

PHASE II: THE CHALLENGE OF LOW-CARBON DEVELOPMENT
Climate Change and the
World Bank Group

IEG Study Series



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CLIMATE CHANGE AND THE WORLD BANK GROUP

Phase II: The Challenge of Low-Carbon Development



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Table of Contents

Abbreviations.....	vi
Acknowledgments.....	vii
Foreword.....	viii
Executive Summary.....	ix
Management Response.....	xvi
Chairman’s Summary: Committee on Development Effectiveness (CODE) ..	xxiii
Statement of the External High-Level Review Panel	xxiv
Glossary	xxx
1. Introduction.....	1
Climate Context	3
Global Mitigation Context and the WBG	4
Evaluation Questions	5
Evaluation Framework	6
Evaluation Scope	7
2. Renewable Energy.....	11
Low-Carbon Energy Projects and Their Performance	12
Overcoming Barriers to On-Grid Renewable Energy	18
On-Grid Renewable Energy: Hydropower	23
Energy Access and Low-Carbon Development	26
Off-Grid Renewable Energy: Solar Photovoltaics	27
The Way Forward for Renewable Energy	30
3. Energy Efficiency	33
Energy Efficiency in the First Phase Evaluation	34
Using Financial Intermediaries to Overcome Barriers to Energy Efficiency Investments	34
Direct Investments in Energy Efficiency	38
Transmission and Distribution	40
Efficient Light Bulbs	41
The Way Forward for Energy Efficiency	44
4. Beyond Energy: Low-Carbon Paths in Cities and Forests.....	47
Urban Transit	48
Forests	52

5. Special Topics	61
Efficiency in Coal-Fired Generation	62
Technology Promotion and Transfer	65
Carbon Finance at the WBG	71
6. Conclusions and Recommendations	79
The Congruence of Mitigation and Development	80
A Systems View Is Essential	80
Recommendations	81

Appendixes

A. Renewable Energy Tables and Figures	89
B. World Bank Experience with Renewable Energy Surveys	97
C. Energy Efficiency Tables and Figures	98
D. Lessons from Completed Transmission and Distribution Projects	102
E. Coal	104
F. Transport Tables and Figures	106
G. Energy Project Portfolio Databases	108
H. Pilot and Demonstration Projects	110
I. Carbon and Economic Returns of Projects	113
J. Recent WBG Developments in Emission Mitigation Activities	115
K. Executive Summary: Climate Change and the World Bank Group Phase I	118

Endnotes	122
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Bibliography	124
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Photographs	128
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Boxes

1.1 The Strategic Framework on Development and Climate Change	2
2.1 The Economics of Grid-Connected Renewable Energy	19
2.2 Monitoring and Evaluation Provides Rapid Feedback on the Performance of Landfill Gas Projects	20
2.3 Mitigating Political Risks in Renewables: a MIGA case	22
2.4 Gender and Low-Carbon Energy	26
2.5 On-Grid and Off-Grid Renewable Energy in Sri Lanka	31
3.1 Energy Service Companies and Energy Performance Contracting	36
4.1 The TransMilenio Bus Rapid Transit System	50–51
4.2 The Silvopastoral Project: A Successful Example of Demonstration	55
5.1 Technology Learning (or Experience) Curves	65
5.2 Carbon Offsets, a Peculiar Commodity	72

Figures

1.1	GHG Emissions by Sector and Country Group, 2005	3
1.2	Low-Cost GHG Abatement Potential, Non-OECD Countries, in 2030	4
1.3	WBG Investments in Renewable Energy 2003-8: Evaluation Coverage	10
1.4	WBG Investments in Low Carbon Energy Efficiency 2003-8: Evaluation Coverage	10
1.5	WBG Investments in Urban Transport 2003-8: Evaluation Coverage	10
2.1	Location of 2003-08 Low-Carbon Portfolio, by Groups of Renewable Energy-Energy Efficiency	14
2.2	Breakdown of 2003-08 Low-Carbon Portfolio by Country Income Group	15
2.3	Growth in Low-Carbon Portfolio by Project Type	15
2.4	Growth in Low-Carbon Portfolio by Country Income Class	16
2.5	Breakdown of non-low carbon WBG Energy Investments	16
2.6	WBG-Supported Grid-Connected Generation Capacity by Technology, 2003-08	16
2.7	Distribution of Capacity Factors of Hydropower CDM Projects	20
2.8	Impact of Carbon Payments on Return on Equity	21
2.9	The Fall and Rise of WBG Hydropower Commitments, 1990-2008	24
4.1	Average Annual Forest Commitments, \$ millions	54
5.1	Spectrum of Technology Support	66
5.2	World Bank Share of CDM Projects and Tons Registered	75
6.1	Economic and Carbon Returns to Investments Tables	81

Tables

1.1	Map of the Evaluation	9
2.1	IEA Projections of Power Production, 2007-30	12
2.2	Evaluated World Bank Renewable Energy and Energy Efficiency Projects by Rating, Projects Initiated 1990-2007	13
2.3	WBG Low-Carbon Energy Commitments (\$ millions) by Product Line and Investment Category, 2003-08	14
2.4	Commitments to Grid-Connected Renewable Energy by Technology and Funding, \$ million, 2003-08	17
2.5	Off-Grid Investment Projects, \$ million, 2003-08	17
2.6	Hydropower Investments by Size, Storage, and Funding. \$ millions, 2003-8	25
2.7	Outcome Ratings of World Bank Hydropower Projects	25
2.8	Rated Outcomes of Completed Projects with Large SHS Components	28
3.1	Energy Efficiency Interventions by Type in the Low-Carbon Investment Portfolio 2003-08	35
3.2	IFC and World Bank Approaches to Energy Efficiency Financial Intermediation in China and Eastern Europe.	35
4.1	Impact of Protected Areas in Tropical Forests on Forest Fire Incidence	57
5.1	Carbon Funds at the World Bank	73
5.2	Comparative Success at Registration of CDM Projects, WBG versus Other Sponsors and Purchasers	76
5.3	Carbon Projects with Signed Purchase Agreements	76
6.1	Summary of Sectoral Findings	84

Abbreviations

ASTAE	Asia Sustainable and Alternative Energy Program
BRT	Bus Rapid Transit
BRTS	Bus Rapid Transit System
CDM	Clean Development Mechanism
CEIF	Clean Energy Investment Framework
CER	Certified emission reduction
CFL	Compact fluorescent light bulb
CFU	Carbon Finance Unit of the World Bank
CHUEE	China Utility-Based Energy Efficiency project
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
CPF	Carbon Partnership Facility
CSP	Concentrated solar power
ELI	Efficient lighting initiative
EMC	Energy management company
ERR	Economic rate of return
ESCO	Energy service company
ESMAP	Energy Sector Management Assistance Program
GEF	Global Environment Facility
GHG	Greenhouse gas
IBRD	International Bank for Reconstruction and Development
ICR	Implementation and Completion Results Report
IDA	International Development Association
IEG	Independent Evaluation Group
IFC	International Finance Corporation
IPP	Independent power producer
IPR	intellectual property rights
IRR	Internal rate of return
MIGA	Multilateral Investment Guarantee Agency
OECD	Organization for Economic Cooperation and Development
PCF	Prototype Carbon Fund
PES	Payment for environmental services
REDD	Reduced Emissions from Deforestation and Degradation
REDP	Renewable energy development project
ROE	Return on equity
SFDCC	Strategic Framework on Development and Climate Change
SHS	Solar photovoltaic home system
SME	Small and medium enterprise
T&D	Transmission and distribution
TWh	Terawatt hour
UNFCCC	United Nations Framework Convention on Climate Change
WBG	World Bank Group
Wp	Peak watts

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Climate change is one of the biggest long-term risks to global development. That threat has originated largely owing to the greenhouse gas emissions of developed countries, which continue to emit far more per capita than developing countries and which are obliged by the Climate Convention to take the lead in fighting climate change. But developing economies also add to pressure on the limited remaining space for atmospheric carbon dioxide, and their actions, too, matter importantly.

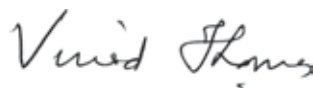
No comprehensive global agreement yet spells out how the Climate Convention's goal of stabilizing atmospheric greenhouse gas levels will be accomplished and financed. Clearly, developed countries will need to throttle back their emissions. The challenge for developing countries is to create a cleaner path to rapid growth than has prevailed in earlier growth episodes, avoiding needless local environmental damage and taking advantage of emerging technologies and financing opportunities. In the absence of a global agreement, the World Bank Group (WBG) has to chart its course, focused on today's urgent development needs yet mindful of long-term risks.

The Strategic Framework on Development and Climate Change walks this tightrope. While putting development first, it urges the WBG to seek “no regrets” actions that advance development with cobenefits in climate change mitigation, while mobilizing funds to defray the added costs of low-carbon growth. The Framework has accelerated a

proliferation of innovative efforts in energy, forestry, transport, and other fields. This evaluation, which focuses mostly on the pre-Framework period, begins the work of sorting out the results of those efforts.

Because the WBG is a small player in the climate arena, in a world of immense needs, it must be as efficient as possible in catalyzing development and greenhouse gas mitigation. It must first be cognizant of where the “no regrets” options lie. If hoped-for climate finance materializes on a large scale, clients and funders will want hard, reliable information on the most effective ways to fund low-carbon development. They will also want to understand the trade-offs and complementarities among social, economic, and climate goals. So a sound, evidence-based results framework—focused on measures of economic and carbon outcomes—is critical.

The WBG has the potential to make a difference greater than its size suggests. It can provide support for policies that enable low-carbon growth. It can contribute to transferring and adapting innovations in technology, finance, and institutions, developing a portfolio of high-return options that can be scaled up and widely deployed. And it can finance and deploy the innovations it has incubated. To do so, it will need to tap the immense value of its experience with countries and partners across the World Bank, the International Finance Corporation, and the Multilateral Investment Guarantee Agency, learning rapidly from its successes and failures and constantly improving its efforts.



Vinod Thomas
Director-General, Evaluation

Executive Summary

Unabated, climate change could derail development, with a one in four chance of a six-degree Celsius hike in temperature this century. Although industrialized countries are historically responsible for the build-up of heat-trapping greenhouse gases (GHGs), the United Nations' goal of stabilizing atmospheric GHG levels requires urgent and concerted worldwide efforts. Choices and investments made in the next two decades—in buildings, power plants, transport systems, and forest use—will irreversibly shape the global climate's future.

This evaluation seeks lessons for development and climate change mitigation from the World Bank Group's (WBG) far-reaching portfolio in energy, forestry, and transport. The assessment is not exhaustive but covers subsectors that represent the great bulk of evaluable WBG activity with potential GHG cobenefits. Over the period 2003–08 the WBG scaled up annual investments in renewable energy and energy efficiency from \$200 million to \$2 billion and helped mobilize more than \$5 billion in concessional funds for GHG reduction. In 2008 it adopted the Strategic Framework on Development and Climate Change (SFDCC), which triggered a spate of investment and analytic activity, too new to assess. Yet the WBG's resources are small compared with the multitrillion dollar investments needed for low-carbon growth. How can the Bank have the greatest impact, both for development and for GHG mitigation?

One important way the WBG can achieve leverage is through **advice and support for favorable policies**: removal of energy subsidies and of other biases against renewable energy and energy efficiency. This topic was covered in Phase I of this evaluation series (IEG 2009).

A second way is to **act more like a venture capitalist**—in the public sphere as well as for private investments—**by supporting the transfer and adaptation to local conditions of existing technologies, policies, and financial practices**. By taking modest risks in pilot projects, the WBG can identify a high-return portfolio of development solutions that can be deployed on a large scale, as climate finance expands. The WBG has been successful in this kind of technology transfer—but only when demonstration and diffusion mechanisms were well thought out. Global Environment Facility (GEF) support has been crucial in mitigating clients' perceived risk, and expanded concessional funds will be needed for larger-scale demonstrations. Support for more advanced technologies has usually been unsuccessful, though there could be niches such as land use where the WBG has a role.

Third, the WBG can **refocus on high-impact sectors and instruments**. *Energy efficiency* stands out among areas for intervention. Early results suggest, for instance, that distribution of compact fluorescent lightbulbs offers economic returns that dwarf those of most WBG investments while providing significant cobenefits in carbon dioxide (CO₂) reduction, exemplifying the Strategic Framework's call for “no-regrets” investments. To meet power demands, the WBG's scarce human and financial resources will be best spent helping clients find domestically preferable alternatives to coal power, such as through increased energy efficiency. Coal support should be a last resort used only when lower cost and concessionally financed alternatives have been exhausted and when there is a compelling case that WBG support would reduce poverty or emissions.

Among *forest interventions*, indigenous and protected areas that permit sustainable use have reduced tropical deforestation by up to two percentage points a year (compared with unprotected areas), thus promoting social, environmental, and climate goals. Among *instruments*, carbon finance needs to be redirected away from hydropower, where it has minimal impact on project bankability, to applications where it can have more leverage. Long-duration loans are critical for support of renewable energy. Guarantees have not transformed the market for energy efficiency lending but could be increasingly important for renewable energy as investors seek reassurance that favorable policies will be maintained over the long run.

To pursue this agenda, the WBG should **orient itself strongly toward results and closely monitor performance**. In this fast-changing area, being able to understand what is working, what's not, and why is a source of value for the institution, for its clients, and for the world.

Evaluation Framework

This evaluation reviews a broad range of WBG activity in the adoption and diffusion of emissions-reducing technologies and practices. It addresses three main concerns:

- What actions will deliver the greatest overlap between GHG mitigation and local development?
- Where and how does the WBG have the highest leverage in promoting those actions?
- How can the WBG best use feedback from ongoing experience to improve performance?

Because the range of activities is great, because most have not yet been subject to a final evaluation, and because most do not generate consistent and accessible data on impacts, the evaluation is selective, though it covers the bulk of evaluable WBG experience. Within each of the main GHG-emitting sectors—energy, transport, and forestry—it examines specific issues that capture a large part of the relevant WBG portfolio (such as support for energy efficiency via financial intermediaries), illuminate sectorwide issues (such as the role of finance for grid-connected renewables), or pioneer novel approaches (such as payment for ecosystem services). It also addresses three special issues: technology transfer, the WBG's carbon funds, and the role of the WBG in coal power. The evaluation looks at how the WBG has diagnosed barriers to technology adoption, the effectiveness of prescribed interventions, and likely economic and mitigation impacts.

The first volume of this climate change evaluation (IEG 2009) looked at WBG support for key areas of policy reform. This second volume focuses on two other areas of intervention: (i) development, transfer, and demonstration of technical and financial innovations and (ii) finance and implementation.



Findings

WBG-supported interventions vary widely in nature and effectiveness. This evaluation first looks at sectoral findings and then at cross-cutting lessons and recommendations.

Congruence of mitigation and development

There is ample scope for projects that promote local development goals while also mitigating GHGs. (See figure 6.1, which illustrates economic and carbon returns for a range of energy projects.) Energy efficiency, more than other investments, offers a combination of high economic returns and GHG benefits. Other projects may individually have high carbon returns (forestry) or economic returns (solar home photovoltaic systems). To optimize carbon and economic gains, it may often be necessary to construct portfolios of projects, rather than pursue multiple goals with a single instrument.

Renewable energy

Grid-connected renewable energy reduces CO₂ emissions, offers the additional domestic advantages of local air pollution reduction and energy security, and could potentially stimulate industrial development. But investors may not take account of the national or global benefits. Lenders may shy away from capital-intensive investments in less-proven technologies. Utilities may not know how to deal with intermittent energy sources.

Technical assistance can help overcome these barriers. The World Bank helped Sri Lanka institute standardized small power purchase agreements that facilitated access to the power grid. Analytic work, capacity building, and demonstration have contributed to Mexican and Chinese adoption of favorable renewable energy payment schemes, which in turn have stimulated more than 20 gigawatts of installed wind capacity in China and hundreds of megawatts under construction in Mexico.

Provision of long-duration loans (as in lending by the International Finance Corporation [IFC] and World Bank on-lending projects) has a much bigger impact on project bankability than the purchase of carbon credits, at current carbon prices. As countries increasingly rely on paying price premiums for renewable energy, World Bank and Multilateral Investment Guarantee Agency (MIGA) guarantees against breach of contract and other political risks could be catalytic.

The WBG's direct lending for renewable energy is dominated by hydropower, the only grid technology for which there is a substantial evaluable record at the WBG. Among evaluated hydropower plants, 76 percent had outcomes rated as moderately satisfactory or better, with better ratings in recently initiated projects. Unsuccessful projects are often those for which preparation or implementation of

resettlement plans has been ineffective. About two-thirds of hydropower investment volume now goes to run-of-river hydropower (that is, without substantial reservoirs), which has less potential for local social and environmental damage but is more vulnerable to climate change.

Direct WBG investments in wind power have been modest. On average, wind power offers significantly lower economic and carbon returns than hydropower because of high capital costs and often low capacity utilization. Manufacturing cost reductions at the global level, together with better siting and maintenance, are crucial to increasing the competitiveness of wind and other new renewable energy technologies.

The largest single area of off-grid renewable energy investment has been in solar photovoltaics, mostly for home use. Since 1992, the WBG has contributed \$790 million to solar home system (SHS) components in 34 countries, almost all using GEF-funded subsidies. World Bank efforts, using quality-contingent producer subsidies and relying on microfinance for consumers, have been more successful than those of IFC. These projects can have economic rates of return of 30–90 percent but have little impact on GHG reductions because off-grid households use so little energy. At current prices, SHSs have been successful in a narrow niche market: the off-grid household that is either relatively well-off by rural standards or can access good microfinance services.

Energy efficiency

Phase I of this evaluation (IEG 2009) assessed the most important barrier-removing policies: energy price reform and promotion of energy efficiency policies such as building and appliance standards. It noted that the Bank had pursued price reforms in energy but had relatively few—and modestly funded—projects dealing with energy efficiency. Since then, there has been increased attention to policy-efficiency linkages, including Bank-IFC support for a recently adopted energy efficiency law in the Russian Federation, support for a G20 study of energy subsidies, and a recently approved Vietnam power sector development policy operation.

Owners of factories and buildings often fail to borrow for apparently highly profitable energy efficiency opportunities. The WBG's diagnosis: Borrowers lack information, and lenders lack experience and comfort with energy efficiency project finance. The largest WBG response has been to support financial intermediaries—banks, special-purpose funds, and energy service companies—with guarantees and technical assistance. These programs have appropriately been directed to China and Eastern Europe, where energy inefficiency has been high.

Parallel programs have been implemented by the World Bank and IFC, both supported by the GEF, and without

much communication between them. Yet, contrary to expectations, loan guarantees have turned out not to be a temporary, market-transforming measure that could be discontinued once the banks gained familiarity with energy efficiency lending. Inadequate lending for energy efficiency often reflects wider credit market failures, including onerous requirements for collateral.

Guarantees have triggered energy efficiency lending to credit-strapped small and medium enterprises. Because borrowers achieved high rates of return, guarantee programs could achieve higher impact through tighter targeting on less creditworthy companies.

World Bank-supported projects have been successful in introducing energy service companies (ESCOs) to China, with high returns, significant GHG impacts, and spontaneous replication. However, further replication and scale-up must address the ESCOs' own credit problems and recognize that energy performance contracting, the standard paradigm for ESCOs, may require major adaptations in many developing countries.

IFC also lends directly to industry for energy efficiency. IFC's program of screening its clients for energy efficiency opportunities supports mostly small loans with low GHG impacts.

Three areas of existing activity stand out as having high impact and high potential for scale-up: first, proactive IFC support for energy efficiency in the atypical but important cases of large, carbon-intensive factories that face credit or information barriers; second, increased support for transmission and distribution loss reduction, which offers economic rates of return of 16–60+ percent and lifetime carbon returns of 7–15 kilograms per dollar. Third, substitution of compact fluorescent lamps (CFLs) for incandescent lamps offers estimated direct economic returns (in saved energy) of 50–700 percent, together with deferred construction of power plants and emissions reductions of 27–134 kilograms of CO₂ per dollar. These returns would be further magnified if initial projects catalyzed spontaneous diffusion of CFLs. However, rigorous evaluation of CFLs is lacking.

Forestry

Forest loss, especially in the tropics, generates a quarter of developing countries' emissions. The local and global values of standing forests often greatly exceed the gains from destroying those forests. Tapping this value could therefore offer large economic and GHG gains. The Forest Carbon Partnership Facility is a pilot that explores options to monetize the value of standing forests. However, the mechanisms to use the funds to conserve forests are still being planned. World Bank experience provides some models for scaling up.

Payment for Environmental Services programs also seek to reward property owners who maintain forests. World

Bank-supported programs in Costa Rica and Mexico have demonstrated the logistics of paying for services and have helped to globally popularize this approach. However, a substantial proportion of payments has gone to areas that are not at high risk for deforestation, diluting carbon and environmental benefits and prompting attention to targeting.

The most prominent line of action associated with forest conservation is support for protected areas. These now cover more than a quarter of the tropical forest estate, an area equivalent to Argentina and Bolivia combined, much of it with World Bank support. A global analysis shows that these areas are on average effective in reducing deforestation. Areas that allow sustainable use are more effective than strictly protected areas, and indigenous areas are most effective of all. They also offer precious biodiversity benefits. These findings support the feasibility of the Reduced Emissions from Deforestation and Degradation initiative (REDD) in combining sustainable development and forest conservation.

Urban transit

Growing transport demand clogs limited roadway space in the developing world, resulting in severe congestion, air pollution, and GHG emissions. The single largest WBG response has been to support the deployment of bus rapid transit systems, which cost much less than tramways or subways. Key barriers have been the lack of intermunicipality coordination, and opposition by displaced minibus drivers. However, systems have been successfully initiated in Bogota and Mexico City and are being expanded there and replicated elsewhere.

The immediate economic benefits in Mexico City provide an estimated 81 percent economic return and a GHG return of 10 kilograms per dollar. Larger, sustainable long-run gains will require demand-side management of traffic and rational land use planning.

