the quality of life and reducing pressure on biomass use, and more equitable

[15] This is outside the review period but the project serves as a good example to demonstrate the potential of including BC emission reduction benefits in cost-benefit analysis.

community development in the case of sustainable woodfuel production. Depending on the technology involved and the state of the equipment and appliances, combustion of oil and coal can emit significant quantities of BC.

52. The health benefits of reducing exposure to fine particulate emissions, of which BC is one component, have been widely documented.[16] Reducing fuel consumption and reaping health benefits are the main drivers of projects that improve the energy efficiency of biomass and fossil fuel use. As discussed in Chapter 2, the global climate benefits of reducing BC emissions from biomass burning are less certain, except where BC deposition occurs on snow or ice. But while climate effects may be uncertain, there are large health benefits associated with reducing debilitating indoor air pollution from traditional biomass use. As such, there is a compelling case for projects that address air pollution from biomass (for example, the Mongolia Ulaanbaatar [UB] Clean Air Project discussed in Annex 3).

53. A recent World Bank study highlighted the need to mainstream household energy interventions in energy sector lending and reforms (World Bank 2011b). A number of recent initiatives have been launched to help scale up clean cookstove programs: Clean Stove Initiative in East Asia (Mongolia, China, Laos, and Indonesia); Clean cookstove component in the access program of Bangladesh in South Asia; Africa Clean Cooking Energy Solutions (ACCES) program in Sub-Saharan Africa; and a dissemination strategy for clean stoves in Central America. The Sustainable Energy for All (SE4ALL) initiative[17] is scaling up activities to provide modern cooking facilities to those relying on traditional use of solid fuels. These activities are also intended to reduce particulate (and hence black carbon) emissions. In addition, the World Bank could deepen its engagement with the Global Alliance for Clean Cookstoves (GACC),[18] which is already a partner in the EAP and AFR programs. It is important to ensure that the technologies deployed are commensurate with the regional socio-economic context and capacity (e.g., expensive gasifier cookstoves may not be affordable for the poor in many parts of the world).

54. SLCP emissions could be reduced and fuel savings achieved in small-scale industrial projects, such as brick kilns and boilers, by improving energy efficiency (see Box 6). The Liaoning Third Medium Cities Infrastructure project approved in May 2008 is replacing 317 small, polluting boiler plants with eight new boiler plants, significantly reducing BC emissions.

55. There are other activities that could reduce BC emissions and have beneficial climate impacts. Their effects, however, are indirect and these projects are not amenable to a portfolio review of this nature. For example, improving the financial and operational performance of the power utilities to improve the reliability of power supply is an important area of engagement for the energy sector of the World Bank. Adequate and reliable supply of electricity can eliminate the need for stand-by diesel power generators which are common in countries with serious power shortages, thus reducing BC emissions. Another source of BC emissions is lighting using kerosene lanterns (Lam et al. 2012). The Lighting Africa Program of the World Bank and the International Finance Corporation (IFC) is catalyzing access to solar-based lighting products and aims to provide efficient and clean lighting to about 250 million people in Sub-Saharan Africa by 2030. Switching to solar power eliminates BC emissions associated with kerosene combustion.

56. Although not directly related to the energy sector, the benefit of phasing out HFC, which is an SLCP, is achieved in energy-efficient chiller projects replacing HFC with non-HFC refrigerants. These projects are typically undertaken as combined Montreal Protocol HFC phase-out and GEF-assisted energy efficiency projects.

Gas Venting and Flaring

57. Reducing transmission losses from natural gas pipelines contributes to methane emissions reduction. The Natural Gas Efficiency Project in Pakistan is an example of a project aimed at reducing unaccounted-for gas in the natural gas distribution system by replacing and repairing pipes and improving the leak detection system (Box 6). To the extent that some leaks are inevitable

[16] According to recent estimates (Lim et al. 2012), close to 4 million annual deaths worldwide can be attributed to exposures to cooking smoke, which affect the poor in particular.

[17] Sustainable Energy for All is an initiative launched by the United Nations Secretary-General to make sustainable energy for all a reality by 2030. There is an intermediate target of programs that would create clean cooking access for 400 million people by 2015.

[18] The GACC is a public private initiative to save lives, improve livelihoods, empower women, and protect the environment by creating a thriving global market for clean and efficient household cooking solutions (www.cleanstoves.org).

Box 6: Addressing Emissions from Brick Kilns and Gas Leakage

Aiming at improving air quality and safe mobility in Dhaka, the Clean Air and Sustainable Environment (CASE) project (approved in May 2009) provides technical assistance and funding to demonstrate environmental initiatives in the two most important air polluting sectors—brick making and urban transport. It is estimated that in the North Dhaka cluster, brick kilns are the city's main source of fine particulate matter ($PM_{2.5}$), accounting for nearly 40 percent of total emissions during the five months of operation. If exposure to urban air pollution is reduced by 20 to 80 percent, it is estimated that 1,200–3,500 lives can be saved and 80–230 million cases of respiratory diseases can be avoided per annum. Other benefits of this project include improving public mobility and energy efficiency.

A US$200 million natural gas efficiency project in Pakistan (approved in April 2012) will repair the country's corroded natural gas distribution system, thereby reducing leakage of about 16 billion cubic feet of natural gas over five years; this is equivalent to 7.5 million tonnes of CO_2-equivalent emissions annually.

in handling natural gas, anything that reduces gas consumption through energy efficiency improvement also reduces methane emissions.

58. Flaring and venting of gas associated with oil production increases GHG and SLCP emissions without extracting the corresponding energy value of the gas. The World Bank hosts the secretariat of the Global Gas Flaring Reduction (GGFR)[19] Partnership. A number of activities sponsored by the GGFR illustrate its growing interest in this subject. For example, at the Gunashli and Neft Dashlari oil fields in Azerbaijan,[20] some 8 million tons of CO_2e in the form of methane have been reduced over five years (see Annex 4). The GGFR Partnership has also supported path-breaking research on BC emissions from gas flares (Annex 4). In cooperation with the European Bank for Reconstruction and Development (EBRD), the GGFR Partnership is co-managing a study on associated gas for Azerbaijan, Kazakhstan, the Russian Federation, and Turkmenistan. The study seeks to develop a number of bankable flaring reduction investment projects.

Solid Waste and Wastewater Management

59. Municipal Solid Waste (MSW) affects public health and the environment on a global scale— including the emission of methane, primarily from landfills (see Box 7). World Bank solid waste activities aim to improve waste management where the need is growing most, and where the services are grossly underfunded. As assessed by the World Bank, the annual budgetary shortfall in the cities of its client countries is US$40 billion. Although methane emissions only occur at the point of treatment and disposal, efforts to reduce those emissions can occur at every stage in the value chain: planning, waste generation, collection, treatment, and disposal.

60. In addition to addressing the most pressing and basic aspects of MSW management, collection and disposal, the World Bank could in the future fund more upstream waste activities, focused on reducing waste generation and increasing source separation. For example, addressing white goods waste disposal offers the opportunity to recover HFCs from discarded refrigeration and air conditioning equipment. Upstream activities also offer co-benefits, such as extending the useful life of a landfill, reducing fossil fuel consumption, and improving air, soil, and water quality. A comprehensive, integrated approach in the solid waste sector would improve service delivery and public health, while reducing methane emissions. See Box 7 for a demonstration of the methane abatement potential of a nationwide program based on one Brazilian project and its significant local development benefits (A detailed write-up on MSW management is included as Annex 5).

61. Wastewater management projects typically focus on investments in constructing, expanding or rehabilitating wastewater collection, transportation systems, and waste water treatment plants to reduce health risks in urban centers. However, wastewater treatment plants also offer the potential to generate other ancillary benefits in terms of reuse of water for productive purposes and energy generation, if the methane can be captured and used. As shown in Figure 5, the World Bank's portfolio has not capitalized on the full potential of SLCP reduction in wastewater management and presents a significant opportunity to pursue in the future.

62. The underlying challenge with wastewater management is weak administration, poor governance, and

[19] The Global Gas Flaring Reduction public-private partnership (GGFR) is a public-private partnership to overcome the barriers to reducing gas flaring by sharing global best practices and implementing country specific programs.

[20] Report on Assessment of Venting and Flaring Rates at SOCAR Offshore Production Platforms.

underfunding, which need to be addressed to deal with the issue of methane emissions in a comprehensive manner. Zero or negative cost carbon wastewater treatment plants are now technically and financially feasible; however, the technology is advanced and difficult to access for most middle-income countries. Upfront investment in new facilities can provide rapid payback. In addition, technically feasible methodologies are needed to monitor and track the methane emissions from wastewater treatment plants.

Agriculture and Forestry Sector

63. The sources of SLCP emissions in the agriculture and forestry sector considered during the review are rice irrigation and livestock manure (which emit methane) and forest fires (which emit BC).

64. Forest fire management activities are typically included in projects that focus on improving forest health, conserving natural resources, or improving agricultural methods through a shift from slash-and-burn cultivation. While BC is the SLCP of concern from forest fires, it is not yet common practice to assess its emission or impacts (see Box 8). There are large uncertainties as to whether this intervention has a net warming or cooling influence on a global basis (see Bond et al. 2013). However, as in the case of other biomass related sources of SLCPs, the local health effect of fine particulate emissions from forest fires is much more certain.