Coal power

Coal is a cheap source of power for a power-hungry world, but coal is a major source of GHG emissions. How does the WBG maximize development returns for clients with no GHG reduction obligations, while protecting other clients threatened by GHG emissions regardless of their source? SFDC criteria restrict WBG support to instances where coal has the lowest cost after environmental externalities have been considered, there is optimal use of energy efficiency, and no concessional funds are available to finance the incremental cost of low-carbon alternatives.

The Independent Evaluation Group (IEG) examined five pre-SFDC coal power projects to determine whether WBG involvement contributed to greater efficiency and whether lower-carbon alternatives had been considered.

IEG found that none of the investment cases would have met the SFDC criteria, either because they were not least-cost for generation after accounting for local air pollution burdens or because they did not fully explore efficiency alternatives. The complexity of the issues, however, is illustrated by IFC's support for a supercritical coal plant in India. On one hand, it will be one of the largest point sources of CO₂ on the planet, adding to the atmosphere's pre-existing burden as GHG concentrations climb toward dangerous levels. On the other hand, it may nevertheless have reduced emissions by about 10 percent compared with a scenario without IFC involvement, and indirectly accelerated the diffusion of this higher-efficiency technology in a country that will continue to rely on coal for decades to meet urgent power needs. More than a quarter of India's power is lost in transmission and distribution. Nationwide, reduction in distribution losses and other efficiency measures can offer higher returns in power availability, local environmental improvement, and GHG reductions than new construction.

The WBG's highest leverage for promoting low-carbon growth is at the level of the power system. The World Bank's technical assistance to Kosovo points to a way of resolving the tensions surrounding coal. A study (World Bank 2005) assessed options for power system expansion using a systemwide power model that accounted for local health costs from pollution. It showed if CO₂ abatement was valued at €10 per ton, it would be optimal to retire small, inefficient coal plants but also to construct a large, efficient one. (The impact of higher carbon prices was not explored.) Models like this, if extended to include energy efficiency as an alternative to expanded generation, can serve as a basis of discussion for identifying technical and financial options for pursuing low-carbon growth at a national level.

Carbon finance

As an *institutional innovation*, the World Bank's Carbon Finance Unit (CFU) has played an important demonstration role in helping open an entirely new field of environmental finance, popularizing the idea of carbon markets, and contributing to the institutional infrastructure of the market.

The Bank's carbon business exit strategy called for the CFU to relinquish its role as carbon offset buyer as the private market began to flourish. But although the Bank indeed moved into higher-risk, pilot areas of the carbon market (the Forest Carbon Partnership Facility and the Carbon Partnership Facility), it continued to build up its lower-risk Kyoto-oriented business after that market was already thriving. It also failed to mainstream carbon finance within the Bank.

As a *vehicle for catalytic finance and technology transfer*, the CFU's record is mixed. It has contributed to the diffusion

of some technologies, such as landfill gas, and supported first-of-kind technology investments in some countries. The BioCarbon Fund and the Community Development Carbon Fund have supported small-scale, rural, and forestry projects—and learned in the process that this is difficult to do.

In contrast, much of the CFU's support for energy technologies has gone to projects where its financial leverage—and hence its catalytic impact—was relatively small. In addition, two-thirds of carbon fund purchase commitments have been for projects that destroy HFC-23, a highly potent, industrially generated GHG. The projects tapped a Chinese low-cost GHG abatement opportunity and gave participating companies high profits, 65 percent of which were then taxed for development purposes. Although this was an allowable use of the carbon market, an alternative would have been to use international funding to pay only for the low marginal costs of destroying the gas, deploying carbon funds with higher leverage elsewhere.

Technology transfer

Technology transfer is one of the pillars of the Bali Action Plan (under the United Nations Framework Convention on Climate) and of the SFDCC. The WBG has contributed to the transfer of existing clean technologies through projects that pilot, debug, demonstrate, and diffuse innovations in engineering and finance. These have been successful when the logic of demonstration and diffusion has been well thought out.

The Renewable Energy Development Project (China), for instance, used a combination of quality-contingent subsidies, research and development grants, and technical assistance to foster the growth of a competitive solar photovoltaic industry. The Energy Conservation Project supported China's first ESCOs, with strong emphasis on knowledge sharing and diffusion. The Regional Silvopastoral Project in Latin America piloted different approaches to integrating trees with pasture, rigorously documenting that some techniques were highly profitable even without reckoning carbon and biodiversity benefits, and was able to convince the Colombian government to scale up the project. In all these cases, GEF support was essential to mitigate up-front risk and to pay for global benefits of knowledge created.

Conversely, technology transfer has foundered in the absence of a solid logical framework that links interventions to technological diffusion, especially in the case of advanced technologies. Early efforts to support concentrated solar power, for instance, incorrectly assumed that a few scattered projects would spur cost reductions at the global level. (A new concentrated solar power initiative under the Clean Technology Fund is more appropriately

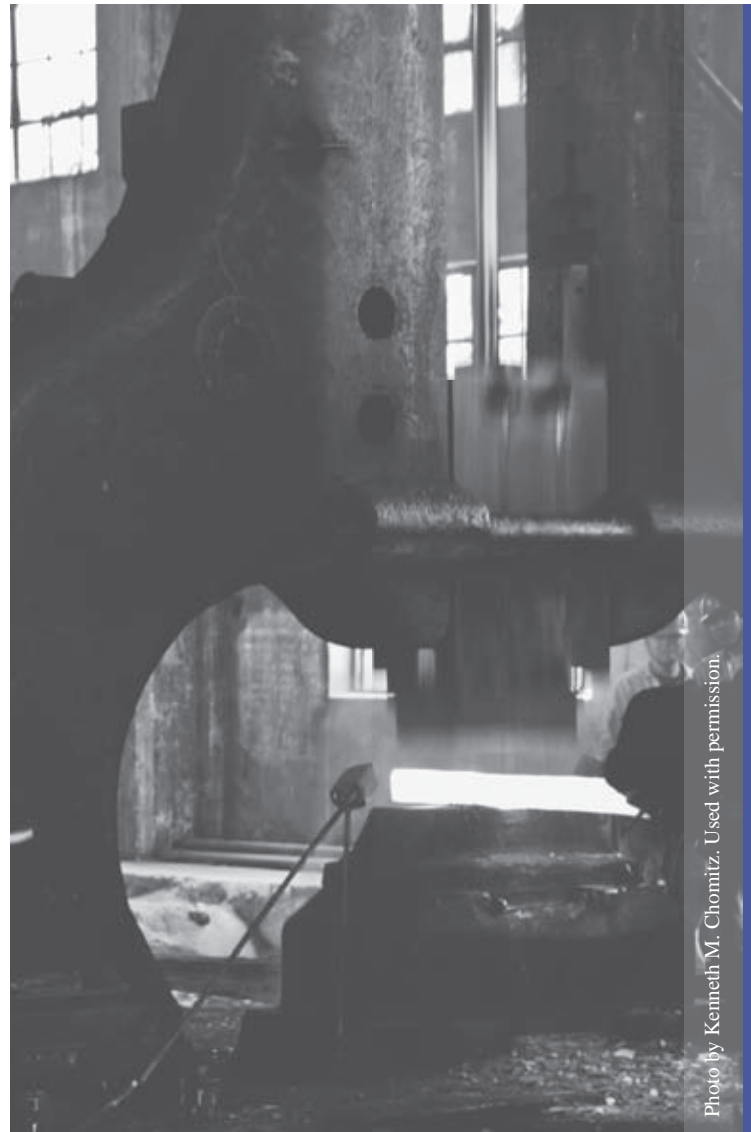


Photo by Kenneth M. Chomitz. Used with permission.

scaled.) Projects incorrectly assumed that private beneficiaries of technology (such as recipients of technology licenses in the China Efficient Boilers Project) would share proprietary technology with competitors. Several IFC investments, pursuing multiple but conflicting objectives, tackled an insurmountable combination of inexperienced entrepreneurs, unfamiliar technology, and an uninterested target market. Finally, both the concentrated solar power and efficient boiler projects underestimated the difficulty of procurement when technology suppliers are few and costs are poorly known—an inherent feature of newer technologies.

Learning and incentives

Rapid feedback and learning is essential for adapting technology to new sites, for deciding which technologies to scale up, and for ensuring that they are working as planned. Technology demonstration projects work best when it is clear what is being demonstrated, how, and to whom. Although recent demonstration projects have good plans

for monitoring their direct results, they do not yet track how effectively these results are reaching their intended audience.

As other IEG reports have noted, cost-benefit analysis has fallen out of fashion, impeding the WBG's ability to identify high-return investments. The estimates quoted here remain an unvalidated and possibly overoptimistic guide. The lack of good impact evaluations of forest projects, for instance, has deprived the REDD agenda of urgently needed guidance on how best to combine forest protection with economic development.

Publicly disclosed monitoring of carbon projects shows the gains from feedback. Landfill gas projects proliferated with the advent of the carbon market, but monitoring reports soon showed that these projects were systematically underperforming, relative to their design expectations. This feedback revealed that the appraisal models were based on US experience, which is inapplicable to the waste streams of developing countries. The WBG helped to publicize this discovery.

Newer projects have incorporated design and operational lessons. This kind of systematic feedback is missing from most projects, though IFC's monitoring system is beginning to cover it. Feedback is especially needed for renewable energy projects, where economic and carbon impacts are proportional to capacity utilization. Many hydropower and wind projects are underperforming for reasons that are not clear.

At the organizational level, the WBG has framed SFDC goals in terms of dollars committed, rather than outcomes or impacts. This sets up poor incentives. For instance, energy efficiency projects are expensive in staff time and lead to relatively modest volumes of lending, yet can benefit clients more than cheaper-to-prepare, larger-volume generation projects.

Recommendations

The WBG should maximize its leverage in promoting low-carbon development. This will require a strategic approach to portfolio choice, instruments deployed, and technology policy. And it means scaling up what works and redesigning what does not, using learning to unlock value for clients and for the world. Key aspects are as follows.

Act like a venture capitalist

In both the public and private spheres, the WBG can support the transfer, adaptation, piloting, and demonstration of innovative technologies, policies, and financial practices—as it has, for instance, with ESCOs, bus rapid transit, solar home systems, and agroforestry. These demonstrations carry risks but can offer high returns. What

counts for clients, the WBG, and the world, however, is the return on the portfolio in development, poverty reduction, and GHG mitigation.

A first challenge is to mitigate risks. This means using GEF or other concessional funds (grants or low-interest loans) to support the earliest and riskiest ventures, so that failures are less costly to borrowers. Because of the potential for high returns, this could be a much higher-leverage use of climate finance than the purchase of carbon offsets from marginally profitable renewable energy projects. Risk is further mitigated by staging successively larger pilots and demonstrations, from test site to province to nation. With increasing experience and comfort, scale expands and risk declines. Changes are necessary, too, in internal WBG incentives to reward staff and managers for conducting informative pilots and for producing results at the portfolio rather than the project level.

A second challenge is to design projects effectively for learning and diffusion. Pilot or demonstration projects must have a clear, logical framework showing how they will promote diffusion the knowledge gained through experience. Pilot, demonstration, and technology transfer projects require additional support for preparation and supervision in funding and on-call expertise.

Though there is a clear case and large scope for WBG involvement in technology transfer at the national level, the case is less clear for WBG involvement in new technology development at the global level. Candidate technologies would be those where WBG support could make an appreciable difference to the global market, helping to push costs down. Of special interest are technologies that benefit poor people and are difficult to protect from copying (and therefore attract little private R&D)—for instance, in agriculture and land use. The proposed new WBG effort to support concentrated solar power is a plausible area of support because a large proportion of the suitable resource is located in client countries, the technology is suitable for manufacture in client countries, and the proposed effort is sufficiently large to globally push the industry down the cost curve.

The World Bank and IFC should—

- **Create incentives and mobilize resources to support effective pilot, demonstration, and technology transfer projects that have a clear logic of demonstration and diffusion.** This will include mobilizing GEF and other concessional funds to mitigate World Bank borrower risk, reshaping incentives for staff and managers, providing adequate resources for the design and supervision of complex projects, and making available specialized expertise in technology transfer and procurement through a real or virtual technology unit.

Scale up high-impact investments

Energy efficiency offers high economic and carbon returns. The WBG should—

- **Place greater emphasis on large-scale energy efficiency scale-up, as measured by savings in energy and reduced need for new power plants.** This includes support for efficient lighting and for exploring the scope for accelerating the global phase-out of incandescent light bulbs. It also includes continued and expanded support for reductions in transmission and distribution losses. And it includes a proactive search by IFC for large-scale, catalytic investments in energy efficiency. There is scope to coordinate World Bank support for demand-side energy efficiency policies with IFC support for more efficient manufacturing and more efficient products.

The WBG should, wherever possible, help clients find cleaner, domestically preferable alternatives to coal power. Moreover, the WBG faces strategic choices in staffing and programming between building up expertise in “sunrise” sectors of broad applicability and limited private sector competition (energy efficiency, land use management for carbon, energy systems planning) versus “sunset” sectors such as coal power. The WBG should—

- **Help countries find alternatives to coal power while retaining a rarely used option to support it,** strictly following existing guidelines (including optimal use of energy efficiency opportunities) and being restricted to cases where there is a compelling argument for poverty or emissions reductions impacts that would not be achieved without WBG support for coal power.

The WBG cannot tackle this issue alone. Complementary financing for renewable energy and investments in technology R&D are needed from the developed world to provide better options for the WBG’s clients.

Protected areas—especially those permitting sustainable use—reduce tropical deforestation, providing local environmental benefits as well as carbon emissions reductions. The WBG should—

- **Continue to explore, in the REDD context, ways to finance and promote forest conservation and sustainable use, including support for indigenous forest areas and maintenance of existing protected areas.**

In terms of its instruments—

- **MIGA’s upcoming FY 2012–15 Strategy should outline the role and scope for MIGA to provide political risk insurance to catalyze long-term financing for renewable energy projects,** building on its expertise

and existing portfolio of climate-friendly guarantee projects.

- The World Bank should **enhance the delivery of its guarantee products** by taking actions to improve policies and procedures, eliminate disincentives, increase flexibility, and strengthen skills for the deployment of the products. It should assess the potential for greater use of partial risk guarantees to mobilize long-term financing for renewable energy projects, particularly in the context of feed-in tariffs or other premiums to support investment in renewable energy.
- **The Carbon Partnership Facility and other post-Kyoto carbon finance efforts should focus on demonstrating effective technical and financial approaches to boosting low-carbon investments.** Funds and facilities should have clear exit strategies.

Reorient incentives toward learning and impact

There is an urgent need to better understand the economic, social, and GHG impacts of a wide variety of scalable interventions. How can REDD programs incorporate the lessons of protected areas, environmental services payments, and community forestry? What is the best way to encourage energy efficiency in the building sector?

Traditional evaluation cycles are too slow when tens of billions of dollars may be deployed annually for climate finance and where there is a danger of lock-in to high-carbon growth. At the same time, information costs are plummeting, remote sensing resources are multiplying, and cell phone access is nearly universal. By wiring up projects to return early information on impacts, global innovation can be accelerated and the WBG can optimize project supervision and new project design.

The WBG’s extensive project portfolio and support for country strategies makes it a natural nexus for this global public good. The WBG should—

- **Measure projects’ economic and environmental impact both during execution and after closure and aggregate this information for analysis.** For instance, renewable energy projects should monitor capacity utilization, and energy efficiency projects should monitor energy savings. This may require the use of concessional funds to defray additional costs of monitoring by staff, clients, and project proponents.
- **Link these measures to a results framework that shifts the SFDC toward a focus on outputs such as power produced, power access, forest cover, and transit share of urban trips, rather than on money spent.**

Management Response

I. Introduction

Management welcomes the second phase evaluation by the Independent Evaluation Group (IEG) of lessons-learned for development and climate change mitigation from the World Bank Group's (WBG) portfolio in energy, forestry, and transport. As noted in the first phase evaluation (IEG 2009), IEG's evaluation covering the expanding project-level experience of the Bank and the International Finance Corporation (IFC) in promoting renewable energy, energy efficiency, and carbon finance enables a comprehensive assessment of the focus and success of the WBG's efforts on low carbon development. Management appreciates the fact that this report covers activities across the entire WBG, including IFC and the Multilateral Investment Guarantee Agency (MIGA).

The report addresses a very important topic and summarizes a major exercise to review how the WBG portfolio has been contributing to low-carbon growth objectives. It approaches this exercise from an appropriate and constructive angle: not to be the "judge" of the past WBG performance in promoting low-carbon growth, since, until very recently, it was not a stated WBG objective, but rather to use available experiences and lessons to inform future actions. It correctly recognizes that projects can contribute to low-carbon growth even if they do not necessarily include it in development objectives, and thus assesses a wide pool of projects with and without explicitly stated mitigation related objectives. While the report does not look at every sector and subsector where significant mitigation cobenefits can be obtained, its selection of sectors is reasonable.

Management appreciates the many useful observations and suggestions provided in the report and concurs with aspects of IEG's main findings. Many of these comments reinforce the messages expressed in the WBG Strategic Framework on Development and Climate Change (SFDCC) and are complemented by emerging lessons from analytical studies, sector strategies, and relevant project level experiences across the WBG. At the same time, management differs with some of IEG's findings and recommendations.

II. Key Issues of Agreement and Divergence

Overview of response

This Management Response first outlines the areas in which management broadly agrees with the analysis in the review, noting, however, areas where IEG could have given a fuller

account of efforts the WBG has made or is making. It then discusses areas in which Management believes that IEG has drawn conclusions from an analysis based on limited coverage, without fully taking into account the significant ongoing changes that have been facilitated by the adoption of the SFDCC.

A. Areas of agreement

Low-Carbon Studies. Appendix J, referring to the low-carbon pilot program, provides a useful summary of the available work. It also includes the comment that access to energy is generally not considered. Management would like to emphasize that this statement should not be generalized about all work on low-carbon studies, since the observation is based only on work presently in the public domain (for example, Brazil and Mexico and the review of renewable energy targets and power dispatch efficiency for China). The low-carbon study for India has paid attention to the access issue.

In addition, the appendix does not address the issue of long-term planning (20 years+) and demand for capacity building in this area, which has been integral to the low-carbon work along with the need to engage and build consensus across broad stakeholder groups. These are the emerging key lessons, and as such should be incorporated in the low-carbon work to be pursued in the future.

Development cobenefits. With respect to the issue of energy access, IEG correctly notes that monitoring and evaluation data are rarely available to quantify cobenefits of low-carbon interventions in terms of poverty reduction, energy/transport access, and gender equity. In this regard, management believes that it is worth noting the priority being given to developing results frameworks for the SFDCC and the Climate Investment Funds (CIF). This ongoing work aims to identify indicators which would allow for a better tracking of distributional and gender dimensions, with a view to assessing the extent to which development cobenefits actually result from low-carbon interventions. A new set of International Development Association (IDA) core indicators has also been prepared to better capture the development impacts of energy projects. Also, the forthcoming report on transport and climate underscores the impact of development cobenefits in moving toward a low-carbon transport sector.

Finally, since the issue of development cobenefits is of central importance to the WBG, management feels that it

should have been strengthened in the report. This would have helped identify a set of concrete suggestions on how best to capture and measure the potential development dividend of low-carbon growth.

B. Areas of divergence

Strategic direction. Management is of the view that several major policy decisions made by the WBG on climate change needed to be better reflected in the IEG report. Specifically, the report tends to imply that the SFDCC requires “optimizing” both local and global benefits and outcomes. However, this premise is not the message of the Strategic Framework; the SFDCC very clearly states that the WBG is to help clients “maximize” national and local development outcomes, taking advantage of low-carbon growth opportunities to achieve these outcomes whenever possible. It would have been better if the IEG report had correctly presented current WBG policies as articulated in the SFDCC.

While the IEG report makes selective references to specific recent initiatives that draw on lessons from experiences over the study period, it does not recognize the significance of ongoing changes that have been facilitated by the adoption of the SFDCC. These changes cut across project design and implementation, corporate targets, and new financial instruments and are also reflected in organizational restructuring as well as addition of new staff with specialized expertise. While it is too soon to evaluate their impact, these actions are indicative of greater corporate commitment to addressing climate change. For example, climate change work has become a major focus of IFC’s business.

The IEG report should also have emphasized more strongly that the “debate” has moved beyond “low-carbon” development to “climate smart” development as noted in the World Development Report 2010, taking into account synergies that exist between climate resilience and low-carbon growth.

Cleaner production. An area of difference in views concerns IFC’s Cleaner Production (CP) program, which IEG summarizes as dedicating “significant resources ... to small loans” and largely dependent for impact on concessional lending. In contrast, management perceives cleaner production more broadly as part of a systematic approach to helping clients identify opportunities for resource and energy efficiency which can be implemented at low cost and with continuing benefits. Management would like to stress that the CP program is one initiative among others that aim to improve resource-use efficiency in IFC operations.

Coal power. Management would like to emphasize that the application of the system analysis suggested for evaluating investment decisions for coal power projects should take into account differences across power markets. The IEG report’s conclusion that investment in transmission and

distribution (T&D) loss reduction would avert the needed capacity addition from the Tata Mundra project in India is oversimplified. This conclusion does not account for differences in power supply-demand balances or the level of T&D losses within India’s regional networks (the 27 percent T&D losses cited in the report is an average across five regional networks). An investment decision on capacity additions is always linked to a prospective service market, not to the entire country. The analogy of using the same system wide approach as for the Kosovo electricity system analysis is an inappropriate extrapolation, since the total system capacity is only about 1,000 MW linked through a single national transmission network. For Kosovo, any investment in T&D loss reduction will result in capacity availability in any region of the country; whereas in India, the power market is much larger, and the supply-demand situation varies locally.

Energy efficiency. Management is of the view that the report’s evaluation of energy efficiency is somewhat oversimplified in that it does not include a discussion of operationally-relevant nuances vis-à-vis energy efficiency barriers. By limiting the discussion to specific financing tools such as credit lines, the analysis does not fully appreciate the broader challenges in dealing with energy efficiency implementation through key delivery mechanisms (for example, incentive systems, market-based approaches, and regulatory policies to implement energy efficiency sub-projects) which are required to overcome energy efficiency sector constraints and address transaction risks. Furthermore, by focusing on only a few types of interventions, the discussion does not mention some of the barriers addressed through other operations (technical assistance, policy work, and so forth), which are meant to create additional drivers for energy efficiency (mostly through incentives or through new policy drivers). As a result, the evaluation depicts an incomplete picture of World Bank programs in some countries, most notably in China.

Management also believes that barriers to investment in energy efficiency, particularly within many large energy-intensive industries, remain significant and justify continued targeted efforts to work with banks and commercial lenders. This conclusion is underscored by recent announcements of setbacks in achieving Chinese targets for energy efficiency improvements in key industrial sectors. IEG’s methodology, which relies primarily on self-reporting by industrial enterprises already under government mandate, needs to be reassessed, with more attention given to commercial realities and constraints on clean energy lending.

Outstanding data issues. Management finds that the data file provided in the report is difficult to reconcile with the energy database, and as such, does not allow for verification of IEG’s numbers. Further efforts to ensure consistency of data would be desirable.

Technology. As a general observation, in recent years the WBG has been becoming much more involved in the promotion of efforts to develop and transfer new energy technologies. These efforts build on donor-funded programs, particularly the Global Environmental Facility (GEF) and more recently the Clean Technology Fund (CTF), but also include significant on balance sheet investments by IFC's clean tech unit and funds department. The combined resources of the WBG, GEF and CTF, if leveraged, can help scale up advanced technologies including concentrating solar power (CSP) and carbon capture and storage (CCS) in developing countries. IEG should have recognized the WBG's efforts in this regard, including the establishment of the CCS Capacity Building Trust Fund in 2009. The WBG's proactive approach to CSP and CCS is helping to considerably change the Bank's role in supporting advanced technology transfer.

Carbon finance. There are significant differences between the views of management and the IEG report with regard to the exit strategy, knowledge transfer, and technical assistance provided through the Bank's involvement in carbon finance. The report does not differentiate between carbon markets (e.g., the market for allowances in Europe and the Clean Development Mechanism market), and fails to understand that withdrawal by the Bank in 2005 from the carbon markets where its Carbon Finance Unit operates would have been catastrophic to the long-term stability of these markets. Management also believes that the report should have acknowledged that a major goal of carbon markets was to bring in private capital as per United Nations negotiations, and that the unpredictable nature of carbon flows poses a fundamental problem in using carbon financing in the Bank and elsewhere. Management feels that the report misses the knowledge transfer and technical assistance provided through instruments such as the Prototype Carbon Fund Plus, Community Development Carbon Fund (CDCF) Plus, or Forest Carbon Partnership Facility (FCPF) Readiness Fund, and by the World Bank Institute's CF Assist program, all of which help increase the availability of

carbon finance to potential projects inside and outside the Bank. Finally, the report argues that "carbon finance needs to be redirected away from hydropower, where it has minimal impact on project bankability." Here, management believes the report should have discussed alternative financing avenues, in particular for Africa, where hydro remains a vast and largely untapped reservoir of clean energy.

Management would have liked to see a stronger emphasis in the report on the potential role the Bank may play in promoting carbon finance reform, so as to facilitate transition toward programmatic and ecosystem based approaches, and speedier and simplified administrative processes.

Agriculture. IEG's review made the decision to exclude the agriculture sector, while acknowledging its contribution to greenhouse gas (GHG) emissions. Management believes, however, that given this sector's importance (together with Forestry it accounts for 30 percent of GHG emissions and more in many developing countries), the report should have recommended that management pay more attention to the role of agriculture, including livestock and land and water management, in low-carbon growth in the future.

In this regard, the report and its recommendations would have benefited from using a broader perspective. The evidence is that many of the "causes of deforestation" lie outside the forestry sector (for example, forest fires related to land clearing for agricultural intensification), and in the use of biomass energy (for example, wood and charcoal) for cooking and heating.

III. IEG Recommendations

Management welcomes and in general agrees with the IEG recommendations. These recommendations largely fit with what the WBG is doing at present, and are relevant to the Energy and the Environment Strategies currently under preparation. Management's specific responses to IEG recommendations are outlined in the attached draft Management Action Record.

Management Action Record	
Major monitorable IEG recommendations requiring a response	Management response
<p>The World Bank and IFC should— Create incentives and mobilize resources to support effective pilot, demonstration, and technology transfer projects that have a clear logic of demonstration and diffusion. This will include mobilizing Global Environment Fund and other concessional funds to mitigate World Bank borrower risk; reshaping incentives for staff and managers; providing adequate resources for the design and supervision of complex projects; and making available specialized expertise in technology transfer and procurement through a real or virtual technology unit.</p>	<p>Ongoing/Agree This recommendation is consistent with the SFDCC. Key ongoing work consistent with the recommendation includes—</p> <ul style="list-style-type: none"> • WBG expects to expand its partnership with GEF, which is well positioned to take on early research and development risks, through the recently established Technology Transfer Program and GEF/IFC Earth Fund. • Through the Clean Technology Fund (CTF), Scaling-up Renewable Energy Partnership (SREP) and Forest Investment Partnership (FIP), WBG is supporting technology scale-up with the help of innovative financing. • A climate technology program, launched in September 2009, is exploring the feasibility of climate technology innovation centers in developing countries as a way to stimulate locally relevant climate technologies and harness economic opportunities at the small and medium enterprise (SME) level (first centers already under development in Brazil, India, and Kenya). • A new MDTF has been established for supporting the introduction of CCS technologies and providing technical assistance to clients. • IFC’s clean-tech investment practice will be housed in the newly-created Climate Business Group. CLEANTECHNET is a practice group that meets virtually and in person to share knowledge and issues in the technology space. • The potential for additional initiatives to support these objectives will also be explored in the Energy Strategy.
<p>The WBG should— Place greater emphasis on large-scale energy efficiency scale-up, as measured by energy saved and generating capacity avoided. This includes support for efficient lighting and exploring the scope for accelerating the global phase-out of incandescent light bulbs. It includes continued and expanded support for reductions in transmission and distribution losses. And it includes proactive search by IFC for large-scale, catalytic investments in energy efficiency. There is scope to coordinate World Bank support for demand-side energy efficiency policies with IFC support for more efficient manufacturing and more efficient products.</p>	<p>Partially Agree WBG agrees with the general emphasis proposed, but does not agree with the specific action areas proposed. WBG does focus on large-scale or bundled energy efficiency projects to avoid high transaction costs associated with small-scale investments. Estimates of energy saved are computed as part of the appraisal of projects with energy efficiency components.</p> <p>However, World Bank finds the recommendations on efficient lighting and T&D to be rather prescriptive and limited in terms of scope and impacts. They do not account for a variety of untapped energy efficiency scale up opportunities and available long-term EE potential in other sectors, on both the supply and demand sides, which could have much larger impacts, such as in district heating, industry, and municipalities. IFC intends to increase its climate-related lending from 10 percent of annual commitments in fiscal 2009 to 20–25 percent in fiscal 2013, and will undertake a proactive search for suitable investments. Energy efficiency is expected to be a significant contributor to meeting this target. IFC will define an approach to estimating avoided emissions associated with its climate-related activity. IFC agrees with the potential for investments in manufacturing of more efficient products and is actively seeking such opportunities, having made several such investments in fiscal 2010.</p>

(continued)

Management Action Record *(continued)*

Major monitorable IEG recommendations requiring a response	Management response
<p>The WBG should— Help countries find alternatives to coal power while retaining a rarely used option to support coal power, strictly following existing guidelines (including optimal use of energy efficiency opportunities) and being restricted to cases where there is a compelling argument for poverty or emissions reductions impacts that would not be achieved without WBG support for coal power.</p>	<p>Ongoing/Agree The policy proposed is consistent with SFDCC criteria for coal investments. SFDCC criteria for coal investments have been clarified in the “Operational Guidance for the World Bank Group Staff: Criteria for Screening Coal Projects Framework for Development and Climate Change,” which took effect on April 15, 2010. The specific stress on “optimal use of energy efficiency opportunities” presented in the IEG recommendation seems unnecessary, as there are no priority criteria either in SFDCC or the Operational Guidance and all required criteria must be adequately addressed. The Operational Guidance makes clear that coal investments should focus on cases where there is a compelling argument for poverty reduction and a clear need for WBG support.</p>
<p>The WBG should— Continue to explore, in the REDD context, ways to finance and promote forest conservation and sustainable use, including support for indigenous forest areas and maintenance of existing protected areas.</p>	<p>Ongoing/Agree By definition, REDD+ includes reducing emissions from deforestation and forest degradation and addressing the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. The World Bank is assisting countries to engage in REDD+ activities through two programs: FCPF and FIP. Both of these will contribute to financing and promoting forest conservation and sustainable use, including support for indigenous forest areas and forest conservation. FCPF involves 37 countries, and has mobilized \$160 million for capacity building and performance-based payments to pilot projects which aim to open financial flows for sustainable management of forests and land. FIP, funded at approximately \$600 million, will pilot programmatic investments to reduce deforestation and forest degradation, promote sustainable forest management, and conserve forests in Brazil, Burkina Faso, the Democratic Republic of Congo, Ghana, Indonesia, Lao PDR, Mexico, and Peru.</p>
<p>MIGA’s upcoming FY 2012–15 Strategy should outline the role and scope for MIGA to provide political risk insurance to catalyze long-term financing for renewable energy projects, building on its expertise and existing portfolio of climate-friendly guarantee projects.</p>	<p>Partially Agree MIGA intends to address these issues in its annual business plan/budgeting process, but will not do so in the upcoming FY 2012–15 Strategy. MIGA will consider a set of actions aimed at supporting eligible renewable energy and energy efficiency projects. These actions are subject to the willingness of private sponsors to invest in renewable energy and energy efficiency projects and the need for political risk insurance as a risk mitigation tool and/or a facilitation mechanism for funding and operations of those projects. MIGA understands that decisions to invest by project sponsors are subject to the uncertainties of future carbon market structures and prices. These markets have been actively pursued by sponsors as a complementary source of funds for renewable energy and energy efficiency projects. MIGA’s current portfolio and expertise can serve as an initial step in supporting renewable energy and energy efficiency projects, however MIGA’s actions will need to evolve and adapt to changing conditions in the carbon markets. As MIGA’s upcoming FY 2012–15 Strategy will primarily be focused on MIGA’s risk-return dynamics, including the agency’s overall appetite for risk, it may not focus on specific subsectors such as renewable energy and therefore may not be the appropriate vehicle to address this issue. This subsector focus will therefore need to be addressed through a more appropriate mechanism such as MIGA’s annual business plan/budgeting process.</p>

Management Action Record (continued)

Major monitorable IEG recommendations requiring a response	Management response
<p>The World Bank should take the necessary steps to enhance the delivery of its guarantee products by taking actions to improve policies and procedures, eliminate disincentives, increase flexibility, and strengthen skills for the deployment of the products. It should assess the potential for greater use of partial risk guarantees to mobilize long-term financing for renewable energy projects, particularly in the context of feed-in tariffs or other premiums to support investment in renewable energy.</p>	<p>Partially Agree</p> <p>In response to IEG’s evaluation of WBG guarantees, Management has been engaged in ongoing discussions on opportunities to optimize the delivery of WBG guarantee instruments and has taken action to introduce greater flexibility in the use of Bank guarantee instruments in response to dynamic country and client needs and market developments. A Memorandum of Understanding was recently signed between the World Bank and MIGA to provide incentives to staff to collaborate and a similar agreement is being worked on with IFC. The Bank is working to increase potential for greater use of partial risk guarantees for renewable energy projects and is allocating more staff and resources accordingly. The World Bank feels that the delivery of renewable energy guarantee products should not single out the feed-in-tariff instrument, as the effectiveness and efficiency of its application varies across market structures and varies across countries depending on their energy access levels, with the potential to result in high energy costs that will need to be borne by consumers.</p>
<p>The Carbon Partnership Facility and other post-Kyoto carbon finance efforts should focus on demonstrating effective technical and financial approaches to boosting low-carbon investments. Funds and facilities should have clear exit strategies.</p>	<p>Ongoing/Agree</p> <p>CPF and FCPF were clearly established for the purposes described. Beyond these facilities, the World Bank is invited to explore how to facilitate developing countries’ further access to the carbon market and expand the reach of market mechanisms in land use, including in agriculture. Work is under way to develop successor facilities to CDCF and the BioCarbon Fund.</p> <p>Each fund and facility has its own clear exit strategy corresponding to when its capital has been fully committed. Regarding CPF, each tranche is to be established based on an assessment of the needs for further methodology development and piloting of new approaches to scale up the use of market mechanisms.</p>
<p>The WBG should—</p> <p>Measure projects’ economic and environmental impact during execution and after closure and aggregate this information for analysis. For instance, renewable energy projects should monitor capacity utilization, and energy efficiency projects should monitor energy savings. This may require the use of concessional funds to defray additional costs of monitoring by staff, clients, and project proponents.</p>	<p>Disagree</p> <p>While WBG assesses projects’ environmental impacts before, during, and after implementation, there are methodological difficulties in aggregating these.</p> <p>There is not a clear source of concessional funding to defray the additional cost of monitoring by staff and project proponents, apart from climate-related trust funds, such as the CIF. Under the CIF, results frameworks are currently under development. Each multilateral development bank partner and client will be responsible for monitoring results in accordance with the frameworks. Under the CTF and the SREP, indicators for renewable energy and energy efficiency investments will be tested in CIF-funded operations.</p> <p>Measurement is being strengthened with respect to climate change mitigation. As outlined in SFDCC, a methodology for “carbon tagging” has been developed and prototyped. Once this methodology is adopted, this will help aggregate the project commitments coded as GHG mitigation (CO₂ emission reduction). In addition, a new set of core indicators for IDA investment lending operations was approved by the Energy and Mining Sector Board in 2009, to better capture impacts of the implementation of renewable energy projects. For energy efficiency projects in the IDA portfolio, a similar set of indicators, including project energy savings, is currently under review. The formulation of new core indicators for energy projects is also proposed for IBRD-financed operations.</p> <p>IFC feels that collecting information on project performance may be complex and unrealistic for some financial intermediation-based lending instruments (for example, small loan programs for SMEs). Nevertheless, more efforts could be made in terms of monitoring, if additional resources were available to cover the extra costs of staff, clients, and project proponents.</p>

(continued)

Management Action Record (continued)

Major monitorable IEG recommendations requiring a response	Management response
<p>The WBG should—</p> <p>Link these measures to a results framework that shifts the SFDCC toward a focus on outputs such as power produced, power access, forest cover, transit share of urban trips, rather than money spent.</p>	<p>Ongoing/Agree</p> <p>A long-term results framework for SFDCC is under development, as stated in the Interim Progress Report for SFDCC, May 2010.</p> <p>The SFDCC results framework will be outcome-oriented and is currently being developed in a consultative manner as envisioned in SFDCC. In addition to tracking WBG actions at the input level, the new results framework is being designed to track outputs, outcomes, and impacts related to WBG actions. Potential indicators at all of these levels (including the suggested output indicators: power produced, power access, forest cover, transit share of urban trips) are currently being assessed for their feasibility, simplicity, and suitability in communicating results at different levels and scales.</p> <p>Separate results frameworks are under development for the CIF with an emphasis on impact, outcome and output indicators. Results chains link projects to the CIF final outcomes through pilot country outputs and outcomes, program replication outcomes, and transformative impact. The multilateral development banks are currently in a process to identify reliable indicators to measure results and achievements at each level.</p>

Chairman's Summary: Committee on Development Effectiveness (CODE)

On September 15, 2010, the Committee on Development Effectiveness (CODE) considered the report *Climate Change and the World Bank Group—Phase II: The Challenge of Low-Carbon Development*, prepared by the Independent Evaluation Group (IEG), and the draft management response.

Summary

The Committee welcomed the timely discussion of the IEG report which, as noted by management, highlighted important areas that are currently considered in the updates of the World Bank Group (WBG) Energy and Environment Sector Strategies. In this regard, members cautioned that, given the ongoing consultations, the IEG findings and recommendations should not be perceived as preempting the new strategies but inform the ongoing process. They welcomed the report's emphasis on energy efficiency and its perspective on a "venture capital" approach and endorsed the call for a greater focus on results to complement the focus on mobilization and transfer of resources. There was appreciation for the report's findings that many types of renewable energy require concessional finance.

The IEG evaluation sought to draw lessons from recent WBG experience (2003–08) with promoting the adoption

and diffusion of technologies and practices that reduce GHG emissions. Members noted that since the Strategic Framework for Development and Climate Change (SFDCC) was launched in 2008, it would be premature to evaluate the experience with the SFDCC. IEG clarified that the report is not an evaluation of the SFDCC but rather an assessment of earlier activities to inform the implementation of the SFDCC. In addition, members agreed with management that addressing climate change as a development issue raises the questions of how to address the access agenda while taking into account low-carbon development. IEG clarified that Phase I of the report considered this important aspect.

Some members felt that the IEG evaluation should have addressed the World Bank commitments at the country level rather than project-by-project, suggested guidance to emerging countries on how to support low-carbon growth, and looked at geothermal, biofuel, and biomass energy. There were also comments on global vis-à-vis national efforts; trade-offs of having a climate change agenda, energy access, and social development; the role of carbon funds; and shortcomings of current staff incentives and resource constraints. Different views were expressed on the WBG's involvement in coal plant projects.

Statement of the External High-Level Review Panel

The High-Level Review Panel (Panel) has been asked to comment on the Phase II report of the Independent Evaluation Group's (IEG) evaluation *Climate Change and the World Bank Group*. The Phase I evaluation was devoted to assessing the role of policy actions in support of low-carbon growth and stressed the importance of energy price rationalization. Like the Phase I report, this report places special stress on the need for systems thinking in key sectors such as energy, transport, and forestry. The Panel appreciates both the extensive amount of work and the scope of the assessment assembled by the two reports together and separately. Summarizing World Bank Group (WBG) activities and giving a comprehensive review of the changing role of the Bank and future options is difficult because of the size and diversity of the Bank. The challenge of preparing such a report is compounded by the decline in the use of cost benefit analysis over recent decades that has been documented in another recent IEG report (IEG 2010a).

We find the current report to be written with exemplary clarity. As far as we have been able to ascertain, it gives both an even-handed overview of the changing WBG practice in this area and a level-headed analysis of the options and alternatives ahead.

The report is at once supportive and critical of the various dimensions of the WBG activities and represents an element of an ongoing evolution of the thinking about the work already under way, or in need of further implementation, in the multiple activities of the WBG. The Panel also both supports and criticizes the reviewed practices of the WBG and equally recommends a continuing evolution of WBG perspectives in its adaptation to the pressing needs for climate finance. In this comment, we want to reinforce the key messages in the report: that the WBG can and should play a central role in the multilateral and national responses to the worldwide development/climate problems before us.

We believe that the tensions between development and climate are a chimera: the damages from climate change will counteract the development aspirations of low-income countries. To mitigate climate damages is a vital development goal. Again, in agreement with the report, we believe that the newer and integrated strategies for low-carbon growth can, if well and consistently pursued, minimize or overcome these tensions. Finally, we emphasize that the

WBG, as other institutions that grew up before the challenges of climate resilient development were apparent, must alter its practices of investment and capacity building to adapt to the different politics and technologies that now are present. We hope our comment will be read in the same spirit as the IEG report, reinforcing and extending the work we are charged to review.

The Challenge of Climate Change and Low-Carbon (Green) Growth

A number of features set the management of climate risks apart from most developmental and environmental problems. It spans centuries, forcing us to rethink intergenerational equity issues between and within countries. If unchecked, climate change might threaten the development aspirations of the poor. If approached creatively, it opens development opportunities. Rapid economic growth in the last decades has substantially reduced poverty in some countries, but now the very sustainability of this growth is seriously threatened by climate change unless we change our growth strategies. Some implications of the long-run low-carbon strategy are clear, such as the virtual phase-out in this century of fossil fuel use. This will require a high price on carbon emissions or other aggressive policy measures and incentives, with inclusive participation across the world. Other aspects of these alternative development strategies in the areas of forestry and innovation suggest quite immediate interventions to preserve depletable assets or lay the foundations for the commercialization and diffusion of newer technologies that cannot be deferred.

Although the short-run capital, operational, and transition costs of managing climate change risks are sizable, they are still dwarfed both by the benefits of and by the resources available from a century of growth. Green growth and win-win opportunities are increasingly recognized by national leaders as real options, but coal is often the cheapest current investment and the (shadow) carbon prices currently discussed are, as shown by the IEG report, inconsequential. In the multilateral climate negotiations, the distribution of these costs is deeply contentious and it will take some time to resolve. Eventually we will live in a world where all productive resources, including the climate regulating functions of the atmosphere have a price—just like land does today in

most places. Before we get there, we are in an interregnum when policy making is quite complex. What the situation needs are credible agents that provide the vision to bridge the gap, leadership in this crucial task, and the capacity to mobilize and channel resources responsibly. As suggested in this report, the WBG can and must contribute to this leadership.