65. Manure management is often included in projects to improve sanitation, improve environmental health management practices on the targeted farms, address nitrate pollution and provide energy for households or fertilizer for farming. Methane is the main SLCP of concern in manure management. Its potential use for cooking in households, for example, has the added benefit of freeing up time spent collecting cooking fuel, especially for women and children, and reducing black carbon emissions with its attendant health risks. Some projects have identified the potential for methane mitigation in livestock farming by incorporating various measures to abate methane emissions (see Box 8). Such projects that are linked to livestock farming represent a good opportunity to further expand efforts that can address the animal waste problem and methane emissions.

Box 7: SLCP Reduction and Co-benefit Potential—National Scale-up of MSW Program in Brazil

The CAIXA Solid Waste Management and Carbon Finance Project being carried out in Brazil offers a basis for considering the SLCP reduction potential nationwide through broader replication. The original project involves a US$50 million financial intermediary loan to Caixa Exonomica Federal who will use the funds to leverage private investment to improve the treatment and final disposal of municipal solid waste, while generating carbon finance credits through the capture and use of methane. The original loan is estimated to achieve up to 14.2 million tons of CO_2e over a ten-year period, along with improved water and soil quality, the potential for better working conditions of informal waste collectors and natural resource savings through recycling and composting. In scaling up this project to a nationwide program, it is assumed that waste from all open dumps would be diverted to modern sanitary landfills, and a variety of treatment options ranging from simple landfills to onsite power generation, intensive sorting and anaerobic digestion, and composting would be applied. These scenarios could reduce methane emissions by the equivalent of 15 to 29 million metric tons per year nationwide and additional benefits would be observed, if the electricity generated is used to offset fossil generation and the compost is used to reduce fertilizer manufacture.

In addition to the direct climate and carbon finance benefits of this project (US$300 to 560 million/year at US$20/ton CO_2), additional global co-benefits result from the diminished formation of tropospheric ozone, which have health and agricultural impacts. Benefits of a Brazilian national MSW program include 240 to 460 lives saved (avoided premature mortality) globally (3.4 to 6.5 in Brazil) and US$9.4 to US$17.8 million of avoided crop losses (US$18,000 to US$34,000 in Brazil), depending on extent of MSW program (that is, just landfills or including composting and anaerobic digestion component).

While the carbon finance opportunity is quite large, the investment in the Brazilian economy (US$1 to US$2 billion/year) coupled with the co-benefits, electricity generation (0.5 to 1.1 percent of national power demand), employment benefits (44,000 to 83,000 new jobs), compost, and recycling products have additional benefits of between US$8 and US$20 billion on the macroeconomy over the 30-year investment period.

66. The World Bank's support to rice irrigation projects is mainly geared at constructing or repairing irrigation dams and canals to improve competitiveness of selected domestic supply chains, increase nontraditional agricultural exports, and increase rice production in project areas. Included in this typology are projects that address improved rice farming methods, such as the use of high yielding varieties and system of

Box 8: Addressing Emissions from Agriculture and Forestry Projects

The Mexico Sustainable Rural Development Project (approved in February 2009 and recently extended with additional financing until 2016) estimates the reduction of at least 2.0 million tons of CO_2e over eight years. This reduction is being achieved primarily through 1) establishing and operating almost 500 small, medium, and large-scale bio-digestors (many with additional biogas generators for electricity generation) in the dairy and pig-production industries, and 2) promoting energy efficient and low emissions technologies in existing agribusinesses operating at the various stages of agricultural production chains in Mexico. The project is also validating and promoting the utilization of alternative forms of solar and biomass utilization, and the quantification and promotion of environmental and economic co-benefits from biomass utilization.

The Russia Forest Fire Response Project (approved in September 2012) seeks to improve forest fire prevention and suppression in select forest ecosystems, including targeted protected areas, and to enhance forest management in pilot regions. The project is expected to avoid an estimated 215 million tons of CO_2e over a 25-year period (or a 31 percent reduction in emissions over the baseline). Implied in this reduction are avoided black carbon emissions. This has, however, not been accounted for in the project. Assuming a price of US$10 per ton of CO_2 saved, the economic benefit from carbon alone could amount to approximately US$2 billion over 25 years. This does not include the co-benefits of reduced damage from fires that spread from forest to other landscapes (such as agricultural crops, loss of peat soils, and damaged infrastructure), reduced fire-related deaths and injuries, and health problems.

rice intensification. As Figure 5 shows, rice irrigation presents the potential for reducing methane emissions, however that potential has not been realized because of a complex set of tradeoffs.[21]

67. Further opportunities for SLCP abatement exist in the agriculture and forestry sector. In countries with large production and exports of agricultural, fish, and food products, cold storage and transport presents an opportunity to exclude or bypass refrigerants that are harmful to the climate. In the livestock subsector, the World Bank Livestock Roadmap and Action Plan and U.N. Food and Agricultural Organization (FAO) Global Agenda of Action offer an opportunity for mainstreaming the SLCP agenda.

Air Conditioning, Refrigeration, and Foam Conversion Projects

68. Montreal Protocol (MP)-supported projects (including several addressing short-lived HFCs) are part of the World Bank's portfolio. A number of key measures for addressing HFCs are found in the energy, transport, building and construction materials, and the industrial and consumer product sectors. Examples in the transportation sector include the use of standards with respect to refrigerant choice in mobile air-conditioners of new vehicles and trains procured under World Bank projects. Building sector opportunities include requirements for green building codes (including insulation), and implementation of building certification. The case study in Box 9 from the current MP portfolio demonstrates how HFCs have been avoided or minimized in the foam production sector.

69. Furthermore, HFCs could also be addressed by identifying complementary activities in World Bank non-lending activities. For example, support for energy efficiency and greening activities is a point of entry for technical assistance that complement energy efficiency measures (for example, upgrading/retrofitting refrigeration equipment or replacing inefficient ODS-based equipment/systems with non-HFC equipment/systems). Development of enabling policies and

Box 9: HFC Emission Alternatives in Indonesia

A US$2.7 million plan for supporting Indonesia to meet its first HCFC phase-out commitments under the Montreal Protocol targets the elimination of 301 metric tons of HCFC-141b equivalent to 218 kt of CO_2—through industrial conversions at foam companies.

The country's strategy for the first stage of HCFC phase out is to prioritize companies that select low-GWP alternative technologies. HCFC-141b will consequently be replaced by alternatives, such as hydrocarbon in foam production in the domestic refrigerator and freezer subsectors. However, because of the risks of handling hydrocarbon (HC) technology and the high costs of safety measures, HC technology is not always suitable for small enterprises. The project, therefore, found technology that would meet the needs of these enterprises and permit them to phase out HCFC use, while minimizing impact on the climate. Thus, in cases where selected enterprises lack the capacity to adopt HC technology, a 50 percent reduced HFC formulation can be applied. As a result of phasing in HC for the larger enterprises and actively minimizing HFCs in the small enterprises, it is estimated that nearly 186,000 tCO_2e could be avoided.

Note: 100-year GWP values utilized.

[21] Achieving methane emissions reductions from a wet rice irrigation project would depend upon a location that permits guaranteed seasonal drawdown of the water table by gravity. In addition, intermittent aeration could increase emissions of nitrous oxide, another greenhouse gas. Flooding of paddy has the dual function of inhibiting weed growth and getting nitrogen —a natural fertilizer—into the root zones. An additional risk of drainage, if not properly managed, is peat combustion which can lead to significant warming.

capacity for enforcement and monitoring results of the HFC reduction increment would be an essential part of overall integration efforts.

Development Policy Operations/Lending

70. Development policy operations are vehicles for policy change and regulatory measures. They provide a good opportunity to address complex issues that have fiscal implication and require cross-sectoral coordination (for example, changing fuel-quality standards for diesel). This component of the portfolio review evaluated the World Bank's Development Policy Operations/Lending activities (DPOs/DPLs) between FY07 and FY12. The DPOs/DPLs whose development objectives supported potentially SLCP-relevant activities amounted to approximately US$4.8 billion.

71. Support is geared towards increasing wastewater treatment capacity, reducing forest fires, establishing national standards to reduce particulate matter emissions from vehicles, and reducing fugitive emissions of methane from oil and gas activities, among other examples. While these operations do not directly invest in infrastructure, there is a direct link between expected program outcomes and SLCP emission reductions, for example in programs directly tackling air quality (see Box 10). Such programs could be leveraged to harness opportunities for incremental abatement measures. In addition, there are DPL/DPO programs that do not specifically aim to reduce SLCP emissions but do so indirectly.