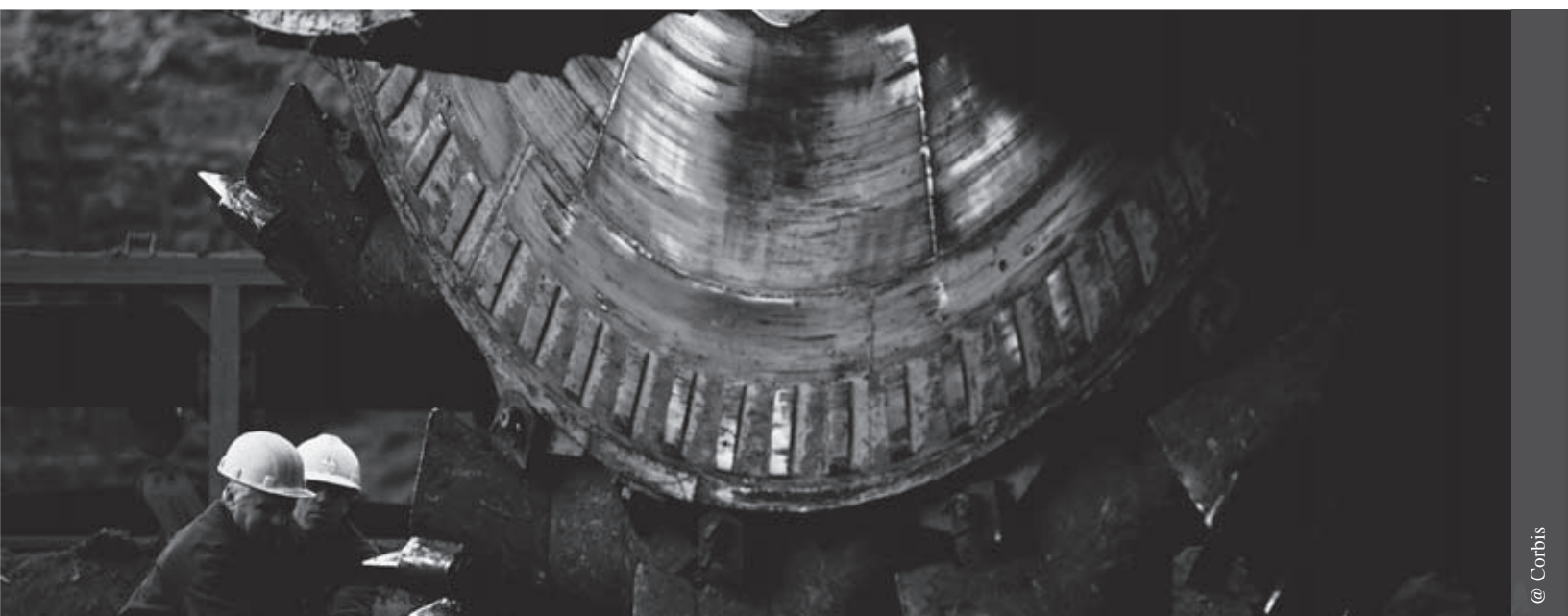
The WBG Role

The report finds that there are multiple and overlapping reasons for WBG involvement and action. First, it is evident that when environmental externalities are taken into account, unregulated markets will not optimize social well-being. Second, given past regulatory practices and the rising costs of sustainable energy services associated with climate change and with other environmental and resource problems, there is good reason to believe that greener growth built on less extensive exploitation of this resource base can increase productivity and development. Third, the historically low resource prices associated with prior industrial growth have failed to motivate innovation of systems that use resources in smarter ways. Looking systematically at these opportunities through integrated planning is the responsibility of agencies such as the WBG, which make investment capital available, especially in poorer countries with less institutional capacity to perform this analysis.

The IEG report highlights that the problem of responsible leadership in this field is compounded by the inability of the multilateral system over the past years to agree on a regime for giving meaningful price signals and complementary incentives for managing carbon risks. It has been recognized in principle that climate change is a true threat

to development and poverty alleviation, and there is a growing (although not yet sufficiently large) willingness to pay for global mitigation services. Yet there are not inclusive sanctions imposed on greenhouse gas emissions that would signal to all nations that resource use must change or provide the funds for climate-specific transfers to put a significant positive incentive behind cleaner technologies in less developed countries. In the absence of such agreed international policy guidance to markets, it is especially important that established global coordinating agents use financial markets to internalize the shadow costs of carbon and the prospective returns of green investment into their investment portfolios. We believe that the WBG—with its access to world capital markets, the ears of policy makers in all countries, and a credible engagement in both development and environmental issues—is a strong candidate for this position. There are many other important agents, including governments, industry, and the United Nations. However, in the current situation, there is a particular need for the WBG to consider its exceptional position to articulate and promote the long-run investment horizon, the production of global public goods and services, and the systemic planning perspective that few other financial bodies are able to define and pursue.

Although the report does not make the overall portfolio of WBG energy investments a principal subject of criticism, we urge that this question of WBG perspective receive more direct attention. The bottom line is that virtually all forms of energy supply entail some serious issues, and hence optimization of demand through effective management, overview of tariff structures, reduction of grid losses, and other methods of increasing energy productivity should



be WBG priorities. The WBG has made significant gains in recent years through its Clean Energy Investment Framework, and it reports that it achieved a 40 percent share of its total energy commitments for renewable energy and energy efficiency for fiscal 2009. This total commitment figure can include funds for energy efficiency in fossil energy, hydro-power facilities, new renewable energy technologies, and both specific donor funds and structural lending. These alternative types of climate finance should be clearly and separately reported to facilitate transparent understanding of the changing composition of WBG activities. The Panel also makes specific remarks about continuing WBG lending to coal fired power below. However, given the strong findings of the IEG report on the economic viability of increasing numbers of renewable energy or clean transport investment and the social value of the WBG acting to lower capital and operational costs of newer technologies and systems, the Panel urges the WBG to move more quickly in its structural energy lending to assume the coordinating role of a strategic renewable energy investor.

As does the IEG report, the Panel realizes that a change in WBG investing stance is not a simple or politically easy task. Our position, like that of the evaluation, is more forceful than the WBG Strategic Framework on Development and Climate. We recognize that various WBG stakeholders contest its ability to lead on climate finance, that the WBG operates in a partial policy vacuum, and that it has neither a clear mandate nor control over many of the necessary international policies to complement its investments. In spite of these factors, the Panel would go beyond even the IEG evaluations and reiterate by consensus that the Bank Group is uniquely positioned to take on roles that would as an investor and trustee be internally innovative and politically opportune in showing the way toward a comprehensive multilateral system in which the financing of low-carbon growth is the essential reform.

General Findings

It certainly is true in the short run that low-carbon growth costs more (ignoring externalities) than business as usual growth (the evaluation emphasizes that renewable energy, aside from medium to large hydropower, does have higher costs or lower returns than other kinds of power generation); but the Panel, like the report, puts great stress on the potential for a congruence of mitigation and development. The report shows there is ample scope for projects that promote local development goals while also mitigating greenhouse gases (see figure 6.1 of the report). In addition to energy efficiency investments, other projects may individually have high carbon returns (forestry) or economic returns (solar home photovoltaic systems). To optimize carbon and economic gains, it may often be necessary to construct portfolios of projects, rather than pursue multiple goals with a single instrument.

The IEG report directs attention to energy efficiency, which offers low-cost or negative-cost opportunities to reduce carbon emissions. It finds that many people, inside and outside the WBG, do not appear to take energy efficiency seriously. However, especially noting that hoped-for large-scale climate funding may not appear soon and that many countries simply do not have good immediate alternatives to fossil power, many kinds of energy efficiency offer both high economic returns to the borrowing country and high abatement returns to the world. Some types of energy efficiency investments can be undertaken immediately, with concurrent huge economic benefits and significant climate benefits. At the same time, aggressive pursuit of energy efficiency today can defer the locking in of new carbon-intensive power construction like diesel or coal plants for a few years, allowing time both for technical progress to reduce the cost of renewable alternatives and for the international political process to muster more climate finance. Although the Panel insists that it is necessary to reinforce the effects of such investments by anticipating with complementary policies—such as tariff and tax reform—the rebound effects of falling energy prices, it emphasizes the conclusion of the IEG report that the WBG should give very high priority to energy efficiency.

The Panel also underscores the evaluation's finding that the WBG can emulate a role played by venture funding in the private sector. With current carbon prices, the power of concessional finance is often limited in mitigating the risk of high-risk projects. At \$10/ton for CO₂, carbon finance simply doesn't constitute a make-or-break factor in low-carbon investments. Yet there is a whole class of projects that offer high economic returns (to the adopting country) together with carbon benefits, but that present some a priori risks. Bus rapid transit and silvopastoral systems are examples given in the text. Although risk-averse borrowing countries will shy away from these until they are proven, concessional funds can mitigate this risk. WBG clean technology funds or other WBG climate finance could be used to support a number of individual "start-up" projects, scaling up the ones that work, and produce an overall portfolio with very attractive rates of return. The difference between this and private venture capital is that the benefits accrue to the Bank's client countries rather than the Bank itself—hence the need for concessional capital.

Although the IEG report demonstrates a record of considerable success in many WBG projects in the energy efficiency and off-grid photovoltaics (renewable energy), the WBG's record in renewable energy more generally has been more mixed and modest. Many hydropower and wind projects have underperformed relative to expectations. Still greater caution about the value of WBG programs should be attached to the Group's extensive efforts in piloting international carbon markets between Annex I and

non-Annex I countries. The World Bank's Carbon Finance Unit (CFU) has led, through its extensive activities in Clean Development Mechanism markets, to expanding the role of, and the infrastructure for, carbon trading between developed and developing nations. However, there has been criticism of the environmental quality of many projects that the WBG has supported, including industrial gases, hydro-power, and fossil (gas and coal) power plants, which may well have been either profitable in themselves or were pursued primarily for the purpose of national energy diversification and security policies. In addition, although the CFU was promoted as a market maker that could act as a carbon offset buyer until the private market flourished, the WBG continued to build up its trading after that private market was fully established. Finally, as a vehicle for catalytic finance and technology transfer, the IEG finds the CFU's record is at best mixed. The Panel suggests that the WBG has a public responsibility to ensure that its behavior advances

programs have been valuable in exposing that inadequate lending for energy efficiency often reflects wider credit market failures, including onerous requirements for collateral. However, it is important to note that, contrary to expectations, although market transformation programs were often conceived as temporary, WBG experience indicates that these actions proved difficult to discontinue even as banks or firms gained familiarity with energy efficiency lending. The Panel finds that the WBG could focus even more extensively on these less usual categories of transition financing, but needs to pay careful attention to the incentives that will help convert such demonstrations of market potential into commercial local finance as rapidly as possible.

The Panel also applauds the report's attention to the importance of technology development or promotion and its transfer or diffusion. Technological innovation requires special conditions to be successful. The report argues that innovations are more apt for WBG support when the



Photo by Dana Smillie, courtesy of the World Bank Photo Library.

the quality of international institutions that regulate carbon finance markets, rather than acting principally as a pure market player profiting from expanding market scale.

Both the report and the Panel underline the importance of market transforming measures. The Panel confirms the view in the report that loan guarantees, innovative forms of insurance for joint ventures and other types of commercial organizations that encourage the international transfer of technologies, can be valuable. Likewise, investment in new service providers such as energy service companies (ESCOs) or transmission and distribution loss reduction programs are especially valuable in climate-related activities. WBG

Bank can help defray risks that are peculiar to a certain environment or when the supported innovations are particularly adapted to conditions, inputs, or skills found in developing countries. The barriers to technology diffusion are very often related to institutional factors such as the character of competition and industrial structure. Depending on market structure, competitors may resist the diffusion of technology and the WBG must have a realistic strategy and realistic goals that take this into account. The report argues that in numerous cases international support was essential to mitigate up-front risk and to pay for global benefits of knowledge created.

Yet WBG experience shows that the returns from investment in technology development may often be lost without associated programs to encourage and facilitate wide technological diffusion. Some projects have incorrectly assumed that private beneficiaries of technology would share proprietary technology with competitors. As discussed in the IEG report, other lessons on fomenting technology innovation and diffusion can be garnered from projects that fail because of multiple, conflicting objectives, inexperienced entrepreneurs, unfamiliar technology, an uninterested target market, and the difficulty of procurement when technology suppliers are few and costs are poorly known. The Panel suggests that the WBG devote particular attention to the analysis and selection criteria for programs to compensate private actors for technology and diffusion risks in its future climate finance portfolio. Analytical clarity by the Bank may also help dispel confusion about these issues, often found in the multilateral climate negotiations. We believe that the role of *capacity building*, though mentioned in the report, could be given even more emphasis as an integrated part of WBG programs and as a separate standalone activity.

The WBG needs to demonstrate a comprehensive low-carbon development pathway for developing countries. In promoting low-carbon development, it should apply a strategic approach, rather than simply supporting projects based on sector-specific priorities. The IEG correctly highlights how difficult this is, in the absence of a global deal that requires governments to account for the external costs of climate risk. Naturally, one can focus on combating perverse subsidies and on pursuing currently available win-win options, but these will not be enough. The climate-development dilemma is that many green options are *not* economically profitable, especially in the short term, or they threaten governments with substantial transitional or political costs.

However, the report also suggests that a portfolio of lower carbon actions across many sectors—including energy, industry, transport and forestry—can mitigate overall development costs and bring ancillary benefits from improved local environmental services and energy security. And over the long term, technical progress will reduce the costs of currently noncommercial technologies, yielding systematic productivity gains. Prospective economic gains from innovation imply that it is most important to avoid land use patterns and technology investments that have almost irreversible lock in. Cases illustrated in the report include options to use energy efficiency savings to increase electricity supply and forestall the need for more current investment in power plants with 50 years useful life, and to avoid urban architectures (buildings, roads, and so forth) that “require” (or at least promote strongly) heating, cooling, or passenger

car transport. As many nations currently lack the capacity to implement more systemic and forward-looking development planning, there can be a particularly high return to WBG support in building and institutionalizing intellectual and political capacity in climate science, climate economics, and technology strategy.

Specific Findings

In addition to the main points raised above, the Panel agrees with many of the recommendations of the IEG report. We cannot comment on all sectors or recommendations, but we would particularly like to emphasize a number of specific additional issues.

Energy efficiency

Although the emphasis on large-scale energy efficiency scale-up goes in the right direction, further study is needed on the relative importance of efficient lighting and reducing power losses in transmission, for WBG intervention. Incandescent bulbs and power loss are problems for both developed and developing countries. The potential scope for WBG intervention in developing countries, particularly in household and building sectors or other areas where opportunities for decentralized actions are needed but substantial, needs to be systematically analyzed. In addition, many ESCOs are already playing a role in implementing profitable efficiency opportunities, such as phasing out incandescent bulbs. The WBG needs to explore how better to complement and leverage the role of ESCOs by providing them concessional funds. Likewise, the potential for WBG intervention to reduce power loss in developing countries needs to be measured, and the carbon saved per dollar by reducing power loss needs to be compared with that of other projects. Large-scale gains are also available in the industry and transport sectors. These gains are often more simple to organize because the scale of savings offers reduced transaction costs, and so they may deserve top priority in many developing countries.

Finally, the Panel emphasizes its particular appreciation that the IEG report consistently highlights and analyzes the separate roles of renewable and energy efficiency. We agree both with the importance of the scale-up of energy efficiency programs and with the practice of measuring and evaluating results by energy saved and generating capacity avoided rather than by funds dispersed, which can easily lead to inefficient effort.

Transportation and urban design

Another major field covered is urban architecture. The focus when it comes to urban issues is rightly and well placed on transit, although rising demands for local indoor climatization (cooling and heating as well as other demands for urban energy) could perhaps have been given some more

attention. In a couple of decades, countries that spent large sums on urban infrastructure—such as big roads, sparsely populated cities, and homes with high heating or cooling requirements—will feel that they wasted resources—just like those who spent their money on copper telephone lines. The WBG should help tilt the building of long-run infrastructure in a carbon-lean direction: shipping rather than air freight, rail rather than road, virtual communication rather than physical, and so forth. Thus, urban planning, building design, modern and climate-adapted systems for transport, forestry, energy portfolio, and infrastructure could be the critical structural factors in pursuing low-carbon development pathways by developing countries. The WBG should aim to incorporate a low-carbon paradigm shift in those structural areas.

Though reliable data are not readily available, economic loss caused by traffic congestion in most developing countries would range from three percent to six percent of GDP, particularly in urban areas. Thus, investment in mass transit could not only save carbon but could also reduce economic losses in developing countries. The WBG should aim to incorporate a low-carbon paradigm shift in these structural areas.

In almost all developing countries, the transport sector, in particular mass urban transit, chronically suffers from underinvestment. The historical trend of developed countries clearly shows that it is the transport sector that will be the most difficult in which to curb the soaring increase of carbon emissions. The bulk of future emissions from developing countries will come from the transport sector. This must be forestalled by massive investment in infrastructure, rapidly and through a paradigm shift toward comfortable and accessible low-carbon mass transit, which will be a critical component of low-carbon development. The WBG, in particular the International Finance Corporation, should engage in mapping out an ambitious strategy of promoting low-carbon mass transport systems in developing countries. This is consistent with the large-scale energy efficiency scale-up recommendation. As with other energy sectors, it is crucial to complement these investments with a sound price and tariff policy. In this case we recommend tax reform, shifting more of the burden of taxation away from goods used by the poor and onto environmentally unsustainable goods such as fossil fuels. Without high fuel prices, grand schemes for urban transit cannot compete and will merely fall into disrepute.

Coal-fired power

We appreciate the care that the IEG report has taken in discussing the thorny issue of support to coal-fired power plants. The report recommends assistance to countries to find alternatives to coal power and raises fairly formidable barriers to coal projects by requiring adherence to

guidelines that include optimal use of energy efficiency opportunities as well as restricting coal projects to cases where there is a *compelling argument* for poverty or emissions reductions impacts that would not be achieved without WBG support.

However, the report stops short of fully banning engagement in the sector for fear that the Bank would lose influence over and contact with the sector where such investments will go ahead without even the advantage of the WBG guidelines. The report gives an example of a country that urgently needs base load power and where a new efficient coal-fired plant replaces a number of older and highly inefficient plants—also within a context of overall system optimization. Although it appreciates the latter argument, this panel would want to emphasize the signaling value that the WBG has both when it chooses to finance and when it chooses not to. It is hard to envisage situations where the arguments in favor of WBG support to coal power outweigh the arguments against. This applies particularly if sufficient concessional carbon funding can be leveraged. The argument against a complete ban may, however, have some validity.

It is necessary to make sure that coal is used in a most prudent manner, but it is better to focus on improving the energy portfolio as a whole rather than focusing only on coal at the project level. The WBG should be able to advise and offer a strategy of diversifying and scaling up renewable energy sources in order to shift toward a low-carbon energy portfolio.

Forestry, land, and other resource use

In addition to access to carbon finance in energy-related investment, one of the potential advantages of the WBG is its superior overview of such issues as global externalities and the related politics of negotiations. In the shorter run, the rapid depletion of forests and other land-based carbon storage systems (for example, peat lands and agricultural soils) represents a stock of assets that can rapidly be exhausted. Immediate opportunities to prevent the continuation of long-standing resource exploitation practices in these sectors are abundant. Substituting degraded lands, themselves the consequences of inefficient resource use, for the further loss of primary stocks can allow national development of timber, pulp and paper, oil palm, agroforestry, agropastoral, and fishery economies that are currently promoted in an unsustainable manner by exploitation of natural areas. Food security concerns in many developing countries are equally open to better management through productivity increases using intensive techniques instead of simply extending traditional production by plowing under more forests or throwing out more nets. Because these newer techniques are usually more capital and knowledge intensive than what has been done under business as usual, the WBG is in a particularly strong position to support national agricultural and forestry

services with increased loan capital and concessional funds to cover the added costs of transition to new practices.

Because forestry, agriculture, and fishing are often critical areas for many poorer developing countries in pursuing low-carbon development, the WBG should not only “explore” these mitigation opportunities, but should be able to prioritize immediate support. This support may demand the use of public funding to supplement the privately available income flows that firms, families, or communities can reap from less-sustainable resource uses and the delivery of these public funds through innovative measures like easements or contracts for ecosystem services. Moreover, as the WBG expands its activities in these sectors, it needs to carefully synchronize its approaches with the Reduced Emission from Deforestation and Degradation negotiations and other elements of the United Nations process in order to complement and encourage political progress in this priority negotiation field.

Recommendations

The panel agrees with most of the excellent IEG report. Our own statement is short enough to not require any summary.

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Thomas C. Heller

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We close by reiterating only four key points that have been emphasized both in the IEG report and our statement:

- Climate damage is a serious threat to development, especially for the poor.
- It is essential that the WBG as a development institution lead in building capacity, understanding, and practical standards to support governments' implementation of low-carbon growth strategies.
- The WBG can and should expand its structural lending and grant programs for energy efficiency, renewable energy, and market transformation programs that create correct incentives consistent with these strategies.
- Finally, the WBG is well placed to take on a mission to encourage and leverage financing for low carbon growth. To do so, it must continue to reform its organizational goals, operational practices, internal incentives, and performance management criteria to value and reward results at the systemic, rather than at the project level.

Glossary

<i>Additionality</i>	To generate carbon offsets recognized under the Clean Development Mechanism or Joint Implementation, projects must show that their emission reductions would be in addition to those that would occur in the absence of carbon finance.
<i>Bankability</i>	The ability of a project to attract sufficient financing to be viable. A project might not be bankable if its profits are not high enough in early years to cover the needed debt payments.
<i>Base load</i>	The amount of power required to supply minimum customer demands (as power demand fluctuates throughout the day, or seasonally).
<i>Bus rapid transit (BRT)</i>	An efficient urban transit form using priority or dedicated bus lanes.
<i>Bus rapid transit system (BRTS)</i>	An integrated system of multiple bus rapid transit lines.
<i>Carbon dioxide equivalent (CO₂e)</i>	Number of tons of carbon dioxide considered to have the same impact on global warming as a ton of a specified gas. For instance, one ton of methane is considered equivalent in warming to 25 tons of CO ₂ .
<i>Carbon finance unit (CFU)</i>	The World Bank unit that manages carbon funds and purchases carbon offsets.
<i>Carbon fund</i>	A trust fund established to purchase carbon offsets.
<i>Carbon offset (or credit)</i>	A commodity representing a reduction in greenhouse gas emissions (including gases other than carbon dioxide), used by purchasers to meet regulatory or voluntary limits on emissions. Certified emission reductions are one type of carbon offset.
<i>Carbon return</i>	The effectiveness of a project in reducing carbon dioxide emissions (as opposed to the economic return, or other environmental benefits). Measured in lifetime kilograms of CO ₂ e emissions reduced per dollar of investment cost.
<i>Certified emission reduction</i>	A carbon credit (measured in tons CO ₂ e) for an emissions reduction associated with a Clean Development Mechanism project.
<i>Clean Development Mechanism (CDM)</i>	A mechanism under the Kyoto Protocol by which developed countries can finance greenhouse gas emission reductions or removal projects in developing countries. In turn, the developed countries receive credits for doing this, which they may apply toward meeting mandatory limits on their own emissions.
<i>Combined heat and power (or cogeneration)</i>	The production of both electricity and economically valuable heat (for industrial processes or space heating), for example, from a steam boiler.
<i>Combined-cycle turbine</i>	A relatively efficient technology for power generation from combustion, usually of natural gas.