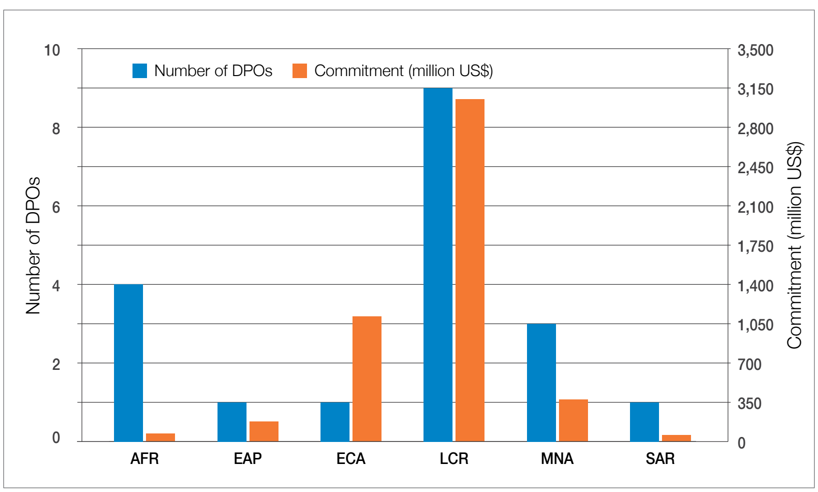
Box 10: Emissions from Development Policy Operations

In Morocco, a €100 million Urban Transport Sector Development Policy Loan (approved in March) was aimed at, among other objectives, mitigating GHG emissions by ensuring that inspection stations test for compliance with the stipulated vehicle emission limits, implementing specific actions to enable urban transport operators to submit their vehicles for regular technical inspections, and defining and adopting mandatory standards for emissions from the various types of new vehicles available on the Moroccan market. These measures are most likely to reduce BC emissions from the transport sector.

In Peru, the Third Programmatic Environmental Development Policy Loan (approved in August 2010) is assisting the government reduce the high levels of particulate matter and other air pollutants that are contributing to poor health in Peru's cities where it is estimated that 3,900 persons die prematurely every year as a result. Specific activities include support to the implementation of an effective inspection and maintenance system in Lima and three additional cities through the introduction of information and communication system.

The third development policy operation (DPO-3) in Ghana is supporting the government as it implements reforms under the Natural Resources and Environmental Governance (NREG) program (approved in June 2012) aimed at the forestry and mining sectors. A component of the program is to improve forest health though a significant reduction in the incidence of wildfires, which would reduce BC emissions.

Figure 6: Number of DPOs and Commitments to DPOs across Regions



4 Roadmap for SLCP Integration

72. As the portfolio review demonstrates, the World Bank has delivered an average of nearly US$3 billion a year (US$18 billion in six years) in activities that have the potential to reduce SLCP emissions. Going forward, the World Bank has to work to convert as much of the SLCP-relevant activities in its portfolio into SLCP-reducing activities. The World Bank can do more to undertake SLCP-reducing activities with strong health and other development benefits and integrate these activities in the World Bank portfolio, including better integration with GHG accounting, low-carbon growth strategies, and inclusive green growth planning. Some of the steps are described below.

4.1 Raising Awareness

73. The World Bank can play an important role in communicating the importance of SLCPs using its convening power with internal and external stakeholders. A growing number of client countries are interested in addressing SLCPs, as evidenced by the growing membership of the Climate and Clean Air Coalition (CCAC).[22] The strong country-led demand for SLCP reduction demonstrated in this forum, together with other global partnerships that the World Bank is active in, could be leveraged to facilitate action on SLCPs. Such partnerships include the UN SE4ALL, the GGFR partnership hosted by the World Bank; the UN Food and Agriculture Organization's Global Agenda for Action (GAA) for a Sustainable Livestock Sector being developed closely with the World Bank, the Global Methane Initiative (GMI) that engages more than 40 countries, the UN Foundations Global Alliance for Clean Cookstoves that the World Bank is a partner in, and the Joint Work Program on Cities and Climate Change with UN agencies and others. The World Bank could support these partnerships by sharing its experience in reducing SLCPs as an ancillary benefit of development projects with synergies between local and global objectives.

74. There is some risk that a focus on SLCPs could be perceived as shifting the onus for climate mitigation action to developing countries. In high-emitting, high- and middle-income countries, the main focus of climate mitigation should remain the reduction of GHGs, but the health, agricultural, and ecosystem benefits of methane reductions can be highlighted to strengthen resolve to tackle SLCPs, without a perceived shift in focus. In developing countries, the clear health benefits of reducing particulate matter are of obvious interest, and a focus on health with additional resources for SLCP and climate mitigation could enable action and help mitigate the risks.

4.2 Integrating SLCP Considerations in Decision Making

75. Raising awareness internally will help strengthen the integration of SLCP opportunities into decision making at the World Bank. This integration requires systematic exploration and exploitation of opportunities to reduce the costs of low-carbon economic development, without harming the progress towards shared prosperity and poverty reduction. The World Bank could integrate actions to address SLCPs in its decision making in several ways. At the strategic level, it could discuss SLCP opportunities in County Partnership Strategies so they are an integral part of the agreed support program between the World Bank and client countries. Development policy operations could serve as good vehicles for the integration of regulatory or fiscal measures into emission reduction efforts (Chapter 3).

76. The impetus for action on SLCPs needs to be based on strong analysis. As a knowledge institution, the World Bank could make an important contribution by strengthening the analytical base for measuring and valuing SLCP impacts and local benefits but this must be accompanied by resources to enable appropriate staffing for this exercise. This would help inform a comprehensive economic evaluation of projects.

77. The World Bank has a policy that requires project-level economic analysis (OP 10.4, Economic Evaluation of Investment Operations) and guidance documents for economic analysis that address the inclusion of environmental externalities (World Bank 1998) and climate related co-benefits (World Bank 2010a). This evaluation framework—in which the full range of benefits from an investment can be weighed against

[22] Thirty governments and 29 non-state partners have become partners in the CCAC. The country partners that are the World Bank's client countries are Bangladesh, Chile, Colombia, Côte d'Ivoire, Dominican Republic, Ethiopia, Ghana, Israel, Jordan, Mexico, Nigeria, Peru, Poland, and Republic of Maldives.

alternatives to identify project options that deliver the greatest economic value—is consistent with the World Bank's operational policy (OP 4.01) on environmental assessment. OP 4.01 requires analysis of alternatives, and along with the Bank's Environment Strategy (2012a), acknowledges that such alternatives may or may not be the cheapest option.

78. These policies and guidance documents suggest that analysts should evaluate project costs and benefits, and when necessary, account for opportunity costs associated with environmental degradation and any societal benefits of project alternatives. The multiple benefits associated with SLCP reduction should be included in economic analysis by taking account of the SLCP-related value that extends beyond direct project benefits (such as improved health outcomes, agricultural benefits, or climate benefits) and any incremental costs associated with SLCP-reducing project alternatives. Projects targeting urban transport, for example, provide an opportunity to integrate the reduction of emissions of fine particulate matter (which includes black carbon). Reducing fine particulate emissions through improved traffic flow is likely also to save lives through improved air quality and reduced traffic fatalities, improve productivity, and save time,[23] while providing fuel savings and CO_2-related climate benefits.

79. There are two barriers to applying this evaluation framework: (1) many of the co-benefits of BC and methane reduction are difficult to estimate, and (2) the principles of cost-benefit analysis are not always rigorously followed (IEG 2010). Simplified estimation methods are needed to balance project planning costs and the precision of cost-benefit calculations.

4.3 Addressing Data and Analytical Challenges

80. Projects face major data and analytical challenges; both for emissions quantification and for quantifying and monetizing associated development and climate benefits. Emissions data are generally scarce in the World Bank's client countries. However, estimates may be needed to compensate for data shortages.

81. In response to an Independent Evaluation Group's review, *Cost-benefit Analysis in World Bank Projects* (IEG 2010), the World Bank has committed to revisiting its policies on cost-benefit analysis in a way that recognizes the legitimate difficulties in quantifying benefits, while preserving rigor for project justification. Options include development of a map of tools to better understand the full costs and benefits of projects and support and training for staff on the use of tools for cost-benefit analysis. This presents a unique opportunity to include SLCP-benefit accounting tools into this review.

The goal will be to transform as much of the SLCP-relevant activities as possible into SLCP-reducing activities.

82. It is proposed that net SLCP accounting be initiated across SLCP-relevant sectors, accompanied by an estimate of the value of the local and global externalities associated with the emission reductions, wherever it makes sense to do so and where these can be reasonably assessed, and that this information be factored into economic analysis to assess the multiple benefits of projects. In cases where there is uncertainty about impacts (such as net climate impacts from addressing BC emissions from biomass), it would be important to follow scientific developments and adjust the evaluation framework as more robust information becomes available. The methodologies for such comprehensive economic analysis will need to be simple, cost effective, transparent, and feasible so that they can be used by the task teams without high implementation costs.

[23] A study in California showed that improved air quality can translate into increased worker productivity (Zivin and Neidell 2011).

83. Even when data is available, translating emissions changes into air quality benefits and assessing the climate impacts is challenging. Economic analysis that accounts for externalities is undertaken for World Bank projects, but accounting for the benefits of SLCP reduction requires the availability of evaluation tools that are not resource-intensive to use.

84. New tools are available and are being refined to quantify and monetize select benefits, such as public health benefits and avoided agricultural losses. These tools could be used to better value SLCP reduction benefits.[24] Box 11 shows how some of these tools have been used to value health and agricultural co-benefits in the World Bank's carbon finance portfolio. New modeling methods (Carmichael 2008; Henze et al. 2009) enable the rapid assessment of public health, agriculture, and even direct climate forcing (Henze et al. 2012) for locations around the world. The European Commission has also supported research on the identification of transfer functions that allows a user to estimate evaluation results in different policy and project contexts (Maibach et al. 2008). In addition, location-specific climate benefits—one tonne of BC reduction in Mexico may not have the same benefit to the climate system as one tonne of BC reduced in Nepal—can be estimated in terms of radiative forcing.

4.4 SLCPs, Low-carbon Development, and Green Growth

85. The case studies and examples cited throughout this report illustrate that the reduction of SLCPs yields multiple benefits (public health among them), and that addressing SLCP strategies can be complementary to a low-carbon development agenda. Furthermore, the SLCP agenda is also consistent with the World Bank's green growth agenda—defined as growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters. The link to green growth is not only through the benefits afforded by reducing air pollution to protect public health and preserve agriculture and ecosystem services, but also through the short to medium timeframe over which the benefits of these measures accrue.

[24] Examples of tools include the U.S. EPA's BenMAP tool that estimates the health impacts and economic benefits occurring when populations experience changes in air quality on the urban or regional scale (BenMAP 2012). Another CCAC-sponsored rapid assessment tool is being developed to estimate national-scale SLCP reduction co-benefits (for health and agriculture) based on the adjoint method of chemical transport modeling.

Box 11: Portfolio Co-benefit Analysis: Carbon Finance at the World Bank

Data necessary to quantify the SLCP emissions benefit associated with World Bank projects are often lacking with certain exceptions. One exception is the portfolio of methane-reducing carbon finance projects. This provides a unique opportunity to further quantify the health and agricultural co-benefits for the entire portfolio of 52 projects. For an investment of approximately US$543 million on these projects, US$228 million of direct carbon finance benefits are derived from the nearly 375,000 tons of methane emission avoided each year.

These benefits are known and included in financial analyses of the individual projects. However, additional benefits occur that have not been accounted for in economic analysis of the carbon finance portfolio. Using the TM5/FASST tool (developed by the European Commission's Joint Research Centre), project-specific methane reductions were aggregated within the 56 regions of the model and cumulative benefits of the entire portfolio of reductions were calculated and attributed to each region individually. Based on these modeled calculations, 150 incidences of premature mortality were avoided through global improvements to air quality. A majority occur in China and India because of their relatively larger populations. Using a U.S. EPA value for a statistical life of a U.S. citizen, this benefit works out to be nearly US$1 billion (the lower earning potential of a typical Chinese or Indian citizen will result in a significantly lower monetized benefit for these avoided deaths). In addition to the health benefits, nearly 33 thousand tons of crop losses will be avoided with a market value of US$5.8 million. As with the Brazil Solid Waste Country Analysis, macroeconomic benefits associated with these productivity gains accrue more broadly throughout the economy, but they are normally not accounted for in the carbon finance portfolio.

86. Looking ahead, it is proposed that the synergies between addressing SLCPs, low carbon development, and green growth will be assessed and strengthened. Whether using a classical economic framework or a green growth framework, full accounting of the value of SLCP reduction measures will assist in highlighting the economic and health benefits that low-carbon, green growth offers.

4.5 Harnessing HFC-related Opportunities

87. HFC programs at the World Bank are somewhat different from traditional lending programs. To leverage additional HFC reduction opportunities the World Bank could (1) through the Montreal Protocol portfolio, promote non-HFC technologies and lower GWP HFCs where possible, and (2) work across sectors to accelerate

the growth in the market for non-HFC refrigerants and coolants. Some foundations for this already exist, such as the Ozone Operations Research Group (OORG), which is a roster of technical experts supporting Montreal Protocol-related work, and which could be adapted to service a broader array of investment projects that interface with HFC-related issues.

4.6 Expanding the SLCP Agenda

88. While this report has primarily focused on the role of SLCP-relevant activities as they relate to ongoing and future operations, the World Bank is also engaging in analysis of SLCP mitigation actions and their associated development impacts, in collaboration with a number of external partners. In a follow-on analysis to the UNEP/WMO (2011) integrated assessment report, the World Bank is collaborating with the International Cryosphere Climate Initiative to examine the impact of BC deposition on snow and ice regions of the World. A forthcoming World Bank report prepared by the International Council for Clean Transportation examines the costs and benefits of reducing emissions of BC from diesel transportation, taking into account the local and global climate impacts. In addition, through a partnership with the ClimateWorks Foundation, the World Bank is undertaking analytical case studies to demonstrate the multiple benefits of SLCP mitigation. The new information derived from these analyses will strengthen the efforts to transform the World Bank's portfolio of SLCP-relevant activities to SLCP-reducing activities.

4.7 Stepping-up Action: Access to Finance

89. While the net *economic* costs of a number of SLCP mitigation measures are zero or negative, they could still potentially carry significant *financial* costs, and lack of access to finance can prevent these opportunities from being realized. For example, small-scale SLCP reduction opportunities, such as bio-digesters for manure management, are attractive targets from the local development and climate perspective, but investment depends on end-user creditworthiness and access to finance.

90. Project-based carbon finance has been instrumental in reducing methane and HFCs under the mandate of the Kyoto Protocol. The HFC23 project in China was the biggest carbon finance operation ever undertaken, and most importantly, it helped establish the framework for further carbon deals in the world's second largest GHG emitter at that time.

An investment of US$543 million on 52 carbon finance projects by the World Bank to reduce methane emissions is estimated to **avoid**:

150
Premature Deaths
…through global improvements to air quality.

33
Thousand Tonnes of Crop Losses
…with a market value of US$5.8 million.

375
Thousand Tonnes of Methane
…emissions each year.

91. Globally more than 920 million tonnes of CO_2e of methane emissions and 473 million tonnes of CO_2e of HFCs emissions are expected to be reduced by Clean Development Mechanism (CDM)/Joint Implementation (JI) projects up until the end of 2012. However, the CDM has demonstrated limited success in channeling underlying or upfront financing for some GHG mitigation interventions that employ less mature technologies, target small or dispersed sources of emissions, or address sectors (countries) with less conducive investment climates. The CDM's high transaction costs and its relatively long and unpredictable project cycle are contributing factors, together with recent depressed carbon prices.

92. Results-based financing mechanisms have the advantage of linking funding with the delivery of benefits. This has been demonstrated in some carbon finance projects (for example, municipal solid waste projects that address methane) where certified emission reductions are issued based upon monitored and verified methane reductions and then traded for revenue. The G8 has suggested a pay-for-performance model building on this experience to achieve greater methane abatement.

93. The Partnership for Market Readiness (PMR) provides systemic support to enhance countries' technical and institutional capacities to implement market-based instruments. The PMR or other similar readiness mechanisms could be used to support the preparation of strategies and plans for reducing SLCPs and delivering climate benefits.

94. Other innovative climate finance mechanisms, such as the Climate Investment Funds (CIFs), could also provide sources of upfront financing. While the core mandate of the CIFs is not to address SLCPs, they could potentially play a significant role in delivering SLCP reduction as a co-benefit (see Box 12). Green bonds could potentially generate financing for SLCP-reducing projects and guarantees could underwrite the risks for investments. Finance instruments, such as the Global Environment Facility (GEF), blended finance streams, or public-private options that have been instrumental in financing the incremental cost of GHG emission reduction, could provide useful lessons on designing financing instruments for SLCP mitigation. Additionally, charges for local emissions can make investments in SLCP reduction self-financing. The Bank could also use its experience in microfinance schemes to develop micro-credit programs implemented through financial intermediaries as a means of increasing the potential for reducing BC emissions from small-scale emission sources.

95. Implementation of activities that reduce SLCP emissions and provide climate benefits can be expedited significantly through innovative instruments to finance the incremental costs of SLCP mitigation. Harmonization with other multilateral development banks (MDBs) will be important when designing finance mechanisms for such mitigation projects. It will therefore be necessary to reach out to the MDBs to minimize conflicting project objectives and duplication of efforts.

Box 12: The CIFs and SLCPs

Clean Technology Fund (CTF): The Clean Technology Fund focuses on large-scale, country-initiated investments in renewable energy, energy efficiency, and sustainable transport. Projects in the transport sector, which account for 15 percent of the CTF portfolio, are likely to have co-benefits of reducing SLCPs. A number of waste-to-energy and energy efficiency projects may also generate SLCP co-benefits.

Forest Investment Program (FIP): The FIP supports developing countries' efforts to reduce or avoid GHG emissions from deforestation and forest degradation, support sustainable management of forests, and enhance forest carbon stocks (Reducing Emissions from Deforestation and forest Degradation-Plus [REDD+]). Activities that have co-benefits for reducing the emission of SLCPs include agricultural intensification (for example, Brazil), integrated fire management (for example, Indonesia) and the provision of access to alternate energy sources in cities instead of charcoal (for example, Democratic Republic of the Congo).

Pilot Program for Climate Resilience (PPCR): The PPCR supports countries' efforts to integrate climate risk and resilience into core development planning and implementation. Activities that have co-benefits associated with SLCPs include improved livestock management (for example, Niger), climate-smart agriculture (including rice paddies and improved seeds; for example, Cambodia), forest ecosystem restoration (for example, Grenada) and ensuring access to off and on-grid energy to villages.