<i>Compact Fluorescent Lamp (CFL)</i>	An efficient light bulb that uses only 20%–30% as much power as a standard incandescent bulb.
<i>Concentrated solar power</i>	A solar power technology that uses focused sunlight to drive a steam turbine or heat engine in order to produce electricity.
<i>Concessional funds</i>	Donor-provided grants and subsidized loans.
<i>Demand-side management (DSM)</i>	Actions or incentives, often directed by energy utilities to their customers, to reduce the level of energy demands (typically through efficiency measures) or change the timing of those demands. Can also apply to measures to reduce demand for transport, such as road or parking pricing.
<i>Debt service coverage ratio</i>	The ratio of net operating income to debt repayment obligations (interest and principal).
<i>Development Policy Loan (DPL)</i>	A World Bank lending instrument used to support structural reforms in an economic sector or in an economy as a whole.
<i>District heating</i>	Centralized system for the provision of steam heat to an urban neighborhood or district.
<i>Economic Rate of Return (ERR)</i>	The annual percentage rate of return on a project, considering all costs and benefits to society. In this evaluation, ERRs are computed using only domestic costs and benefits; carbon benefits are reckoned separately.
<i>End user energy efficiency (or demand-side energy efficiency)</i>	Energy efficiency improvements carried out by power consumers, such as through appliances or industrial equipment that consumes less energy.
<i>Energy services company (ESCO)</i>	A company that provides clients with some combination of assessment, financing and implementation of options for increased efficiency of use and reduced expenditure on energy.
<i>Financial intermediaries</i>	Financial institutions such as banks that borrow money and then lend it on to other institutions.
<i>Global Environment Facility (GEF)</i>	An independent, international financial organization that provides grants to developing and countries with economies in transition for projects that support environmental objectives, including those related to climate change.
<i>Greenhouse gas (GHG)</i>	Gases whose atmospheric buildup contributes to global warming and climate change. Greenhouse gases regulated under the Kyoto Protocol are CO ₂ , methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.
<i>HFC-23</i>	A potent greenhouse gas (with a global warming impact 11,700 times that of CO ₂) generated as a byproduct of the manufacture of the refrigerant HCFC-22.
<i>Hydropower with storage</i>	Hydropower plants that have substantial reservoirs (as opposed to run-of-river hydropower).
<i>Incandescent Lamp</i>	The “standard” lightbulb technology, in use since the 19th century.
<i>Incremental cost</i>	The additional cost of substituting a low-carbon for a high-carbon investment.

<i>Joint Implementation</i>	A mechanism under the Kyoto Protocol through which a developed country can receive “emissions reduction units” when it helps finance projects that reduce net greenhouse gas emissions in another developed country.
<i>Low-carbon</i>	Term applied to activities that provide outputs while producing less CO ₂ (or other greenhouse gases) than alternative “standard” methods.
<i>Mitigation</i>	Abatement of greenhouse gas (or other pollutant) emissions.
<i>No regrets/win-win actions</i>	An action that provides net benefits both to the nation that adopts it and to the world at large. Individuals or groups may suffer losses under win-win policies, though in principle they could be compensated from the benefits. Also, actions that would be valuable even without considering climate change mitigation benefits.
<i>Nontechnical losses</i>	In a power system, power that is consumed but is not billed to customers, because of power theft, meter failure or utility employee collusion. Also called commercial losses.
<i>Off-grid</i>	Power generation not connected to the main power grid, such as solar home systems, mini-grids, or small portable diesel generators.
<i>On-grid</i>	Power generation connected to the main power transmission grid.
<i>Parts per million (ppm)</i>	A measure of concentrations of greenhouse gases in the atmosphere.
<i>Payment for Environmental Services (PES)</i>	A mechanism for rewarding landholders for providing environmental services (for example, watershed protection or carbon storage), such as by growing or conserving forests.
<i>Peak load (or peak demand)</i>	The amount of power needed to supply consumers when demand is at its greatest. Peak demand typically occurs in early evening hours, when electric lights and household appliances are turned on.
<i>Protected area</i>	A clearly defined geographical area, recognized, dedicated, and managed—through legal or other effective means—to achieve long-term conservation with associated ecosystem services and cultural values.
<i>Renewable energy</i>	Energy produced sustainably without net carbon emissions and without consumption of fossil or nuclear fuels. Includes hydropower, wind power, solar power, geothermal power and biomass power.
<i>Return on equity</i>	The rate of return realized by shareholders in a project.
<i>Run-of-river hydropower</i>	Hydropower plants without significant storage capacity. These usually still have a small dam but do not create a large reservoir.
<i>Silvopastoral systems</i>	The practice of combining agroforestry and pastoral animal grazing.
<i>Solar home systems (SHS)</i>	A small solar photovoltaic powered system (with battery storage) for use by off-grid households.
<i>Strategic Framework on Development and Climate Change (SFDCC)</i>	A strategic framework adopted by the World Bank in 2008.
<i>Supercritical coal</i>	A technology that burns coal at high temperature and pressure (as opposed to subcritical coal.)

<i>Supply-side energy efficiency</i>	Energy efficiency improvements carried out by energy suppliers, such as reducing the amount of fuel needed to be consumed to generate a given amount of power from a power plant.
<i>Technical losses</i>	The difference between electric power that is generated and power that is consumed. As power passes through transmission/distribution lines and transformers, some energy is converted to heat and lost.
<i>Technology transfer</i>	Transfer of technical hardware or know-how, or financial and institutional innovations, between countries.
<i>Tenor</i>	The total length of time for a loan to be repaid, including grace periods.
<i>Traditional financing</i>	The principal financial instruments used by the World Bank Group (IDA credits and grants, IBRD loans, IFC loans and equity financing, MIGA guarantees), as opposed to new financing sources with environmental aims such as carbon finance and GEF grants.

Chapter 1

EVALUATION HIGHLIGHTS

- The World Bank Group's Strategic Framework on Development and Climate Change promotes national sustainable development and global action.
- Prior to the Strategic Framework, the World Bank Group had limited objectives specifically related to climate change, but many of its activities have potential mitigation benefits.
- The evaluation draws lessons from that experience, seeking ways for the World Bank Group to maximize its impact on development and climate change mitigation.
- Within the areas of energy, forestry, and transport, this evaluation looks at specific subsectors that illustrate the challenges to overcoming barriers to the adoption of low-carbon technologies and practices.



Introduction

In 2008, the World Bank Group (WBG) adopted a Strategic Framework on Development and Climate Change (SFDC). This framework addresses the challenges of promoting development in a changing climate. The Independent Evaluation Group's (IEG) climate evaluation series does not directly assess the performance of this new framework. Rather, it recognizes that the WBG has for some years been deeply involved in renewable energy, energy efficiency, forest conservation, and other activities at the cusp of development and climate change. An early assessment of that experience can help inform the implementation of the SFDC.

The first volume of IEG's series (IEG 2009) examined World Bank experience with the promotion of the most important win-win (no regrets) energy policies—policies that combine domestic gains with global greenhouse gas (GHG) reductions. These included energy pricing reform and policies to promote energy efficiency (see appendix K, Executive Summary of Phase I).

This second phase covers the entire WBG, including the International Finance Corporation (IFC) and the Multilateral Investment Guarantee Agency (MIGA). It assesses

How can the WBG increase its impact on development and climate change mitigation?

recent experience with promoting the adoption and diffusion of technologies and practices that reduce GHG emissions while advancing other development goals. It encompasses a diverse range of activities, including renewable energy, energy efficiency, urban transport, and forest management. And it encompasses a broad repertoire

BOX 1.1 The Strategic Framework on Development and Climate Change

OBJECTIVES

- To enable the WBG to effectively support sustainable development and poverty reduction at the national, regional, and local levels, as additional climate risks and climate-related economic opportunities arise.
- To use the WBG's potential to facilitate global action and interactions by all countries.

ACTION AREAS

- Support climate action in country-led development processes.
- Mobilize additional concessional and innovative finance.
- Facilitate the development of market-based financing mechanisms.
- Leverage private sector resources.
- Support accelerated development and deployment of new technologies.
- Step up policy research, knowledge, and capacity building.

Source: World Bank 2008.

of interventions, from technical assistance to financing to regulatory reform. This project-eye view of activities pertains to all the action areas of the SFDCC (see box 1.1). The third phase will look at the challenge of adaptation to climate change.

The WBG's resources—human and financial—are small compared to the task at hand. The International Energy Agency estimates that developing and transition countries need \$16 trillion of energy sector investments over 2008–30 under “business as usual” operations—plus an additional \$5 trillion to shift to an ambitiously low-carbon path (IEA 2009). Much more is needed for sustainable land and forest management and for urban transport. So a prime focus of this evaluation is how the WBG can get the most leverage—the widest positive impact on both development and climate change mitigation—from its limited resources.

Climate Context

Climate change is a threat to development

Climate change threatens development (Parry and others 2007; World Bank 2010). Most of this burden falls on developing countries. Coastal areas will be exposed to inundation, flooding, and brackish water supplies. Snowmelt-fed watersheds will face winter floods and summer droughts. Crop yields will fall in many areas. Infrastructure, designed to cope with an increasingly unpredictable climate, will become more expensive.

Most of the climate change burden falls on developing countries.

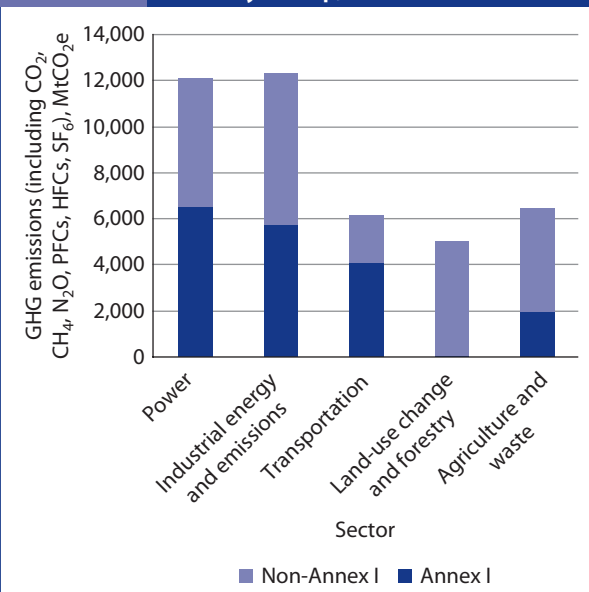
Uncertainty about the magnitude of these impacts strengthens rather than weakens the case for urgent action. To quantify this uncertainty, researchers (Sokolov and others 2009) ran a climate change model under hundreds of different assumptions about economic growth, technical change, and climate response. The range of outcomes represents, in their view, the gamble that the world takes from inaction. They found that, absent climate mitigation, there is a 24 percent chance that average global temperatures will rise this century by more than 6 degrees Celsius (13 degrees Fahrenheit).¹ A change of this magnitude, during the lifetime of many alive today, would be broadly catastrophic.

Managing climate risk requires urgent, globally cooperative action

To mitigate these risks, the United Nations Framework Convention on Climate Change (UNFCCC), to which virtually all countries subscribe, sets a goal of stabilizing the quantity of heat-trapping GHG in the atmosphere. Although precise limits have not been agreed on, the 2009 Copenhagen Accord called for limiting the global increase in temperature (relative to preindustrial times) to 2 degrees Celsius, often equated with an atmospheric GHG concentration limit of 450 CO₂-equivalent (CO₂e) parts per million.²

It will be difficult or impossible to achieve this goal without immediate mitigation actions in all major emitting nations, according to 14 climate modeling exercises undertaken by 10 independent research groups (Clarke and others 2009). (Mitigation refers to *where action takes place* rather than *who funds it*.) Although developed countries have contributed most of the atmospheric stock of GHGs and emit far more per capita, developing countries account for about half the current flow (see figure 1.1), and these emissions are growing rapidly. Even for less-ambitious stabilization targets, participation of middle-income countries is key to keeping

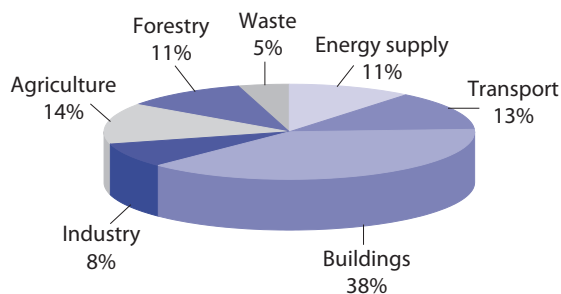
FIGURE 1.1 GHG Emissions by Sector and Country Group, 2005



Source: WRI CAIT (version 7.0).

Note: Annex I countries are the industrialized countries assigned emissions limits under the Kyoto Protocol. GHG = greenhouse gas.

FIGURE 1.2 Low-Cost GHG Abatement Potential, Non-OECD Countries, 2030



Source: Metz and others 2007.

Note: Cost < \$20/ton of CO₂e. Estimated economic potentials for GHG mitigation at a sectoral level in 2030 for different cost categories using the SRES B2 and International Energy Agency World Energy Outlook (2004) baselines. Total abatement potential is 9.2 Gt CO₂e. GHG = greenhouse gas; OECD = Organisation for Economic Co-Operation and Development.

global mitigation costs affordable. (There is, however, no agreement yet on how those costs might be apportioned.)

The long-run goal of stabilizing the level of atmospheric GHGs cannot be achieved without mitigating actions in all major emitting nations.

The need for action is urgent. If installed today, inefficient coal-fired power plants, poorly insulated buildings, and poorly targeted energy subsidies will be needlessly pumping GHGs into the atmosphere through mid-century. Those GHGs will linger in the atmosphere for many decades longer, intensifying warming and increasing the chance that the climate will pass a critical threshold—leading to accelerated warming, dieback of the Amazon forest, or other climatic disruptions.

There are many routes to mitigation

How might mitigation take place? GHG emissions arise in many ways, in many sectors. To motivate the sectors covered in this evaluation, consider first the current patterns of emissions.

In the developing world, 83 percent of emissions come, in roughly equal proportions, from power generation; industrial processes (including steel manufacture, cement production, oil refining); deforestation; and agriculture (largely methane from rice paddies and livestock). Transportation accounts for another 7 percent. However, energy and transport emissions are expected to grow rapidly as economies expand.

Emphasis on energy efficiency now buys time for renewable energy costs to fall and for development of advanced energy technologies.

Costs and benefits of mitigation differ by sector and are the subject of intense investigation. The consensus estimate of the Intergovernmental Panel on Climate Change is summarized in figure 1.2, which shows low-cost abatement opportunities. Like many other analyses, this one points to increased energy efficiency (in buildings and industry) as the largest and most economically attractive option for mitigation over the next few decades.

An emphasis on energy efficiency in the next few decades buys time for solar and wind power to become more cost competitive with fossil fuels and to develop and deploy advanced low-carbon energy technologies (such as carbon capture and storage and nuclear fusion) in the second half of the century. Energy efficiency helps preclude construction of coal power plants that might otherwise stay in service for 40 years or more.

Because mitigation is a global public good, it makes economic sense to compensate countries, firms, farms, and other actors for their contribution to mitigation. The quest to use global demand for climate stability as a means of financing climate-friendly development has shaped both United Nations and WBG approaches to climate change.

Global Mitigation Context and the WBG

The WBG's approach to climate change has coevolved with the international climate regime. One line of coevolution was with the Global Environment Facility (GEF), which was established in 1991 as a pilot program within the Bank. The GEF mobilized donor funds to address climate change, biodiversity loss, and other global environmental problems. Recognizing that climate and biodiversity are global public goods, the GEF's approach was to pay countries for the incremental costs of supplying these goods.

The GEF rapidly realized that its funds were too limited to plug the funding gap (project by project) and shifted to activities aimed at catalyzing replicable win-win actions. The GEF became an independent agency in 1994, but the Bank remained its trustee and largest implementing agency. This has been an important avenue for fostering attention to climate change inside the Bank and to developing a cadre of staff and managers with climate expertise.

The WBG's approach to climate change has coevolved with the international climate regime and carbon market development.

Another line of coevolution was with the carbon market. The UNFCCC, which became effective in 1994, did not specify how its mitigation goals would be accomplished. Attention turned to an economic approach that

would allow industrialized countries to seek cost-effective opportunities for GHG reduction in developed or transition countries. This was in line with the UNFCCC's principle of "common but differentiated responsibilities and respective capacities." It would take advantage of low-cost options to retrofit aging infrastructure in transition countries and to install cleaner greenfield equipment in rapidly growing developing countries.

This approach was piloted in the Activities Implemented Jointly Program, in which the World Bank participated. It evolved into the Kyoto Protocol, which was adopted in 1997 (but did not enter into force until 2005).

The Kyoto Protocol assigned GHG emissions allowances to industrialized countries. To exceed its emissions limit, a country was obliged either to purchase allowances from another industrialized country or to purchase a carbon offset from a developing or transition country (see box 5.2). The World Bank's Prototype Carbon Fund (PCF; whose staff had been involved in GEF and the Activities Implemented Jointly Program), put in place after Kyoto and launched in 1999, was intended to pilot the concept of carbon offsets and help catalyze this avenue for investment in GHG mitigation.

The 2001 WBG Environment Strategy included win-win approaches and mobilization of concessional funds.

The dual-track approach—win-win opportunities complemented by mobilization of concessional funds—was included in the 2001 WBG Environment Strategy and has been pursued since. An independent review (Nakhooda 2008) assessed 54 Country Assistance Strategies issued over 2004–07 and found that 32 discussed GHG mitigation in a sectoral context. At the 2004 Bonn International Conference on Renewable Energies, the WBG committed to expand its lending for renewable energy (excluding large hydropower) and energy efficiency by 20 percent per year over 2005–09 from a baseline of \$209 million. The Bank surpassed its commitment by a large margin (see chapter 2). In 2007, the Bank endorsed an Investment Framework for Clean Energy and Development. The framework had a broader scope than its name suggests, emphasizing electricity access and including climate adaptation as well as mitigation. The mitigation component focused on mobilization of concessional funds for investments in clean technologies and promotion of carbon trading.

Meanwhile, the UNFCCC process began to focus on the era after 2012, when the Kyoto provisions expire. The 2007 Bali Action Plan emphasized mitigation, adaptation, and financial and technological support for developing countries. It opened the negotiations to include reducing emissions

from deforestation and forest degradation (REDD), a major source of emissions not addressed in the Kyoto Protocol. And it called for setting a long-term global goal for emissions reductions. The Bali Action Plan was widely expected to culminate in a new international agreement at the 2009 Copenhagen climate meetings.

Development and Climate Change: A Strategic Framework for the World Bank Group was adopted in 2008. Although the SFDCC recognizes the primacy of the UNFCCC in the climate area, its goals are to support sustainable development, including "climate-related economic opportunities," and to "facilitate global action."

The SFDCC emphasizes six action areas (box 1.1), aligned with the Bali Action Plan. Four of these areas are concerned with mobilizing finance, from traditional and novel sources, and with supporting technology investments. The framework commits the WBG to increase the share of energy lending devoted to low-carbon projects (including large hydro) from 40 percent in 2009 to 50 percent in 2011, by increasing financing of energy efficiency and new renewable energy by 30 percent per year. It coincides with the mobilization of the \$6.2 billion Climate Investment Funds, a new source of financing for pilot projects aimed at initiating transformational changes. The core of the Climate Investment Funds is the \$5.1 billion Clean Technology Fund, providing financing for demonstration, large-scale deployment, and transfer of low-carbon technologies. These funds were seen as transitional devices, pending mobilization of much larger-scale financing as part of a new climate agreement.

The 2008 strategic framework emphasizes six action areas, four of which concern finance and investment.

However, the 2009 meeting in Copenhagen did not result in a comprehensive, binding climate agreement. This leaves the WBG to operate in a partial vacuum.

If there were an agreed, funded operationalization of the UNFCCC goal of GHG stabilization that spelled out roles, responsibilities, and funding sources, the WBG and its clients would be better able to make development choices consistent with a low-carbon growth path. Absent such an agreement, each development choice is fraught with ambiguity, as in the controversy over coal-fired power generation (see chapter 4). And it is not clear when, if ever, anticipated multibillion dollar per year climate financing sources may come into being.

Evaluation Questions

Before the SFDCC, the WBG had limited objectives explicitly related to climate change. Where such objectives exist, IEG can assess performance against them. Activities with

relevant goals include GEF projects with goals to reduce GHGs, the Bonn Commitment to scale up renewable energy and energy efficiency, and the carbon funds.

But because development and climate change are so closely linked, many development activities look like mitigation projects, even if they were not so labeled. These offer a wealth of lessons for a more climate-conscious future. In particular, they may hold lessons for the implementation and follow-up of the SFDCC and for the use of hoped-for additional climate financing.

The WBG has had limited objectives specifically related to climate change, but many of its activities look like mitigation projects.

The SFDCC addresses national goals of sustainable development and global goals of climate mitigation. It puts particular emphasis on the pursuit of no-regrets (win-win) actions that promote both goals and on the use of concessional funds (additional to development finance) that promote GHG reduction in a development context. The SFDCC is an evolving, adaptive framework that stresses learning. To increase its effectiveness, it is important to understand how development options compare along different dimensions of impact. To what extent are there untapped no-regrets options? If concessional finance is limited, which are the most attractive “climate-related economic opportunities”?