Program on Scaling up Renewable Energy in Low Income Countries (SREP): SREP aims at demonstrating the social, economic, and environmental viability of low-carbon development pathways in the energy sector and seeks to create new economic opportunities and increase energy access through the production and use of renewable energy. Some SREP investment plans include components such as waste to energy (for example, Nepal) and improved cookstoves (for example, Honduras) that could potentially reduce SLCPs, such as methane and black carbon.

5 Conclusions

96. This report discusses how IDA/IBRD projects can incorporate measures that can reduce SLCP emissions directly or indirectly so as to maximize the combined benefits for local development and climate mitigation. It makes the case that scaling-up SLCP-reducing activities requires enabling measures to facilitate integration of actions on SLCP reduction at the Bank, and presents a roadmap for action.

97. A review of the World Bank's lending during FY07 to FY12 shows that 7.7 percent of IDA/IBRD commitments (approximately US$18 billion) were on SLCP-relevant activities in energy, transport, roads, agriculture, forestry, and urban waste and wastewater. This level of engagement represents an opportunity to transform as much of the SLCP-relevant activities as possible to SLCP-reducing activities. Specific commitments for the World Bank on SLCP reducing activities will be articulated as part of the broader climate action planning process which is expected to conclude in 2014.

98. To better assess the SLCP impact at the project level, accounting methodologies are being developed for methane and HFCs, and will be introduced over three years starting in FY14 as part of the rollout of GHG accounting. Assuming that adequate budget will be allocated, the Bank will also initiate work on developing and piloting methodologies to account for black carbon emissions. However, to better integrate actions that address SLCP emissions and climate benefits at the project level, it is proposed that a comprehensive economic analysis framework be developed that accounts for all the local and global benefits that projects provide due to SLCP emissions reductions. Subject to funding, this would be undertaken in

Table 3: Proposed Actions to Address SLCP Emissions

Topic	SLCP actions proposed to be undertaken by the World Bank
Commitment to SLCP reduction	Transform as much of the SLCP-relevant activities as possible into SLCP-reducing activities; commitments for SLCP-reducing activities to be articulated as part of the climate action planning process, which is expected to conclude in 2014.
Outreach and awareness raising	Consult with client countries on SLCP issues and strengthen outreach efforts among clients, donors, and partners.
Analytical basis for action	Strengthen the analytical basis for valuing the local and global impacts of SLCPs, and factoring them into project cost-benefit analysis; develop / map tools to better understand the full costs and benefits of projects. This includes analytical work on i) impacts of BC reduction measures on snow and ice covered regions of the developing World; ii) framework for including the health and climate impact of BC emissions from diesel vehicles in project cost-benefit analysis, and iii) analysis of the multiple development benefits of SLCP mitigation through case studies in select World Bank client countries covering urban transport, solid waste management, manure management, and household energy.
Staff capacity	Support training for staff on SLCP-related interventions, analytical approaches and use of tools.
SLCP accounting	Initiate SLCP accounting across SLCP-relevant sectors, with a view to estimating the local and global impacts where it makes sense, and using the information in project cost-benefit analysis; accounting for methane and HFCs to be initiated from July 2013 in some energy and forestry sector projects and rolled out to other relevant sectors and activities over a three-year period; subject to funding, initiate methodology development for BC accounting.
HFCs	Help countries to transition from HFCs to systems using low-GWP and/or non-HFC alternatives where technically and financially feasible and achieving greater energy efficiency, while introducing longer-term capacity building measures to facilitate adoption of more benign technologies when they do become available.
Financing	Explore innovative finance opportunities including CDM, results based finance, and potentially CIFs to defray the incremental costs of SLCP reduction where possible.

tandem with methodology development for BC emissions accounting, since the local benefits for health are driven by reducing BC emissions. A decision on the coverage of projects subject to BC accounting will be taken once there is a better understanding of the resources required to implement evaluation methodologies and the feasibility of collecting requisite data.

99. The World Bank Climate Action Plan is expected to provide a timetable for implementation of full SLCP accounting and comprehensive economic analysis with a focus on multiple development benefits. It is also expected to provide a timeline to track the financing of SLCP-reducing activities at the World Bank. Under the umbrella of the Climate Action Plan, the World Bank proposes to work with MDBs to explore options to extend the harmonized systems for climate finance tracking and GHG accounting to include SLCP reduction (based on the interest of other MDBs).

100. As a part of strengthening the implementation of the comprehensive economic analysis framework, the World Bank proposes to train staff in the use of tools for SLCP accounting and economic evaluation that incorporate environmental externalities (health impacts in particular), and demonstrate the integration of SLCP reduction in World Bank portfolio. To scale up efforts on the ground, it is proposed that work be carried out to address project-level technical barriers, such as the challenge of assessing the timing and location of SLCP emission reductions that maximize multiple benefits; as well as policy and regulatory barriers, such as the lack of a roadmap to capture and use gas from wastewater treatment. Annex 6 provides examples of activities that could enable scaled-up action, if coupled with appropriate financing instruments.

101. Table 3 summarizes the proposed actions to address SLCP emissions articulated in this report. The climate action planning process—expected to conclude in 2014—will further highlight the key priorities and commitments on SLCP mitigation action at the World Bank.

102. Finally, while SLCP reduction could reduce the rate of warming in the coming decades, over the long run, it makes only a modest contribution to climate change mitigation. As UNEP (2011a) underscores, immediate and substantial reductions of CO_2 and other long-lived GHGs are needed to avoid a 4°C warmer world. However, SLCP reduction can deliver significant local development benefits, particularly for human health, which provides a strong impetus for taking action.

4° Celsius

While SLCP reduction could reduce the rate of warming in the coming decades and deliver significant local developmental benefits, immediate and substantial reductions of CO_2 and other long-lived GHGs are needed to avoid a 4°C warmer world.

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Annex 1 / Development Benefits of SLCP Reduction

Air Pollution, Visibility, and Infrastructure

BC and tropospheric ozone are air pollutants that are ubiquitous in the modern urban and rural environment. BC emissions are detrimental regardless of where they are emitted, although emissions in populous areas have greater public health effects and emissions at high latitudes have greater effects on the cryosphere. SLCP reduction benefits are often nonlinear in terms of the location and timing of reductions as well as the specific co-pollutants reduced, making it difficult to quantify the precise benefits of a given reduction intervention. There are many other benefits of improved air quality, including visibility, reduced infrastructure damage, reduced acid deposition, and other welfare-related benefits (USEPA 2001; USEPA 2006). However, the main driver for air quality improvement programs has been the public health effects discussed below (WHO 2005).

Public Health

High ambient concentrations of tropospheric ozone and fine particles pollutants can significantly increase the risk of many respiratory and cardiac health endpoints, including asthma and heart attack (USEPA 2001). Ozone is a strong oxidant and respiratory irritant. It can damage the surface of the lungs and the lining of the esophagus (USEPA 2006). Fine particles come in a range of sizes, but the smallest particles, smaller than two and a half microns in diameter, PM2.5, can penetrate deeply into the lungs where it is easier for the chemicals incorporated into the particles to pass into the blood stream (USEPA 2001). Black carbon is only one component of fine particulate matter, but diesel combustion and traditional cookstoves can lead to particles of almost pure BC that are smaller than 1 micron. The public health effects of these emissions are particularly dangerous given their size and toxicity. The health effects of BC per unit mass have been shown to be greater than undifferentiated PM and are more robustly associated with short-term illness (WHO 2012).

Agricultural Impacts

BC can significantly alter regional climate-energy interactions and affect rainfall patterns, leading to impacts on agriculture. Tropospheric ozone as a secondary pollutant requires reductions in emissions of precursor pollutants, such as methane, carbon monoxide, other nonmethane hydrocarbons, and nitrogen oxides (that are part of the chemical reactions that produce ozone). At high concentrations, ozone is phytotoxic and leads to crop losses. More than half of the increase in ambient levels of background tropospheric ozone is estimated to result from anthropogenic emissions of methane, making it a prime target for emission reduction.

Ecosystem Services

There is evidence that tropospheric ozone pollution reduces crop productivity and natural vegetation (UNEP 2011a). It can impact the occurrence and severity of natural disturbances (for example, fire or erosion) by affecting water balance, cold hardiness, and tolerance to wind, and by predisposing plants to insect and disease pests. This can result in a loss of biodiversity as well as decreased ecosystem resilience to both extreme events and natural or human disturbances.

Energy Efficiency

Certain energy efficiency projects—such as regulatory reforms, improved building codes, appliance efficiency standards or retrofits to meet new standards—are conducive to HFC emissions reduction given that HFCs are often found in heating and cooling equipment that contribute most to energy demand in residential and commercial settings. Whether motivated by the opportunity to reduce or minimize HFC impacts, or the energy savings potential, HFC reductions and energy savings go hand in hand because of both the energy intensity of typical HFC utilizing equipment and the opportunity to minimize HFC impacts when embarking on energy efficiency activities. In addition, BC emissions fundamentally arise from incomplete combustion of organic matter. To the extent that combustion efficiency can be achieved, BC emissions will be reduced as a fraction of particulate matter with a potential reduction in CO_2 emissions.

Carbon Finance

Methane and HFCs reductions may have additional carbon-offset value associated with greenhouse gas emission reduction under the CDM and voluntary markets, and could be assigned a market price in addition to other non-climate benefits (in the case of methane).

Annex 2 / Key Short-lived Climate Pollutants, Their Primary Climate Effects, and Estimates of Their Warming Potential

Black Carbon

Black carbon (BC) affects the global climate system in multiple ways that are more complicated than for long-lived GHGs. Part of this added complexity is because BC is a particle consisting of many compounds rather than a molecule, interacting differently with light and heat. BC has a direct radiative impact (absorption of light and converting it to heat), affects snow and ice when it settles out of the atmosphere, and alters cloud properties. These processes are discussed below.

Radiative Effects

BC is similar to carbon dioxide (CO_2) and other long-lived GHGs in terms of its light absorbing properties that allow it to convert light energy to heat and warm the air around it. However, BC acts much more intensely than CO_2 for a much shorter time. Light is absorbed by BC particles and re-radiated in a similar manner to black objects, such as pavement. When BC particles are suspended in the air, light that would otherwise be absorbed or reflected at ground level may be redistributed higher in the atmosphere. BC may reduce the amount of light reflected back into space, depending on the reflectivity of the underlying surface and how BC is mixed with other particulate matter and the particle size. The direct radiative forcing of black carbon has most recently been estimated at +0.71 W/m^2 (range: +0.09 - +1.26 W/m^2; Bond et al. 2013), significantly greater than the 2007 estimate of +0.34 ± 0.25 W/m^2 (IPCC 2007). To put this in context, the total anthropogenic forcing on the earth's climate was estimated at +1.6 W/m^2.

Interaction with Snow and Ice

Fundamentally different from long-lived GHGs, BC remains in the atmosphere for one to two weeks before it is rained out or settles out of the air. BC particles' light absorbing properties may darken the surface when settling on snow or ice. This increases snow and glacial melt, enabling strong feedback with land and ocean surfaces that may otherwise reflect sunlight. Many arctic regions are now able to absorb significant quantities of heat for whole seasons because of early season melting of snow cover (World Bank 2011a). The regional specificity of impacts suggests that BC emission reduction near the Arctic, the Himalayas, and other snow and ice covered regions will have a greater relative benefit than reductions elsewhere (USEPA 2012b). The overall radiative forcing of this effect is estimated most recently as +0.13 W/m^2 (range: +0.04 - +0.33 W/m^2; Bond et al. 2013).

Cloud Properties

BC can significantly influence cloud properties. BC may be incorporated in clouds either as additional condensation nuclei seeding the formation of clouds, or by adding to existing nuclei, which may spread the same moisture across a greater number of cloud droplets. Clouds with a high fraction of black carbon may be less reflective than normal clouds, rise to different atmospheric levels, and alter rain cycle frequency and location. BC particles contribute to the formation of atmospheric brown clouds (ABCs) with large regional climate impacts, including shifting rainfall patterns and temperature gradients. ABCs have been implicated in the changes in the South Asian monsoon and rainfall patterns over eastern China (Ramanathan and Carmichael 2008). The way BC interacts with clouds has the greatest uncertainty relative to other modes of forcing and remains an active area of research. The latest assessment puts the global estimate of radiative forcing associated with BC cloud interactions at +0.23 W/m2 (range: -0.47 to +1.0

Annex Table 1: Estimated Global Radiative Forcing Resulting from Black Carbon Emissions

Forcing type	IPCC (2007)	Ramanathan and Carmichael*	UNEP (2011)	Bond et al. (2011)	USEPA (2012)	Bond et al. (2013)
Direct atmospheric	0.34		0.3–0.6	0.4	0.34–1.0	+0.71 (+0.09–+1.26)
Snow/Ice	0.1		0.05–0.25	0.05	0.05	+0.13 (+0.04–+0.33)
Clouds			-0.4–0.4			+0.23 (-0.47–+1.0)
Cumulative		0.9	0.6 (range: 0–1.0)			+1.1 (-0.17–+2.1)
Including OC sources (direct effect only)	0.15		0.41*	0.27		
Including coemissions of BC sources						-0.06 (-1.45– +1.29)
Including all aerosol species	-1.2	-1.4				

*UNEP/WMO assessment includes both the direct radiative effect and snow/ice impacts of the sum of BC and OC.

W/m2; Bond et al. 2013). Many studies and reports have not quantified the radiative forcing of cloud interactions, citing large uncertainties, which makes these new results particularly important.

According to the Black Carbon Bounding Study (Bond et al. 2013), the total cumulative radiative forcing associated with all BC effects relative to preindustrial times (see Annex Table 1) is estimated at +1.1 W/m^2 (range: +0.17 – +2.1 W/m^2), making it the second largest anthropogenic forcing next to CO_2.

Net Impact Accounting for Co-emitted Species

The above estimates capture the total climate forcing from black carbon acting alone. However, black carbon is seldom emitted alone, and what matters in assessing projects is the combined effect of the emissions of black carbon and the co-emitted species. The latter include organic carbon (OC) and sulfate aerosol precursors. Most BC from biomass burning, open burning, and forest fires is co-emitted with substantial OC. While BC is relatively dark and absorbing, OC is significantly lighter and tends to reflect light back to space and may have a cooling influence; hence, teasing out the role of BC specifically from these activities is complicated (World Bank 2011a). While fossil fuel combustion emits far less OC, sulfur in the fuel has a cooling effect, so that fuel with high sulfur may have net negative climate forcing. Table 1 includes additional rows that demonstrate a significant difference in radiative forcing when various components of co-emitted species are included in these estimates. Bond et al. (2013) is the only paper to comprehensively assess the effect of co-emitted species for BC-rich sources in isolation and the net forcing is -0.06 (-1.45, +1.29). Other estimates looked at the combination of BC and OC (but without sulfates) or all aerosol species (including indirect effects) whether they come from BC-rich sources or not.

Methane (and Tropospheric Ozone)

Methane is a potent GHG and behaves perhaps most similarly to the long-lived GHGs of all the SLCPs. Given the fact that its lifetime in the atmosphere is about 12 years rather than several hundred, it is categorized as a SLCP. Despite its short life, each molecule of methane is 25 times more powerful than a molecule of CO_2 in terms of its potential to warm the planet, when its influence is compared to a molecule of CO_2 acting over 100 years.[25] Methane also has an indirect influence on the climate system as a precursor pollutant that aids in the formation of tropospheric ozone, which is a greenhouse gas. Ozone is a common air pollutant causing significant public health concerns and increasing the disease burden. It damages plant tissue and crops lowering agricultural yields. Background levels of tropospheric ozone have tripled over the past several hundred years, in large part because of the global increase in methane emissions (ClimateWorks 2011). The IPCC estimates the radiative forcing of methane at +0.48 W/m^2 and tropospheric ozone at +0.35 W/m^2 (IPCC 2007).

Short-Lived HFCs

HFCs are increasingly replacing ozone-depleting substances (ODS) phased out by the Montreal Protocol,[26] and their use is also increasing with rising demand for HFC-based air conditioning. Some HFCs have direct application in industry and others are unwanted byproducts in the manufacturing of other fluorinated chemicals.[27] HFCs typically have lower lifetimes than their chlorofluorocarbon (CFC) counterparts with similar global warming potential (that is, thousands of times greater than CO_2).

Because of their relatively shorter atmospheric lifetime, HFCs affect the climate for months to years, not centuries or millennia. The radiative forcing of short-lived HFCs (with lifespans of up to 15 years) varies by gas. The IPCC estimated the radiative forcing of HFC-134a at +0.0055 W/m^2 and HFC-152a at +0.0004 W/m^2 in 2005. While the HFC relative contribution to climate is currently lower than other such SLCPs as methane and black carbon, their importance is expected to grow and increase radiative forcing by up to +0.4 W/m^2 by 2050 (relative to 2000) under current business as usual conditions. Much of this will occur in developing countries.

[25] As per the IPCC, the Global Warming Potential for methane is 72 over a 20-year period and 7.6 over 500 years. (http://www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-2-5.html)

[26] The greatest current manufacturing use of HFCs is as a replacement to HCFC-22 in residential air-conditioning and as the dominant coolant in vehicle cooling systems. European and North American markets are nearly entirely HFC-based with an obligation to phase-out of 90 percent of HCFC consumption by 2015.

[27] For example, HFC-23, although long-lived, is produced as a by-product of HCFC-22 manufacture, and is generally of no use otherwise—with very limited exception as a fire extinguishing agent and refrigerant.

Annex 3 ⁄ Short-Lived Climate Pollutants— The East Asia and Pacific Example

East Asia is a nonhomogenous region with tremendous geographic, climatic, and economic diversity that is reflected in the diversity of the World Bank's lending portfolio across the region. The World Bank has considerable experience implementing projects and providing technical assistance to East Asian countries on issues that reduce SLCPs, while focusing on improved health and increased wealth for local communities.