The principal evaluation questions can be organized under three themes. First, *to what extent do GHG mitigation goals overlap with other development goals?*

Second, *how and in what areas does the WBG have the largest impact in promoting low-carbon development?*

- What instruments, in what contexts, have been most effective in promoting the development, adoption, and diffusion of clean(er) technologies (looking across energy, transport, forestry, and carbon finance)?
- What, in turn, is the impact of technology adoption on GHG emission and development outcomes?
- What internal and external factors affect project outcomes and project mix?
- To what extent and with what impact has the Bank’s Carbon Finance Unit (CFU) catalyzed the development of the carbon market and its institutions?

A third emerging theme is *the role of learning, feedback, and incentives:*

- To what extent, and with what rapidity, is the WBG able to monitor the outcomes of its climate-related activities?
- To what extent is feedback used to improve the design, mix, and targeting of interventions?

Though it addresses related issues, this evaluation does not assess the WBG’s overall impact on GHG emissions.

Because of its focus on mitigation activities, the evaluation does not address the WBG’s overall impact on GHG emissions. It does, however, examine in detail the impact of WBG support for coal-fired power plants, which is emblematic of the wider issue.

Evaluation Framework

Barriers block adoption of low-carbon paths

Why don’t people choose lower-carbon paths: wind power instead of gas, agroforestry instead of pasture, fluorescent light bulbs instead of incandescents? Standard explanations cite *barriers* such as:

- Cost-competitiveness: The low-carbon alternative is worthwhile from a social viewpoint that takes climate and other benefits into account, but it is not competitive with high-carbon alternatives from the household, firm, or country viewpoint.
- Credit bottlenecks: Renewable energy and energy efficiency have a big up-front capital component, so lenders and investors need confidence that they will be repaid.
- Lack of information or attention: People don’t perceive the opportunities, don’t know what to do about them, or overestimate the risks of action.
- Unfavorable policies: Laws or regulations (for instance, fossil fuel subsidies) favor the higher-carbon alternative.

The WBG seeks to overcome barriers through analytic and lending support for policy reform, technology transfer, and project finance and implementation.

Interventions can overcome barriers to technology adoption

- The WBG can deploy *interventions* that address these barriers at the site or sectoral level, unlocking carbon and economic benefits.
- These interventions include analytic or lending support for policy reform; transfer, adaptation, and dissemination of technical and financial innovations (technology transfer); and project finance and implementation.

Adopted technologies yield economic, social, and carbon returns

Low-carbon investments can promote development along many dimensions, in addition to mitigating GHGs. Ideally, one would want to assess each intervention’s impact on

growth, poverty reduction (including access to energy and transport), gender equity, and GHG emissions. Unfortunately, monitoring and evaluation data rarely exist for most of these dimensions. This evaluation tries where possible to characterize an investment's economic rate of return (ERR) as a summary measure of development impact. In addition, it tries to quantify as cobenefits the investments' carbon rate of return: the net reduction in carbon dioxide (CO₂) emissions per dollar of investment.

Evaluation findings are illustrated in figure 6.1. (Estimates are based mostly on appraisal and should be taken with caution.) In this figure, any project with emissions savings and a high ERR (say, higher than 15 percent) is likely to be a clear no-regrets investment. Projects with somewhat lower ERRs may still be no-regrets from a local viewpoint, because they confer large but hard-to-monetize benefits such as energy security. Some projects, including some forest conservation projects, may have low measured ERRs but nonetheless contribute to local development objectives again in difficult-to-quantify ways. These would be strong candidates for global financial support.

Leverage and catalytic impacts

This figure points to several avenues by which the WBG can increase its impact. Working at “retail” level, it can assemble portfolios of projects with high returns. It can also aspire to catalytic, widespread impacts (GEF 2008). One way to do this is through financial leverage, attracting capital from lower to higher return activities, along both dimensions. A second way is to increase the returns to equity, for instance, by removing regulatory barriers that discourage investment. A third avenue is to boost the returns to an entire class of activities, such as by supporting technical progress that reduces investment costs.

An important way of boosting returns (public and private) is through *provision of information, especially through pilot and demonstration projects*. These projects can work out technical and regulatory problems and hence reduce cost and risk for all similar projects that follow. This evaluation pays close attention to piloting and demonstration projects. The relevant evaluation questions are: What, exactly, is being demonstrated? How is it being demonstrated, and to whom? How will the results of the demonstration change the behavior of the target audience?

The provision of information through pilot and demonstration projects is an important way to boost returns to relevant WBG activities.

As a result of these catalytic interventions, prices may change, with far-reaching effects that could vitiate leverage.

For instance, an innovation that substantially and cost-effectively increased the efficiency of coal-fired power generation would reduce plant-level CO₂ emissions. But it could result in greater global emissions if it triggered substitution of coal for hydropower or gas power. Improvements in agricultural productivity could increase the incentives for deforestation, rather than lessening pressure on the forest. These system-level issues pervade climate mitigation.

Summary

In looking across a diverse variety of sectors, the evaluation asks—

- What are the barriers to technology adoption and diffusion?
- How appropriate were the WBG's diagnosis of the barriers and prescription of interventions?
- What was the impact of the interventions on technology adoption and diffusion?
- What are the economic and carbon returns to adoption?
- Looking at the chain from intervention to impacts, what is the WBG's leverage in this area?
- How well measured are these impacts?

Evaluation Scope

This evaluation faces two big challenges. First is the trade-off between depth and breadth. The range of relevant activities is dazzling, from geothermal power to community forestry to biogas digesters to school insulation. Any attempt to deal with the idiosyncratic features of each of these endeavors is doomed to be shallow. So this evaluation chooses to undertake detailed analyses of specific subsectors that are important in themselves but that also hold general lessons for omitted subsectors. This is done against a comprehensive description of the overall portfolio.



The second challenge is the need to be current. IEG's evaluations often build heavily on completion reviews of closed projects. That is not feasible in this case. On one hand, the number of projects has increased dramatically over the past decade, technology and financial engineering are changing rapidly, and the national and international policy context is in flux. On the other hand, IFC projects are typically not evaluated until five years after approval, and Bank projects are not evaluated until closure, often eight years or more after approval. Consequently, of the renewable energy and energy efficiency projects initiated since 1990, IEG has evaluated only about 100; and though more than 450 projects were initiated between 2003 and 2008, IEG has evaluated only 3 of them.

These considerations lead to the following definitions of scope.

Temporal scope

For background, the evaluation relies on a detailed and comprehensive review of the low-carbon energy and urban transportation portfolios from 2003 to 2008 and a comprehensive but less-detailed review of the forest portfolio for 2002–08. The post-2008 increase in climate-related activities could not be covered in detail, but is briefly described in appendix J. For subsectoral analyses, however (such as solar photovoltaics or hydropower), the evaluation ranges back as far as 1990 to take advantage of information from closed and evaluated projects. It may also report on current activities.

This evaluation looks at attempts to overcome the barriers that inhibit adoption and diffusion of favorable technologies and practices.

Topical scope

The evaluation is concerned with evidence of attempts to surmount the barriers that inhibit the adoption and diffusion of low-carbon technologies and practices. Hence it excludes most attention to the WBG's "high-carbon" activities, such as oil exploration, road construction, and thermal power. Indeed, as pointed out in the Phase I evaluation (IEG 2009), anything the WBG does to promote economic growth will tend to put upward pressure on GHG emissions.

Instead, the evaluation focuses on projects that potentially promote development and reduce GHG emissions, regardless of whether they had a GHG goal. Where such a goal exists, it is appropriate to evaluate the WBG's success in achieving it. Even where there was no explicit goal, it is useful to try to understand the determinants of success or failure.

Pragmatically, these low-carbon sectors are renewable energy, energy efficiency, urban transit, and forest projects related to afforestation or reduced deforestation. The choice of, and emphasis on, these broad sectors (energy efficiency, renewable energy, forestry, and transport) was informed by consideration of current overall emissions levels (figure 1.1), prospects for emission reductions (figure 1.2), emphasis in the Climate Investment Funds, and the scale of WBG commitments.

An important but unavoidable omission was a detailed treatment of agriculture. Agriculture is a large source of emissions from developing countries. Rice paddies and cattle, in particular, emit large quantities of methane. However, understanding of agricultural abatement options and their impacts is far less advanced than for energy, transport, and forestry. The evaluative base is small. So although this is a crucial area for research and piloting, this evaluation limits discussion to an agroforestry project that illustrates the potential for climate cobenefits from agricultural development.

The core of the evaluation is an in-depth discussion of specific subsectors that are important areas in their own right but that also illustrate the challenges affecting the broader sectors to which they belong. For instance, the challenge of promoting low-emissions urban transportation is illustrated through a detailed examination of bus rapid transit, which is the single largest line of WBG action in urban transit and ties together the issues of modal shift, fuel shift, and land use that are central to a city's transport footprint.

Table 1.1 presents a topical map of the evaluation.

The choice of subsectors was informed by considerations of evaluability (track record and data), current overall emission levels (figure 1.1), potential for generalizable lessons, and scale of 2003–08 WBG commitments.

Within renewable energy there are in-depth discussions of hydropower and solar home photovoltaic systems, the largest and most longstanding areas of on-grid and off-grid investment, respectively. There is also a discussion of the economics of on-grid renewable power that applies to all technologies. A significant omission is biomass technology, itself a very heterogeneous category. Figure 1.3 compares renewable energy coverage to the 2003–08 portfolio.

Within energy efficiency there is extensive discussion of investments via financial intermediaries and of projects that reduce transmission and distribution losses. Together these comprise about half the 2003–08 portfolio (figure 1.4). Also discussed at length are projects involving compact fluorescent light bulbs (CFLs), a tiny part of the portfolio, but, it is argued, one worthy of scaling up. The

TABLE 1.1 Map of the Evaluation	
Sector	Subsector
Specific technologies and practices	
On-grid renewable energy	Hydropower
	Wind
	Landfill gas
	Geothermal
	Biomass, biogas
Off-grid renewable energy	Solar photovoltaic
	Off-grid hydropower
	Biomass
Energy efficiency	Energy efficiency via financial intermediaries
	Direct investment in industrial energy efficiency
	Efficient lighting
	Transmission and distribution loss reduction
	Increased efficiency in coal-fired power generation
	District heating (discussed in Phase I)
	Demand side management (discussed in Phase I)
	Building and appliance codes (discussed in Phase I)
	Efficient cookstoves
Transport	Bus rapid transit
	Demand management
	Commuter rail
	Intercity rail
	Aircraft and truck fuel efficiency
Land use and land use change	Protected areas
	Payments for environmental services
	Community forestry
	Plantation forestry
	Agricultural carbon
Technology transfer	Advanced technologies
	Intellectual property rights
Carbon finance	Carbon finance
Thermal power	Coal power
	Natural gas (discussed in Phase I)

Source: IEG.
Note: Areas discussed are in bold type; areas not discussed are in regular type. For Phase I, see IEG 2009.

discussions of the Afsin-Elbistan coal power rehabilitation and of IFC's direct energy efficiency investments cover most of the supply-side and much of the end-user portfolio for this period. The remaining topics, including district heating, were covered at length in Phase I and are briefly synopsized in this volume.

Much of the WBG's transportation investments go to intercity and rural road construction, an emissions-

increasing activity (though with important growth and poverty-reducing benefits), and are not considered here. Attention focuses instead on urban transit, where there is potential scope for shifting away from carbon-intensive auto traffic. Here, bus rapid transit and its variants constitute half of the overall portfolio (see figure 1.5) and 80 percent of the operations (by number) where GHG reduction is an explicit goal.

FIGURE 1.3 WBG Investments in Renewable Energy 2003–08: Evaluation Coverage (by \$ commitments)

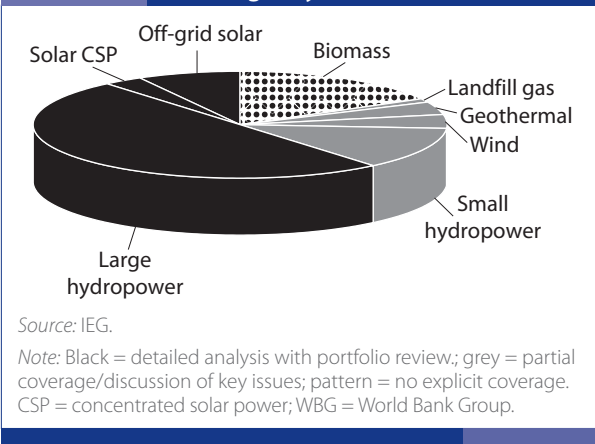


FIGURE 1.5 WBG Investments in Urban Transport 2003–08: Evaluation Coverage (by \$ commitments)

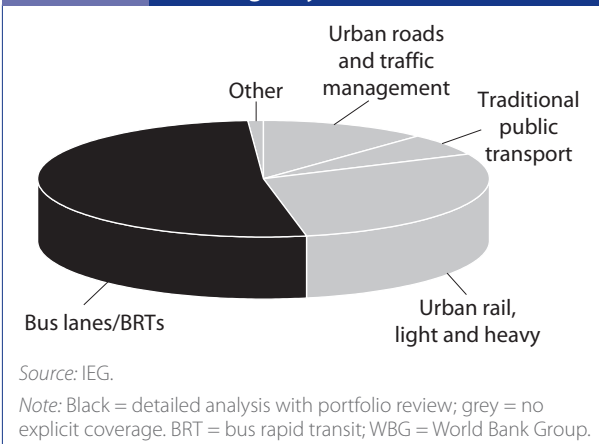
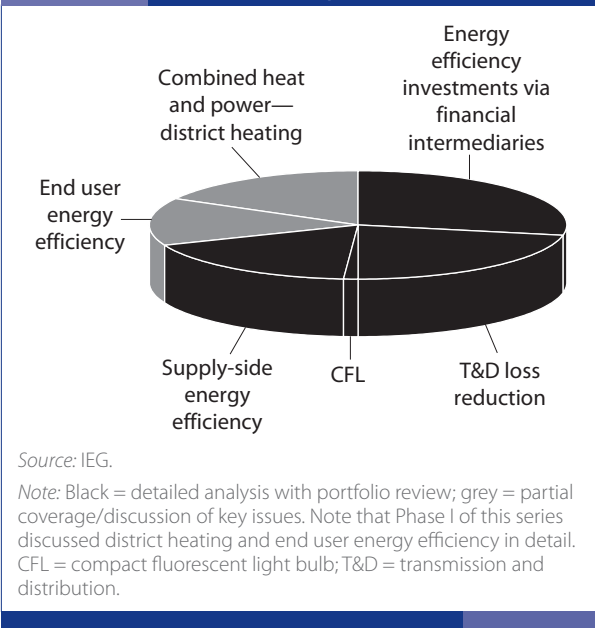


FIGURE 1.4 WBG Investments in Low-Carbon Energy Efficiency 2003–08: Evaluation Coverage (by \$ commitments)



finance to retard deforestation): establishment of protected and indigenous areas; pilots of payment for environmental services projects, including BioCarbon Fund projects; and attempts to foster sustainable agriculture at the forest frontier. Omitted are large plantation projects, which can be carbon sequestering, and community forest projects. The latter, though concerned with impoverished populations and important natural resources, have in general had inadequate monitoring components and hence are difficult to evaluate.

The evaluation also looks at WBG experience in coal power, technology transfer, and carbon finance.

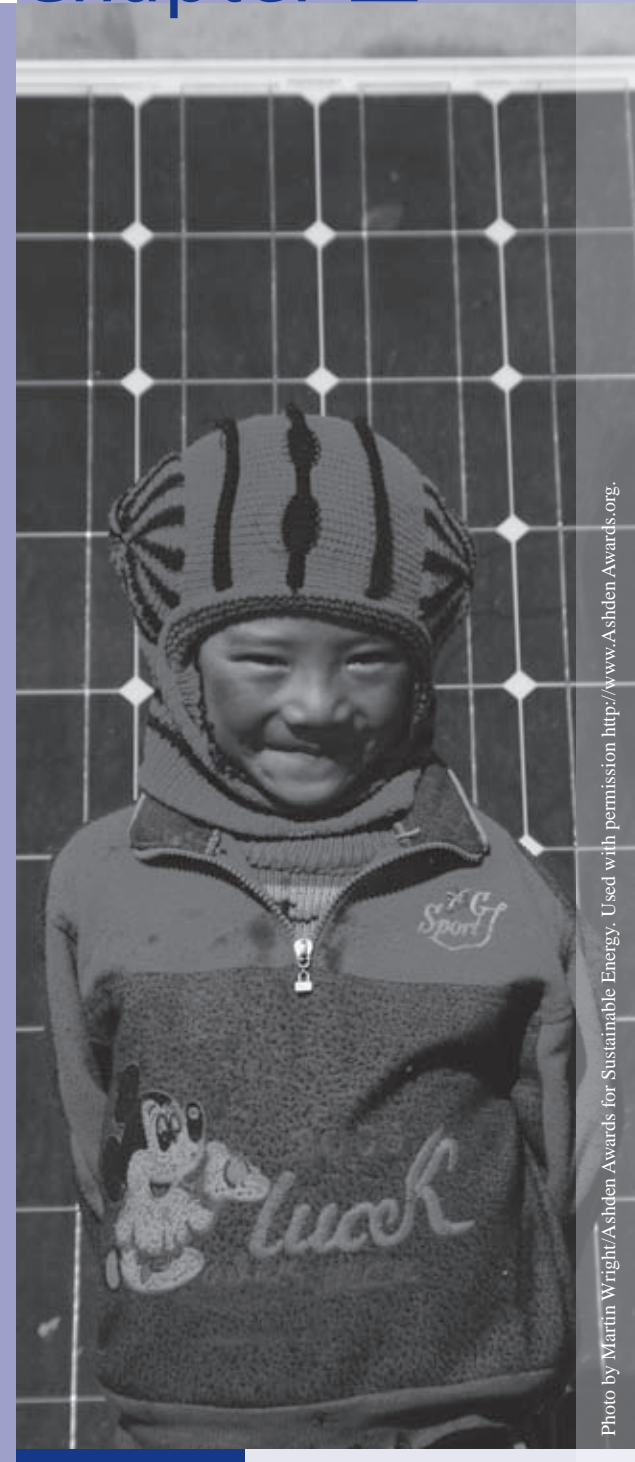
In addition to sectoral discussions, the evaluation addresses three areas of intense current interest. Two are cross cutting: the experience of the WBG in technology transfer and the experience of the WBG’s carbon funds, both as institutional innovations and as financial instruments. The third is an examination of the WBG’s controversial role in supporting coal-fired power plants. This will illuminate some of the general issues regarding the WBG’s role in other high-carbon sectors such as cement and steel production.

The coverage of forestry is the most selective of the sectors. The focus is on three types of activities with strong implications for REDD (an initiative that seeks to harness carbon

Chapter 2

EVALUATION HIGHLIGHTS

- WBG financing of low-carbon energy has increased considerably.
- About two-thirds of closed renewable energy and energy efficiency projects had outcomes that were moderately satisfactory or better.
- Policy advice and piloting have been helpful in catalyzing diffusion of wind power.
- Carbon finance has little impact on the bankability of wind power and hydropower, but significant impact for landfill gas projects.
- Long loan tenors (time to repay) are an important stimulus to project bankability.
- Guarantees and political risk insurance may play an increasingly important role for renewable energy.
- Quality-contingent producer subsidies plus microfinance have been successful in promoting the diffusion of solar home photovoltaic systems.
- Capacity utilization is a key determinant of economic and carbon impacts.
- Better monitoring of costs and impacts is needed to guide future investments.



Renewable Energy

This evaluation devotes special attention to energy because it is by far the largest part of the mitigation-relevant WBG portfolio, is the focus of most existing mitigation-oriented projects and funds, and will play the dominant role in long-term mitigation efforts. As an introduction to both chapters on energy, this section begins by reviewing the outcomes of evaluated renewable energy and energy efficiency projects and then comprehensively describes the recent pattern of low-carbon energy investments.

The chapter goes on to discuss the impact of interventions to overcome barriers to on-grid renewable energy investment. It then discusses the experience with hydropower and with solar photovoltaics, the on-grid and off-grid renewable energy technologies, respectively, with the longest evaluable record at the WBG.

Low-Carbon Energy Projects and Their Performance

As a backdrop it is useful to consider the International Energy Agency's projections of how future power needs will be met over the coming two decades, in two scenarios: reference and ambitious mitigation (450 parts per million; table 2.1). While some energy efficiency is included in the reference scenario, additional efficiency is the main way to satisfy demand while reducing emissions. In both scenarios, increases in hydropower far outpace growth in other types of renewable energy outside the Organisation for Economic Co-operation and Development (OECD).

Performance of closed World Bank projects

Investments in low-carbon energy have increased considerably over the past five years, so most are still ongoing and unevaluated.¹ Of World Bank renewable energy and energy efficiency projects² initiated between 1990 and 2007, 91 had closed and been evaluated by 2009. Table 2.2 shows the outcome of these projects as rated by IEG.

Two-thirds of evaluated renewable energy and energy efficiency projects since 1990 had outcome ratings of moderately satisfactory or better.

TABLE 2.1 International Energy Agency Projections of Power Production, 2007–30

Increase in electricity generation 2007–30: baseline versus 450 ppm CO ₂ scenarios (terawatt hours per year)				
Power source	2007–30 increase under baseline		2007–30 increase under 450 ppm	
	OECD+	Rest of world	OECD+	Rest of world
Hydro	164	1,437	384	2,196
Wind	918	443	1,425	1,180
Solar	215	182	376	554
Other renewable energy	330	414	536	957
Fossil and nuclear power	790	9,644	-1,175	3,751
Total electricity generation	2,417	12,120	1,546	8,638
Incremental energy efficiency			871	3,482

Source: OECD/IEA 2009.