Household Energy: Approximately 50 percent of East Asia's population uses solid fuels (coal, wood, dung, and agricultural residue) as their primary cooking fuel. It is estimated that in East Asia alone, 665,000 people die prematurely every year because of coal and wood burning for cooking purposes. There is an ongoing Clean Stove Initiative that supports capacity building and policy development for scaling up access to clean and efficient stoves. There are also country-specific initiatives in China, Indonesia, and Lao People's Democratic Republic. Recently completed technical assistance projects in Timor-Leste and Cambodia add to the World Bank's technical expertise in this sector. In addition, the World Bank is working with the government of Mongolia in a US$22 million project to enable Ulaanbaatar consumers to access heating appliances that produce less black carbon emissions. A one-time investment, replacing traditional stoves with clean stoves, could reduce particulate matter emissions by 95 percent for each new stove used. World Bank studies estimated that annual benefits would amount to US$515 per stove replaced.

Transportation: Unmanaged growth in transportation demand is causing significant economic impacts from lost man hours, additional fuel consumption, increased health costs, a large number of traffic fatalities, and lost investment opportunities. Urban air pollution has become a critical issue for many large cities in East Asia. The World Bank has been providing assistance in the elimination of high BC-emitting vehicles from the diesel road-vehicle fleets and the establishment of tighter vehicle emissions standards. The Cebu Bus Rapid Transit Project (US$222.5 million), currently under preparation, will reduce emissions through a new BRT System with new buses that will meet the Euro IV emissions standards. The project is expected to reduce PM emissions by 347 to 497 tons, leading to monetary savings of US$269 to US$385 million. The Guangzhou Green Trucks Pilot Project (2010) demonstrated that fuel costs for long-haul trucks could be decreased by 6.6 percent and for garbage trucks by 18.5 percent. If these improved efficiencies were scaled to all Guangdong heavy-duty trucks, through the Guangdong Green Freight Demonstration Project (US$14 million) the PM10 reductions would equal 1,218 tons per year.

Livestock Waste Management: The East Asia region contains more than half the world's stock of pigs and more than one-third of the world's poultry. The World Bank partnered with FAO to complete the Livestock Waste Management Project (US$24 million) in China, Thailand, and Vietnam to reduce the major negative environmental and health impacts of rapidly increasing concentrated livestock production. In Vietnam, it is estimated that methane-caused eye diseases were reduced from 24 percent to 12 percent, and respiratory diseases dropped from 18 percent to 6 percent among participating farm workers and neighboring communities before and after project. Currently China is partnering with the World Bank to invest US$100 million in the Guangdong Non-point Pollution Control Project. Furthermore, the World Bank has the US$80 million China Eco-farming Project and the US$79 million Vietnam Livestock Competiveness and Food Safety Project that also finance the installation of methane recovery from livestock operations.

Annex 4 / GGFR Supports Oil and Gas Venting Reduction Projects and Better Data Collection

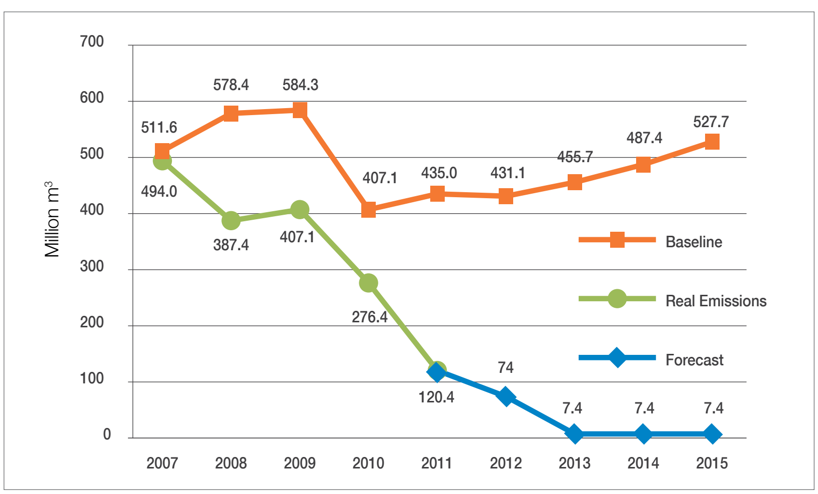
In Azerbaijan, SOCAR, its national oil company, vented to the atmosphere about half a billion cubic meters of natural gas, roughly one-fifth of all associated natural gas produced along with oil. In 2008, SOCAR joined the World Bank-led Global Gas Flaring Reduction (GGFR) partnership. As a result, SOCAR undertook venting reduction projects at the fields of Neft Dashlari and Gunashli. Both of these projects involved the recovery and utilization of low pressure associated gas previously vented.

At the Gunashli oil field, some 310 million cubic meters of low pressure associated gas (mostly methane) were annually vented to the atmosphere. New compressor stations and gas pipelines and extensions of offshore installation infrastructure were installed allowing vented gas to be delivered to end-users. The project reduced some 4.2 million tons of CO_2e (see platform image below). The Neft Dashlari oil field vented some 280 million cubic meters of associated gas. This project collected low pressure gas and transported it to an existing onshore gas processing plant. SOCAR and Gazprom Germany GmbH implemented this project, resulting in 280 million cubic meters of gas capture and utilization, which contributed to reducing some 3.8 million tons per annum of CO_2e.

Between both projects, the GGFR partner in Azerbaijan was able to prevent the venting of 8 million tons of CO_2e.

A key data need with respect to BC from flaring is improved emission factors for BC emissions from gas flares. The GGFR and its member partner in Mexico, Petroleos Mexicanos (Pemex), have supported pioneering research to advance the measurement of black carbon from flares stacks. Flaring is implicated as a potentially critical source of black carbon emissions. The sky-LOSA technique for directly quantifying black carbon emission rates in flares under field conditions is based on Line-Of-Sight Attenuation (LOSA) of natural light and enables accurate quantification of black carbon mass emission rates in atmospheric plumes of flares. In this study, the flare stack was emitting black carbon roughly the equivalent to emissions from 14 diesel buses running continuously. This finding is very encouraging for the prospect of future efforts to significantly improve current emission factor approaches for estimating flare generated black carbon emissions.

Annex Figure 1: Gas venting reduction forecast



Annex 5 ⁄ World Bank Municipal Solid Waste Management: Analysis of Methane Reduction Opportunities and Nationwide Scale-up

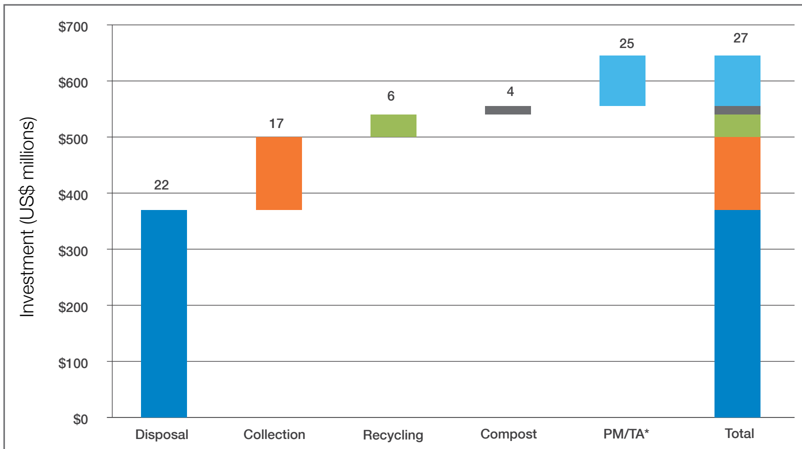
Along with rapid urbanization and population growth, Municipal Solid Waste (MSW) generation from the world's cities is increasing at unprecedented rates—from 1.3 (in 2006) to 2.2 billion tons of MSW (by 2025)—and all of this growth is in developing country cities. World Bank solid waste activities aim to improve waste management where the need is growing most, and where the services are grossly underfunded; the annual budgetary shortfall in the cities of World Bank client countries is US$40 billion.[28]

Though more visible as a local problem, MSW affects public health and the environment on a global scale—most notably by emitting methane, mostly from landfills. Properly managing waste to minimize methane emissions offers a variety of local and global co-benefits. People who live near or work with solid waste have increased disease burdens.[29] Globally, post-consumer waste is an emerging contributor to climate change, emitting 5 percent of global GHGs and 12 percent of methane. However, waste has the potential to be a net sink of GHGs when used as a resource, through recycling and reuse.[30] Uncontrolled burning of waste also affects the global environment, by emitting black carbon, dioxins, and furans—globally mixed persistent organic pollutants (POPs) that are toxic to humans and the environment. Properly managing waste to minimize methane emissions also leads to improved water, air, and soil quality.

Although methane emissions only occur at the point of treatment and disposal, efforts to reduce those emissions can occur at every stage in the value chain: planning, waste generation, collection, treatment, and disposal. For example, designing incentive schemes to promote lower waste generation and increased source separation reduce the amount of methane produced in a landfill (and other GHGs downstream in the value chain), and prevent other sources of SLCP (and GHG) emissions, by displacing the use fertilizers for agriculture and to natural gas for electricity.