Note: Energy efficiency includes price-induced demand reduction. OECD+ = Organisation for Economic Co-operation and Development + non-OECD European Union members; ppm = parts per million.

TABLE 2.2 Evaluated World Bank Renewable Energy and Energy Efficiency Projects by Rating, Projects Initiated 1990–2007

Rating	Energy efficiency	New renewable energy	Large hydro (>10 MW)
Highly satisfactory	2	1	2
Satisfactory	21	14	3
Moderately satisfactory	10	4	2
Marginally satisfactory	0	1	1
Marginally unsatisfactory	1	0	0
Moderately unsatisfactory	7	2	3
Unsatisfactory	5	8	2
Highly unsatisfactory	1	1	0
Total number	47	31	13
Percent moderately satisfactory or better	70	65	62

Source: IEG based on ICR reviews.

Note: MW = megawatts.

Two-thirds of these projects were rated moderately satisfactory or better, versus 72 percent of all energy projects. Energy efficiency projects fared slightly better than renewable energy projects. Just over half of such projects in low-income countries³ were marginally satisfactory or better, compared to 70 percent in higher-income countries. China had 13 projects, the largest number of any country, and all were rated marginally satisfactory or better. About one-third of this portfolio was in energy efficiency projects in transition countries, with a 64 percent success rate.

Performance of evaluated IFC investment projects

During the period of fiscal 1990–2008, IFC made commitments to 102 investment projects in support of renewable energy or energy efficiency, of which 81 were committed during fiscal 2005–08. Because IFC projects are evaluated on a sample basis after five years of operation, only eight projects have been evaluated, all committed between fiscal 1992 and 1999. Five received satisfactory ratings. Twenty-six ongoing projects, committed during fiscal 1992–2008, have internal monitoring data available.⁴ Of these ongoing projects, 22 were reported as progressing successfully.

The 2003–08 portfolio of WBG investment projects

To assess the portfolio of recently initiated (2003–08) projects, IEG reviewed and validated a database of low-carbon project components assembled by the Bank’s energy

anchor (appendix G). In some cases, IEG revised the classification or funding amount of a component designated as “low carbon.”

The WBG has three arms with different products. Two of those arms (the World Bank and IFC) can use both traditional finance and new, environmentally oriented finance: GEF grants and carbon payments.

Table 2.3 breaks down commitments by technology and by whether financed traditionally or together with environmental finance. Off-grid investments are about 11 percent of this \$8 billion low-carbon portfolio and roughly one-fifth of all rural energy access commitments. Grid-connected renewable energy accounts for \$3.3 billion, compared with \$2.9 billion for energy efficiency. Projects that use financial or other intermediaries account for about 20 percent of this portfolio.

Projects with exclusively traditional financing (International Bank for Reconstruction and Development [IBRD], International Development Association [IDA], and IFC)—that is, without even small amounts of GEF or carbon cofinancing—comprise 70 percent of the 2003–08 portfolio and more than three-quarters of the grid-connected renewable energy portion. Nontraditional finance is most important in financial intermediation for energy efficiency, reflecting a perception that risk aversion is deterring profitable efficiency loans.

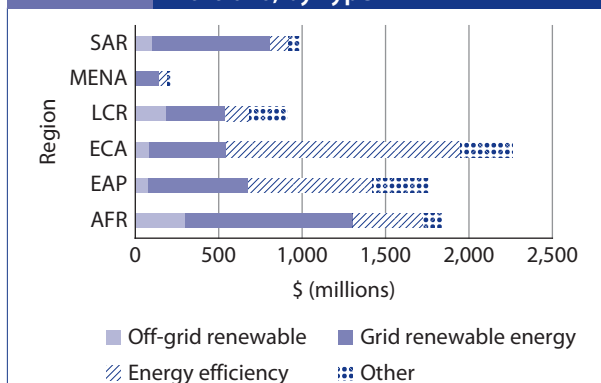
TABLE 2.3 WBG Low-Carbon Energy Commitments (\$ millions) by Product Line and Investment Category, 2003–08

Type of project	Traditional financing (IBRD, IDA, IFC, MIGA)	Blended financing (traditional + GEF or carbon finance)	Stand-alone GEF and carbon finance	Total
Off-grid and mini-grid renewables				
Direct investments, including cookstoves and household biomass/biogas	228	224	64	515
Indirect, with funds that support subprojects	101	124	10	235
On-grid renewable energy				
Direct investments in renewable energy (may include some ancillary transmission and distribution loss reduction)	2,277	282	496	3,055
Indirect, with financial intermediaries	202	0	11	213
Energy efficiency				
Transmission and distribution loss reduction	529	104	0	633
End user energy efficiency	338	21	63	422
Combined heat and power and/or district heating	344	77	56	477
Supply-side energy efficiency	460	2	66	528
Energy efficiency via financial intermediaries	200	514	98	812
Other				
Both renewable energy and energy efficiency, or unspecified, via financial intermediaries	227	85	23	335
Development program lending, other investment programs, and technical assistance	646	14	93	753
Total	5,553	1,446	980	7,978

Source: IEG calculations, low-carbon component database.

Note: Excludes freestanding WBG analytic and advisory activities, IFC advisory services, and special financing. Note that these data exclude transmission and distribution projects that may reduce technical losses but were not classified by the WBG as low-carbon activities. IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation; GEF = Global Environment Facility; MIGA = Multilateral Investment Guarantee Agency.

FIGURE 2.1 Location of 2003–08 Low-Carbon Portfolio, by Type



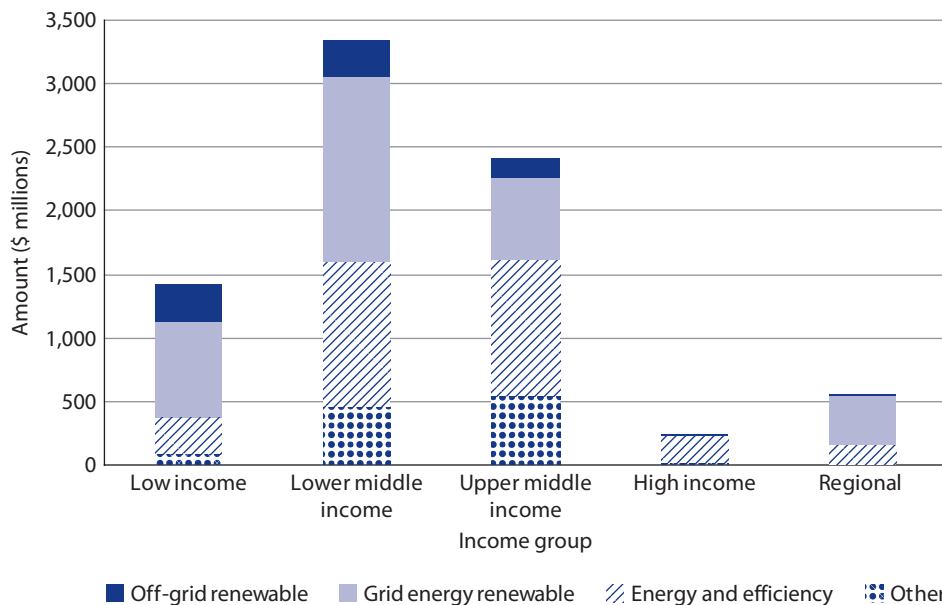
Source: IEG.

Note: Unit of analysis is the project component. Excludes freestanding WBG analytic and advisory activities, IFC advisory services, and special financing. **Regions:** SAR = South Asia, MENA = Middle East and North Africa, LCR = Latin America Caribbean, ECA = Europe and Central Asia, EAP = East Asia and Pacific, AFR = Sub-Saharan Africa. WBG = World Bank Group.

Figure 2.1 shows the location of these projects. Africa's share is large relative to its population; its 30 percent share of grid-connected renewable energy reflects investments in large hydropower. The Europe and Central Asia Region has a large relative and absolute investment in energy efficiency, reflecting a legacy of inefficient equipment and underpriced energy in the transition countries. In contrast, energy efficiency investments in South Asia are small relative to investments in hydropower and coal; this is striking in view of large transmission and distribution losses. (Efficiency and transmission investments increased in fiscal 2009, however.) The Middle East and North African portfolio for this period is very small; the amount counted as renewable energy includes hybrid solar thermal plants that are mostly gas fired.

Seventy percent of the low-carbon energy portfolio was financed purely through traditional instruments.

FIGURE 2.2 Breakdown of 2003–08 Low-Carbon Portfolio by Country Income Group and Type



Source: IEG.

Note: Unit of analysis is the project component. Excludes freestanding WBG analytic and advisory activities, IFC advisory services, and special financing.

Figure 2.2 shows the breakdown of this portfolio by country income group. About 60 percent goes to low- and lower-middle-income countries; China, the single largest recipient, accounts for 16 percent. Energy efficiency is more prominent in the wealthier countries.

Meeting the Bonn commitment

At the Bonn Conference on Renewable Energy, the WBG promised that with the aim of ensuring an institutional focus on the transition toward cleaner energy sources, it would commit to a target of at least 20 percent average growth annually—in both energy efficiency and new renewable energy commitments—over the next five years (fiscal 2005–09).

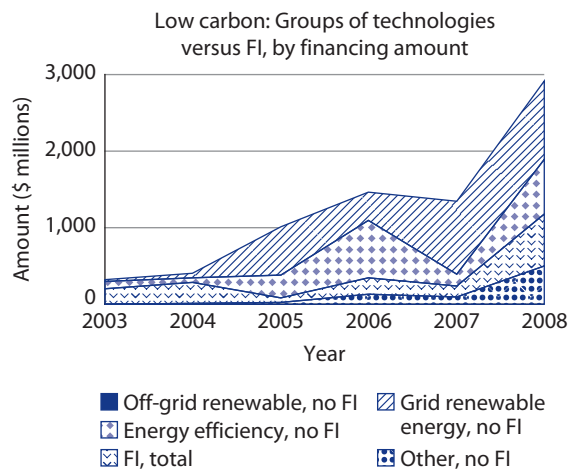
IEG’s reckoning of funds committed to energy efficiency and new renewable energy exceeds that of the WBG. The Bonn Commitment was surpassed, with commitments growing from a base of \$209 million to \$2,061 million in 2008 (IEG calculation) and \$3,128 in 2009 (management calculation).⁵ Figures 2.3 and 2.4 show the growth in total low-carbon commitments, indicating a sizeable boom in grid-connected renewable energy, much of it large hydro-power not counted under the Bonn Commitment.

Energy efficiency grew with large spurts in 2006 and 2008, with financial intermediaries assuming more prominence in the latter period. The growth was mostly in projects that were purely traditionally financed, with a rapid expansion of IFC and IBRD funds, and it occurred disproportionately in the lower-middle-income countries.

The WBG funds committed to energy efficiency and new renewable energy greatly exceed the amounts agreed under the Bonn Commitment.

Based on data reported by the Investment Framework for Clean Energy and Development (management), low-carbon

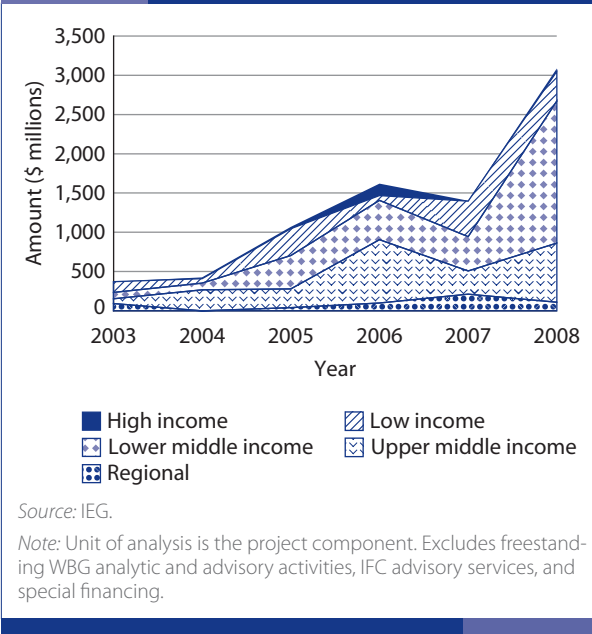
FIGURE 2.3 Growth in Low-Carbon Portfolio by Project Type



Source: IEG.

Note: Unit of analysis is the project component. Excludes freestanding WBG analytic and advisory activities, IFC advisory services, and special financing. FI = financial intermediation.

FIGURE 2.4 Growth in Low-Carbon Portfolio by Country Income Class

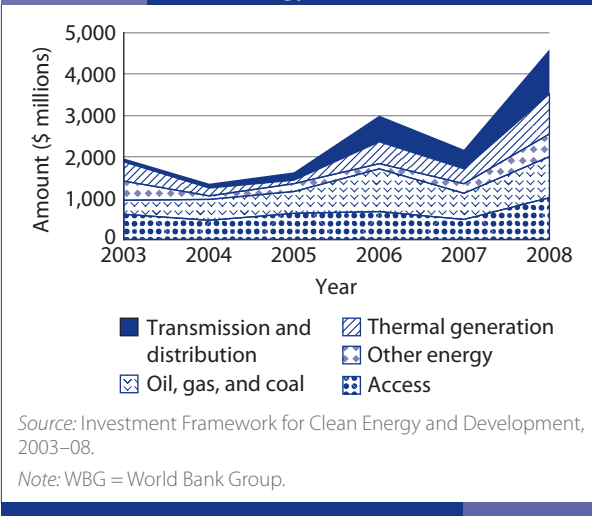


and blended low-carbon and access projects account for 37 percent of all energy portfolio financing in 2003–09. Figure 2.5 shows the growth of the remainder.

Hydropower is by far the largest subcomponent of the recent renewable energy portfolio.

Figure 2.6 shows how total new energy generation capacity was divided between fossil fuels and renewable sources. Large hydropower dominated power investments in IDA countries. In IBRD and blend countries, coal accounted for a third of new capacity, gas 28 percent, and large hydro-power 18 percent.

FIGURE 2.5 Breakdown of Non-Low-Carbon WBG Energy Investments



Coal accounted for one-third of new generating capacity supported in IBRD countries.

The WBG’s on-grid renewable energy portfolio

Hydropower is the renewable energy technology with the longest and largest record within the WBG and the one with the greatest predicted potential scale-up over coming decades. However, there has been a rapid increase in “new renewable energy”: wind, geothermal, biomass/ biogas/landfill gas, and solar (table 2.4) Although this chapter devotes special attention to hydropower, a discussion of barriers and interventions in this chapter also draws on recent experience with wind projects, and lessons from these barriers and interventions apply to other forms of renewable energy. Grid-connected solar power is discussed in chapter 6.

The WBG’s off-grid renewable energy portfolio

In remote areas with low population densities, it can be cheaper to provide decentralized renewable power through home systems or mini-grids than to extend the main electric grid.⁶ This has raised hopes of fighting both climate change and poverty with a single instrument, or using climate finance to promote rural access.

Those hopes are manifest in the large investments in solar home photovoltaic systems (SHS), the off-grid technology with which the WBG has the longest record and the focus of the discussion of off-grid renewable energy in this chapter. However, in the recent portfolio, SHS projects have been overtaken by small hydro and biomass (see table 2.5). Biomass projects include efficient cookstove projects as well as power projects.

Among off-grid renewable energy technologies, solar home photovoltaic systems have the longest record at the WBG

FIGURE 2.6 WBG-Supported Grid-Connected Generation Capacity by Technology, 2003–08

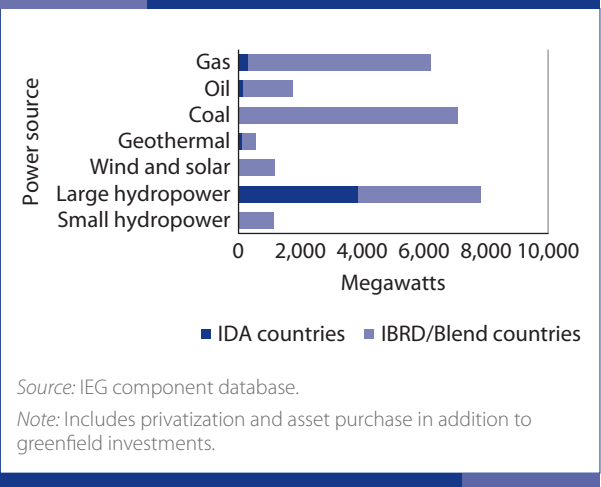


TABLE 2.4 Commitments to Grid-Connected Renewable Energy by Technology and Funding 2003–08 (\$ millions)

Technology	IBRD	IDA	IFC	MIGA	GEF	Carbon Finance, World Bank & IFC	Total
Wind	335.7	32.9	38.5		71.2	42.8	521.1
Hydropower	849.4	825.8	358.7	225.5	0.4	182.3	2,442.2
Geothermal	202.0	31.5	57.3	88.3	8.5	18.6	406.3
Biomass	20.0	28.0	32.7		40.2	108.1	229.1
Solar					142.4		142.4

Source: IEG.

Note: Unit of analysis is the project component. Excludes freestanding WBG analytic and advisory activities, IFC advisory services, and special financing. Components that support multiple technologies are included in each relevant row, so column totals should not be used. GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation; MIGA = Multilateral Investment Guarantee Agency.

Analytic, advisory, and technical assistance projects

The WBG also conducts analytic, advisory, and technical assistance outside of investment projects. Within the World Bank, many of these activities have been funded by two donor-supported programs resident in the Bank: the Energy Sector Management Assistance Program (ESMAP) and the Asia Sustainable and Alternative Energy Program (ASTAE).

Many of the WBG analytic, advisory, and technical assistance activities have been funded by separate donor-funded programs within the Bank.

ASTAE is focused on energy efficiency, scaling up use of renewable energy, and increasing access to energy; it specifically aims for high leverage. In contrast to other analytic and advisory assistance and investment units, ASTAE tracks specific indicators on its projects and sets impact-based (rather than expenditure-based) targets, though tracking and attribution is difficult. With \$6.2 million of disbursements for fiscal 2007–09, ASTAE claimed support for new renewable energy capacity (with

involvement in 1.03 GW of capacity from direct projects and 12.4 GW from framework, regulation, and investment mechanisms), energy efficiency savings (1.6 terawatt-hours direct, 26.2 terawatt-hours indirect 2007–09), household access (611,000 new households direct, 200,000 indirect), and avoided CO₂ emissions (99 million tons direct, 1,003 million tons indirect).

IFC advisory services cover a diverse range of activities related to renewable energy and energy efficiency.

IFC's advisory services cover a diverse range of activity, including some investments. In the 2005–08 renewable energy/energy efficiency portfolio of \$40 million, \$25 million was in GEF-supported projects with explicit climate goals. The largest, comprising about one-third of total value, was linked to an IFC investment project; 19 of the remaining 20 were not. Some projects included broad-based training and capacity building. The non-GEF projects were mostly small (median size of \$130,000) and involved technical assistance to a specific firm; almost half were linked to an existing or prospective investment.

TABLE 2.5 Off-Grid Investment Projects (\$ millions), 2003–08

	IBRD	IDA	IFC	MIGA	GEF	Carbon finance World Bank & IFC	Total
Wind	4.1	23.9	35.0		18.4	0.0	81.4
Hydropower, all	84.0	222.8	0.0		64.0	6.8	377.6
Biomass, all types	0.0	71.5	140.4	1.8	30.8	35.0	279.5
Solar	50.5	171.9	10.0		73.2	7.1	312.7
Unknown off-grid	7.1	67.3	0.0		25.3	0.0	99.6

Source: IEG.

Note: Unit of analysis is the project component. Excludes freestanding WBG analytic and advisory activities, IFC advisory services, and special financing. Individual components may appear in multiple rows if they support more than one technology, so column totals should not be used. GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation; MIGA = Multilateral Investment Guarantee Agency.

Overcoming Barriers to On-Grid Renewable Energy

Renewable energy has strong local advantages in addition to its global benefits. The electricity it provides can drive development and satisfy consumer aspirations. A switch from fossil fuels to renewable power abates acid rain and noxious air pollution. Renewable power also enhances domestic energy security and buffers a country's economy against the gyrations of international prices for oil, coal, and gas.

On-grid renewable energy faces barriers to investment:

- Renewable power is usually more expensive to produce than coal or diesel power, so it can compete only if producers are rewarded for its local or global benefits.
- More of the cost is up-front capital than is the case with fossil-fueled power. So developers need affordable loans, and bankers need reassurance that a stream of repayment will continue for many years.
- Power sector laws, regulations, and operations may be poorly adapted to the peculiarities of renewable energy and often discriminate against small producers.
- In many countries, technical capacity for building, maintaining, and integrating renewable energy may be weak.
- Renewable energy, especially large hydropower, can present environmental and social risks.
- Many kinds of renewable energy are intermittent and thus less convenient than plants that produce assured baseload or peak power.

Among the barriers to on-grid renewable energy are costs relative to coal, oil, or gas; up-front capital needs; lack of adequate regulations and technical capacity; and environmental and social risks.

This analysis of grid renewable energy uses a spreadsheet-based financial model to assess how interventions available to the WBG can boost project bankability, overcoming these barriers. The model, inspired by de Jager and Rathmann (2008), is based on detailed financial appraisals of 20 hydropower, wind, gas, and coal projects financed by IFC and the Bank's Carbon Finance Unit. The projects, chosen for the depth of their documentation, are not a random sample but do illustrate a range of project costs, performance, and economic and fiscal environments. Although the financial model can involve baroque complexities of loans and taxes, a simple approximation (box 2.1) provides powerful insights. (Box 2.5 illustrates how some of these interventions were applied in Sri Lanka.)

Support more profitable technologies

Some technologies are inherently more profitable than others and are thus easier to finance and more competitive with fossil fuels. The key determinants of returns, as shown in box 2.1, are construction cost and capacity utilization. Both can vary substantially. For instance, cost for small hydropower plants has varied from \$1,400 to \$3,000 per KW. Overall, hydropower economics are generally much more favorable than for wind power. IFC experience (on a small sample) shows that large hydropower plants have an appraised average financial rate of return of 17 percent, small plants have a 13 percent rate of return, and wind a 9 percent rate. IEG analysis of project finance confirms this relationship, holding constant variation in taxes and power tariffs, and shows that returns on equity increase sharply as financial rates of return grow (figure A.1 in appendix A).