Over the last six years (2007–12), the World Bank has invested in 27 projects (US$642 million) that potentially reduce SLCP emissions, through increased collection, improved disposal, landfill gas collection, increased recycling, or composting.[31] Most World Bank MSW projects focus on collection and disposal, often considered the most crucial elements of MSW management, and the most important sources of SLCP emissions. Of the 27 projects, most (22) are focused on disposal (US$379 million) and collection (US$122 million); a small number (10) address waste reuse and recycling (US$46 million), and US$7 million for composting. These results are summarized in Figure 2 above.

Annex Figure 2: World Bank Investment in SLCP-reducing MSW Projects (2007-12), Including Number of Projects



*PM/TA referes to project management and technical assistance costs.

In future, the Bank should fund more upstream activities, focused on reducing waste generation and increasing source separation. These activities allow for the maximization of waste-to-resource technologies, such as composting and anaerobic digestion. Upstream activities also offer co-benefits such as extending the useful life of a landfill, reducing fossil fuel consumption, improving air, soil and water quality. A comprehensive, integrated approach in the solid waste sector would improve service delivery and public health, while reducing methane emissions.

28 Hoornweg and Bhada-Tata 2012.

29 Giusti 2009.

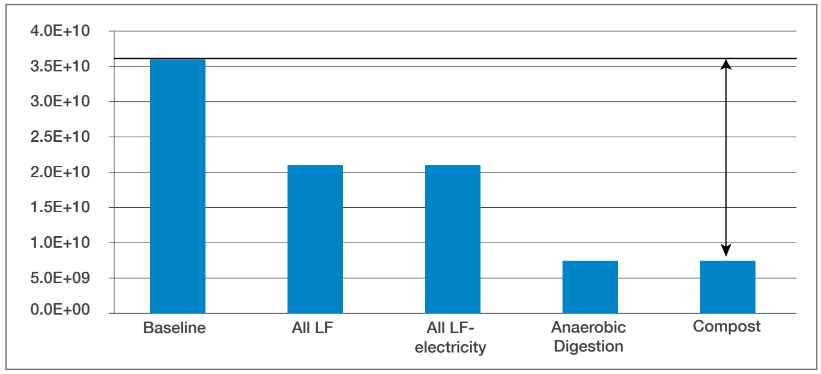
30 Bogner et al 2007

31 This tally includes only World Bank investment projects, and thus excludes carbon finance projects, of which there are many that address landfill gas collection.

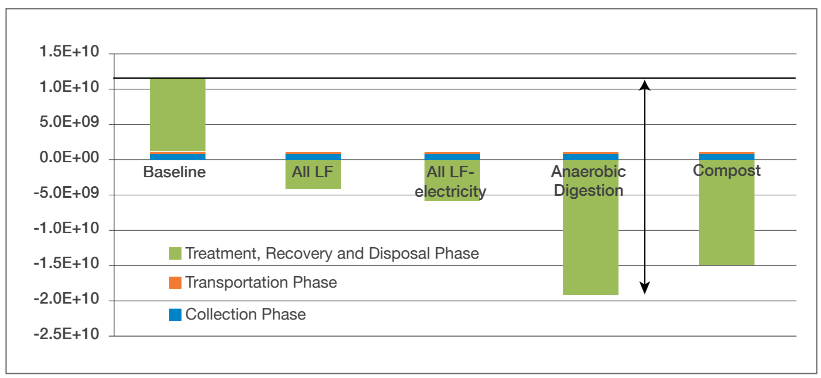
Case Study: Brazilian Nationwide Scale up. To demonstrate the potential efficacy of the integrated solid waste management approach described above, national emissions reduction potential has been calculated assuming the nationwide scale up of one model project. This case study shows that broad emission reductions can be achieved across the solid waste value chain relative to scenarios that target only one area, such as sanitary landfills.

The model project selected is the integrated solid waste management and carbon finance project. The World Bank is providing a Financial Intermediary Loan of US$50 million to Caixa Economica for on-lending to borrowers with solid waste subprojects in Brazil. The project overall aims to improve the treatment and disposal of municipal solid waste; its success is measured by the number of open dumps closed, the increased volume of waste disposed in sanitary landfills, and the increase in volume of waste composted and recycled. Methane reductions from improved solid waste management in Brazil are estimated, assuming a scale-up of this project to cover the entire nation of Brazil.

Annex Figure 3: Lifecycle Methane Emissions for Five Scenarios for Management of Brazil's Solid Waste, in kg CO_2e/year.
(Anaerobic digestion and composting offer the largest reductions.)



Annex Figure 4: Life-cycle GHG Emissions (CO_2e/year) for all Scenarios
(Anaerobic digestion and composting offer the greatest emission reductions.)



Implementing these organic waste treatment technologies on a large scale could reduce methane emissions by 29 million tons of CO_2e per year (assumes effective source separation of organic waste, no market for compost [no substitution for fertilizer], and electricity produced displaces natural gas on the grid).

Anaerobic digestion and composting—which have yet to be used successfully at large scale for waste management in developing nations—offer the potential for the largest GHG reductions, of 30 million tons and 26 million tons of CO_2e per year.

It is found that improved organic waste treatment, through anaerobic digestion and composting, offers the greatest potential for methane reduction from solid waste for Brazil, on the order of 30 million tons of CO_2e per year (roughly equivalent to Belgium's CO_2 emissions from transport in 2008[32]). However, in order for these waste-to-resource technologies to be used on a large scale, major investments need to be made upstream of the technologies, in waste reduction, and source separation. Without separation of waste at the household level, neither composting nor anaerobic digestion is economically feasible. An integrated approach to waste management that considers every step in the waste value chain, from waste generation in the household through final disposal, is needed in order to effectively manage waste as a resource. Doing so would lead to a variety of environmental and public health benefits, including a large reduction in methane emissions.

[32] World Bank. 2012. "CO_2 Emissions from Transport." Accessed 12/7/12. http://data.worldbank.org/indicator/EN.CO2.TRAN.MT

Annex 6 / Activities to Enhance SLCP Reduction Opportunities

Typology	Examples of Actions* that Could Contribute to SLCP Emission Reduction		
	Technical	Policy	Regulatory
Roads			
Urban	Engineering design to reduce rolling resistance on roads	Differential toll tax for low emission vehicles or congestion mitigation	High occupancy vehicle lanes
Rural and Interurban	Engineering design to reduce rolling resistance on roads	Development of auto-fuel road map for cleaner fuels and better technology	Green freight program for fleets
Urban Transport			
Bus-based	Retrofitting emissions reduction devices where feasible	Development of auto-fuel road map for cleaner fuels and better technology	Standards for fuels and emissions
Rail-based	Electric traction with regenerative braking where feasible	Fare rationalization to facilitate inter modal transfers	
Traffic Management and Emissions Control	Automatic vehicle inspection systems	Bike lanes and pedestrian pathways	Mandatory emission testing linked to insurance renewal
Energy			
Promote Improved and Clean Cookstoves	Development of advanced cookstoves	Create incentives for manufacturers to improve technology and reduce costs	Develop improved standards for energy efficiency and emissions
Brick Kilns (technology upgrade)	Promotion of low emitting kilns	Tax breaks for manufacturers to develop low emitting kilns	Standards for energy efficiency and emissions

Typology	Examples of Actions* that Could Contribute to SLCP Emission Reduction		
	Technical	Policy	Regulatory
LPG / Biogas (fuel switching)	Design of bio-digesters that minimize leakage	Incentive programs for LPG/ biogas systems	Technical, safety, quality standards or other market-enabling measures
Gas Flare Reduction	Development of technology to monitor flare emissions	Support the development of downstream gas usage Gas pricing policy that enables capital investment for gas gathering, treatment, and transmission	Penalties for flaring; regulations that minimize flaring
Methane Leak Reduction	Promote technology for leak detection	Tariff-setting policy that penalizes large leaks	Gas pricing policies to encourage leak prevention and regulatory roadmaps aimed at leak reduction
Municipal Solid Waste			
Waste Collection	Replace old diesel trucks with cleaner, fuel efficient trucks; technical assistance to promote proper vehicle maintenance to reduce BC emissions	Development of an integrated solid waste management plan (waste reduction and separation, collection, disposal, recycling, composting) including financing modalities	Waste separation to maximize anaerobic digestion and composting (as well as recycling), through incentive payments, behavior change campaigns
Disposal	Sanitary landfill design that facilitates gas recovery/ utilization		Fine for open dumping of municipal waste; incentivizing proper disposal. Mandate LFG collection for all landfills.
Recycling	Material recovery facilities		Integrating the informal sector
Composting	Compost facilities; waste separation facilities		Mandate the utilization of compost produced

*In the above table, technical opportunities are more likely to be integrated into project design and/or safeguards consideration. Policy and regulatory solutions would likely be achieved through client country actions and/or DPL/DPO lending.

In addition to the *activity-specific* approaches to SLCP reductions listed in the table, the authors note that there are several policy approaches that might be pursed at the *sector level* as opposed to the activity level, such as clean fuels programs, integrated waste management, or sustainable agriculture plans. Such opportunities will require greater coordination across government institutions, broader engagement of stakeholder groups, and a greater focus on technical capacity to ensure that these transformative concepts can successfully take hold where needed.

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