The key determinants of returns for grid-connected renewable energy are unit cost of capacity, capacity utilization rate, and tariff.

Boost capacity utilization

The economic and carbon returns of a renewable energy plant are directly proportional to capacity utilization (the ratio of actual to potential power production). So bankability can be strongly improved by favorable siting of plants (for example, where winds or river flows are more reliable) and by ensuring better maintenance and operations.

The economic and carbon returns of a renewable energy plant can be boosted significantly by improvements in capacity utilization.

Capacity utilization varies greatly and is not strongly correlated with the size of the facility (see figure A.2). Figure 2.7 shows the distribution of imputed⁷ capacity utilization among hydropower plants registered with the Clean Development Mechanism (CDM), most of which are run-of-river. The capacity factor among all plants varied from less than 10 percent to more than 90 percent. No WBG carbon-funded plant achieved greater than 60 percent.

In China, CDM-registered wind plants have an average capacity factor of just 23 percent (for comparison, the US average is 34 percent). The low utilization rate has been attributed to poor siting, inadequate grid integration, and low-quality turbines (Lewis 2010).

Detailed resource maps, such as wind atlases, could in principle help governments and private developers ensure that renewable energy facilities are well utilized, taking into account environmental constraints and availability of transmission

BOX 2.1 The Economics of Grid-Connected Renewable Energy

A stylized model provides useful insight into what financial and policy levers can boost the economic attractiveness of a renewable energy project. The economics depend on four factors: unit cost, capacity utilization, tariff, and carbon credit rate.

A developer needs to finance a power plant with a *unit cost* of \$1,000–\$4,000 per kW. The plant will produce a flow of electricity. But most renewable energy plants do not operate at full capacity. Wind plants, for instance, may only produce 25–40 percent of their theoretical full output. This ratio is the *capacity utilization*. The electricity is sold at a net *tariff* of, say, 5–15 cents per kWh after transmission costs. This renewably generated electricity may also displace fossil-generated electricity, generating a *carbon credit rate* of, say, 0.2–1.2 cents per kWh, depending on the price of carbon and the kind of fuel displaced. Then (with some simplifying assumptions, such as negligible costs of operations and maintenance, no peak-period tariffs, and no payments for capacity or penalties for intermittency) the pretax financial rate of return to the project is

$$\text{Financial rate of return} = (\text{Tariff} + \text{Carbon Credit Rate}) \frac{8,760 * \text{Capacity Utilization}}{\text{Unit Cost}}$$

(To get the ERR, use economic rather than market values for electricity and carbon, and account for local environmental benefits.)

This shows that if electricity sells for \$.06 per kWh, then the following actions would have equivalent impacts on the rate of return:

- Adding carbon credits at \$10 per ton CO₂ (assuming displacement of .6 kilograms per kWh)
- Adding a renewable energy premium of \$0.006 to the tariff
- Boosting capacity utilization from 30 to 33 percent through better siting, better design, or improved maintenance
- Reducing construction costs from \$1,100 to \$1,000 per KW.

The developer cares about the return on equity, not the overall return, and therefore leverages its equity by borrowing, ideally, 60–80 percent of the capital cost. This works as long as the returns are greater than the interest rate on the loan. The prospective returns have to be high enough to outweigh the risks. These include the risk that the buyer will renege on the promised tariff, which must be sustained over many years to pay back the large initial capital investment.

Meanwhile, the lender wants to make sure that the investment is sufficiently lucrative that the developer can readily afford the loan repayments. So lenders insist that the project's revenue be sufficient to easily cover the loan repayments—that is, that the *debt service coverage ratio* be significantly greater than one. This ratio can be enhanced through longer loan lengths and lower interest rates.

Source: IEG.

Note: 8,760 is the approximate number of hours in a year.

lines. The WBG has funded a number of mapping exercises (appendix B). Most of these modestly funded exercises are still under way, and impact evaluation is not possible.

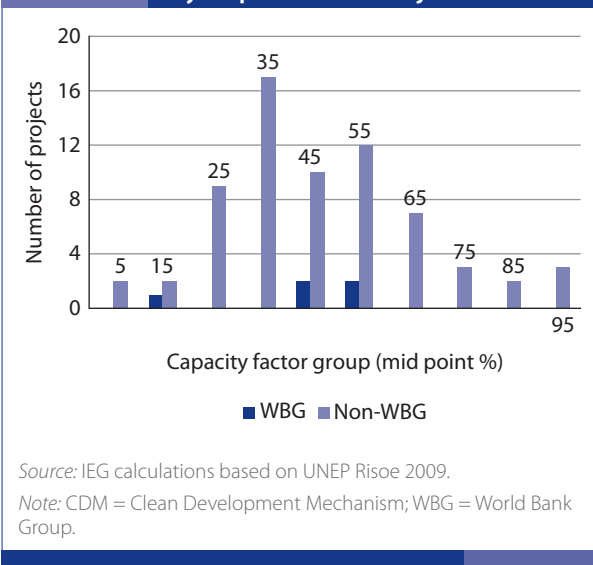
The WBG has financed development of a number of renewable energy resource maps that might assist in siting decisions and thus improve capacity utilization.

The WBG could also help, through technical assistance, to ensure that projects' design plans for capacity utilization are realistic. Hydropower, wind, and landfill gas plants have

undershot their planned production levels; in many cases this is because of inadequate assessment of resources at the site. Box 2.2 explains why this has happened for landfill gas projects and what is being done in response.

Operations and maintenance can affect capacity utilization. Unavailability of spare parts can put turbines out of commission, for instance. Technical assistance for maintenance and manufacturing could reduce downtime. As a crude measure of WBG support in this area, IEG's review of the 2003–08 portfolio found that about one-third of minihydro and one-quarter of wind investment components included training and capacity building for installation or maintenance.

FIGURE 2.7 Distribution of Capacity Factors of Hydropower CDM Projects



Landfill gas projects have produced much less gas than expected, but good monitoring and rapid feedback have prompted more realistic appraisal.

Provide carbon finance

From an economic viewpoint, carbon payments reward renewable energy sources for reduced emissions. In the idealized world of the CDM, such a payment is supposed to nudge an investment project over the threshold of financial viability. In reality, a carbon payment, like a

feed-in tariff, will be one of many factors that elicits a response from investors.

CDM projects must explain the barriers faced by the project and how carbon finance will help overcome them. A review of Bank-financed hydropower plants found that many projects (in China, Guatemala, Honduras, India, Nigeria, and Ukraine) claim barriers related to insecure or short-term power purchase agreements. If these are in fact the barriers, then the use of carbon finance is a project-specific bandage for a sectorwide problem. A higher leverage intervention would be to work at the policy level to correct the problem, potentially catalyzing the entry of many plants.

Carbon finance has had modest impacts on investor returns for CO₂-reducing renewable energy projects.

Figure 2.8 shows the impact of carbon finance in a sample of WBG projects, based on financial data presented for appraisal. The figure shows the return on equity (ROE) computed with and without the contracted carbon payments. The degree to which carbon may have affected investors' incentives clearly differs among the cases. A strong nudge toward investment is plausible in the case of one project with a base ROE of about 13 percent, which received a boost of 2.5 percentage points from carbon. It is less plausible for projects that started with a return of 20 percent or above and received only 0.5 percent additional from carbon.

The relatively modest impacts on ROE reflect the basic economics of carbon. Renewable energy projects that substitute for fossil fuels reduce CO₂ emissions by 0.8 kilograms/kWh,

BOX 2.2 Monitoring and Evaluation Provides Rapid Feedback on the Performance of Landfill Gas Projects

"Sanitary" landfills, as the name suggests, are a big improvement over open dumps and are an essential part of modern urban development. But when waste rots anaerobically in these landfills, it produces methane, a GHG 25 times more potent than the CO₂ produced in open dumps.

With the advent of the CDM, landfill gas projects can claim credit for destroying methane at 25 times the rate, per ton, of CO₂ reduction. This could make them bankable, even in the absence of electricity sales.

Consequently, 136 landfill gas projects were registered under the CDM between 2001 and 2009, and the World Bank's CFU has purchase agreements with 21. Like all carbon projects, landfill gas projects must report and verify their production annually. This mandatory monitoring soon revealed that many of these projects were grossly underperforming relative to design expectations, producing on average only about half the planned credits.

In 2007, the World Bank's carbon fund sponsored an analysis of the reasons for underperformance. This and other studies showed that project appraisers had estimated the landfill's methane yield based on models of US landfills. But developing country garbage is different from US garbage—it is richer in food waste and moisture content, generates less methane per ton, and decays faster. Investigation showed specific ways in which poor operation and construction of the landfill can also depress yields. Feedback on these factors has improved the appraisal and design of subsequent landfill projects, for instance, leading to more conservative estimates of production.

Sources: IEG; SCS Engineers 2007.

on average (Iyadomi 2010). (Reductions are smaller in hydro-power-dominated countries such as Brazil.) Thus, carbon payments at \$10 per ton (World Bank 2009)⁸ would add roughly 0.8 cents/kWh to the investor's revenue—a relatively small increment in many competitively priced power markets. These carbon flows may offer greater security and less exchange rate risk than domestic payments from an uncreditworthy electricity off-taker, and thus serve a kind of guarantee function in some cases. However, as the formulas in box 2.1 show, the impact of carbon on ROE and ERR is proportional to the capacity utilization factor. Thus, ironically, carbon payments are less helpful to economically mediocre projects than to good ones. Of course, the impact would be much stronger if CO₂ were priced at the \$30–\$60 levels that many analysts suggest is necessary for effective global climate change mitigation.

Carbon sales have not catalyzed wind and hydropower investments.

Carbon market participants acknowledge that carbon sales have generally not been catalytic in triggering wind and hydropower investments. But carbon can make a big difference for projects that capture methane emissions and destroy them or use them for energy, as noted earlier.

Provide better loan terms

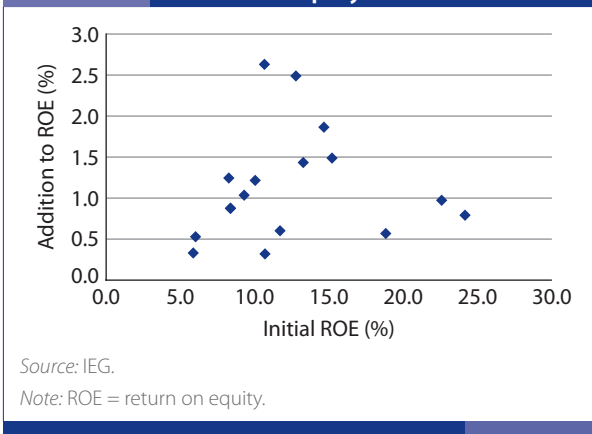
Lower interest rates and longer repayment periods make projects more bankable, though they do not affect the ERR. The financial model suggests that a change from a 5-year to a 10-year tenor could boost the debt service coverage ratio from 1 to 1.4. This is a very significant difference, which might well be sufficient to make a project bankable.

Longer repayment periods make projects much more bankable.

Although IFC does not compete with commercial lenders on interest rates, it can and does offer longer tenors, often around 10 years as opposed to 5 for commercial loans (with much variation). In syndicated loans, IFC terms are usually matched by other lenders. The IBRD can offer both lower interest rates and longer tenors than commercial lenders.

IBRD's Turkey Renewable Energy Project (2004) is an example of the catalytic effect of longer loan repayment periods. This project loaned about \$200 million to a state bank and a private bank. The funds were on-lent to 22 renewable energy investments (mostly hydropower, with wind and geothermal power plants as well) with total value of \$774 million and a capacity of 605 MW; claimed lifetime CO₂ reductions are about 1 million tons.⁹ One success factor was that the Turkish banks offered loans of 10 years' duration or

FIGURE 2.8 Impact of Carbon Payments on Return on Equity



more, compared to prior norms of 4 years. This precedent also convinced other banks to offer lengthier repayment periods for renewable energy projects.

Political risk insurance could be important in catalyzing renewable energy investment.

Mitigate risks

Renewable energy investments can be risky. The investor puts a large sum into an expensive, immovable installation and must trust a utility to keep paying an agreed tariff for many years. This risk is more acute than for fossil fuel plants, because renewable energy plants cost more per MW. In many countries, the off-taker is in poor financial health or subject to external pressures.

The use of feed-in tariffs (a producer subsidy) poses another risk. Governments may promise 10 or 15 years of these premium payments for renewable power to make the initial investment worthwhile for investors. But if a financial crisis were to hit, governments might be tempted to eliminate these subsidies, because the marginal costs of continued operation are low. Governments might also be tempted to renege on feed-in tariffs if prices of coal, oil, or gas declined.

These considerations suggest that guarantees and political risk insurance could be important in catalyzing renewable energy investment. In principle, MIGA can provide political risk insurance at lower cost than private agencies, because the WBG's special relationship with client governments lowers its risk. Both the World Bank and MIGA have in fact provided such insurance. Box 2.3 describes a MIGA example. Mostert, Johnson, and MacLean (2010) explain how WBG partial credit guarantees facilitated longer loan terms for a Philippine geothermal and a Chinese hydropower plant, making them both bankable.

In 2000, an energy company was awarded a build-own-operate contract for a geothermal power plant in Africa, with rights to develop additional geothermal fields and expand capacity. The company signed a 20-year power purchase agreement with the national power utility, a parastatal. The average base generation tariff was slightly higher than the average cost for domestically produced electricity but lower than the cost of imported hydropower from neighboring countries. The country has long suffered from power shortages, and in 2000, only 10 percent of the population had access to electricity.

Major risks for the investor included currency transfer restrictions, government breach of obligations under the power purchase agreement, and civil disturbances. MIGA provided the company (a repeat client) coverage against currency transfer restrictions, war and civil disturbance, and expropriation. Expropriation coverage insures broadly not only against the risk of outright seizure but also against breach of contract and other forms of de facto expropriation.

Shortly after MIGA issued the guarantee for Phase 1 of the project, the government attempted to renegotiate the tariffs because the off-taker's power purchase price from the company, as agreed under the power purchase agreement, was higher than the tariff it charged to end users. The government also refused to honor some of its contractual obligations under the power purchase agreement. The dispute resulted in additional costs and delayed completion of the first phase of the project.

MIGA worked with both parties over five years and played a crucial part in reaching a resolution. The World Bank's long involvement in the sector—it had financed two adjacent geothermal plants—provided a foundation for these discussions. The disputes were resolved when the utility agreed to honor the existing power purchase agreement without price renegotiation. The investor considered MIGA's guarantee as critical for the implementation of Phase 1 of the project and, on resolving the dispute, obtained additional MIGA political risk insurance to cover expansion of the geothermal plant's installed capacity.

Source: IEG-MIGA.

Over 2003–08, guarantees for grid-connected renewable energy were \$541 million, about 15 percent of WBG commitments for grid-renewable energy. During this period, MIGA issued six guarantees for renewable energy projects. By far the largest guarantee was for the 1-GW Nam Thuen 2 hydropower project in Lao PDR, which benefited from \$91 million in MIGA political risk insurance and \$50 million in an IDA partial risk guarantee. These guarantees were essential for the participation of private lenders in the \$1 billion loan consortium, which also included public agencies.

Is there scope for greatly expanded use of the World Bank's partial risk guarantees or MIGA's political risk insurance in promoting renewable energy? IEG's evaluation of WBG guarantees found that guarantees had been underutilized and that high processing and transaction costs and—in MIGA's case—eligibility restrictions on the type of risks that can be covered limited the WBG's ability to expand guarantees. With a change in the MIGA Convention, MIGA's coverage is now expanded, but its institutional constraints would still need to be overcome.

For the World Bank, supporting national guarantee facilities is one approach.¹⁰ The World Bank could, for instance, help countries assess the fiscally prudent opportunities for feed-in tariffs or renewable portfolio standards and support guarantees for countries with sustainable plans.

Guarantees have benefits, but add to the cost of finance. It may be possible to use carbon finance to offset some of this cost. As noted, at current carbon prices, annual revenues from carbon credit sales provides little help with debt finance and little impetus for investment. Much greater leverage could be achieved, however, if carbon sales revenue were used to finance guarantee or insurance payments, which in turn permitted lenders to offer longer loan durations.

Promote renewable energy -friendly pricing regulation

A renewable energy plant's ROE is very sensitive to pricing of power. Appendix figure A.3 shows the ROE for three different plants, evaluated at a range of different tariffs. As in the case of carbon revenue, higher tariffs have a bigger effect on plants with higher capacity utilization, other things being equal. Under the assumptions shown, wind does not become commercially attractive until tariffs exceed 10 cents/kWh.

The returns to a renewable energy plant are very sensitive to power tariffs.

Countries have purely domestic rationales for paying a premium for renewable energy, including local pollution reduction, insurance against fuel price shocks (Hertzmark 2007),

and industrial policy. An increasing number of countries, both developed and developing, have adopted policies that award premium prices to generators of renewable power, for instance, through feed-in tariffs. By early 2009, 43 developing and transition countries or subnational regions had adopted feed-in tariffs for renewable (REEEP 2009).

However, pricing policies are often unfavorable to renewable energy. Fossil fuel subsidies and artificially low electricity tariffs place renewable energy at a disadvantage. (World Bank responses, in promoting rationalized fuel and electricity pricing, were described in Phase I of this evaluation.)

In many countries, small power producers, including hydropower and biomass plants, face unclear or discriminatory regulations on access to the grid. Producers may face daunting years-long negotiations with utilities. In contrast, utilities face difficulties in accommodating intermittent, nondispatchable power sources.

Starting in the 1990s, the World Bank assisted a number of Asian countries in drawing up and implementing small power purchase agreements that reduced transaction costs and risks for independent small power producers while providing incentives to serve peak loads. Ferry and Cabraal (2006) describe the experience in India, Sri Lanka, and Thailand as being generally successful, with less success in Indonesia and Vietnam. IEG's tally of the timing of small power investments (figure A.4) supports a catalytic role in Andhra Pradesh (India), Sri Lanka, and Thailand (where the emphasis was on small combined-cycle gas turbine plants); additional factors may be at work in Tamil Nadu, India.

Several WBG client countries have drafted or implemented renewable energy legislation. These legislative and regulatory initiatives were complex, country-driven processes often involving many external counterparts, so attribution of impact is difficult. Nonetheless, it appears that relatively low-cost analytic assistance and capacity building from the World Bank has helped countries craft domestically acceptable policies to promote renewable energy. In many cases, receptivity to this advice is heightened by associated investments. However, counterparts view the World Bank as a trustworthy source of advice and analysis.

Relatively low-cost analytic assistance and capacity building have helped countries craft policies to promote renewable energy.

This was true in China, where there is a history of analytic work dating back to the early 1990s. World Bank-funded seminars, study tours, and analyses helped lay out the design choices for renewable energy pricing and funding,

contributing to the renewable energy law of 2006. The law enabled a systemwide levy to fund renewable energy, triggering growth of wind power capacity from 3 GW in 2006 to 26 GW at the end of 2009.

Dialogue in Mexico, together with demonstration wind projects, contributed to a renewable energy law that overcomes previous policy biases against renewable power. GEF funding was used to simulate a feed-in tariff, allowing construction of the first independent wind power producer. A sequence of dialogue and lending in Morocco culminated in a 2010 renewable energy law, but implementing regulations are not in place. In Egypt, there has been input into a proposed new electricity law.

Financing such advisory work can be difficult within the Bank's administrative budget.

Financing this high-leverage advisory work can be difficult within the Bank's administrative budget, even though the costs are relatively low. Some clients, such as Brazil, have borrowed for technical assistance. The World Bank's Mexico team has developed a strategy of concentrating lending in a single large Development Policy Loan and using the (proportional) preparation budget. Elsewhere, teams have relied on donor funding through ASTAE, ESMAP, and GEF. ASTAE provided important inputs in China.

An unusual IFC foray into policy was unsuccessful. Although IFC routinely provides advice to governments on issues related to utility contracting and privatization, a GEF-funded advisory project in the Russian Federation sought to provide broad regulatory advice to complement an IFC wind farm investment. Even under the proposed rules, however, wind prices were not competitive with existing, subsidized fossil-fuel energy prices. The project was not implemented, and wind power capacity in Russia stood at just 16.5 MW at the end of 2009.

On-Grid Renewable Energy: Hydropower

Hydropower is by far the largest source of renewable energy and according to most predictions will retain that position for decades to come. Hydropower with storage reservoirs is the main form of renewable energy that can provide reliable baseload power.

Hydropower has been controversial because of its potential for environmental and social damage. These risks are greater for storage dams, which have sizable reservoirs, than for run-of-river facilities, which have little or no reservoir storage. Risks and damages can be mitigated by consideration of siting; for instance, there may be less risk in favoring

deep, narrow reservoirs in less populated and sensitive areas. Strategic environmental assessment provides a vehicle for optimizing siting, as in the case of the one undertaken for the Nile Equatorial Lakes region.

Depending on location, reservoirs in tropical forest areas can have disparate levels of GHG emissions.

Hydropower reservoirs can produce methane, a powerful GHG, if drowned forests or vegetation inflows decay anaerobically. Complex biophysical processes determine the rate of methane production, which is thought to be highest in shallow tropical reservoirs (Metz and others, 2007). A study of 9 Brazilian hydropower plants (dos Santos and others 2006) found 3 that produced less than 3 percent of the GHGs of a comparable combined-cycle gas plant and 5 that produced 100–400 percent as much. The study did not measure outgassing at the turbines, which may be significant.

The fall and rise of WBG involvement in hydropower 1990–2008

Hydropower comprises the largest share of the current WBG renewable energy portfolio and has the longest record within the WBG. Hydropower has been supported by every unit of the WBG.

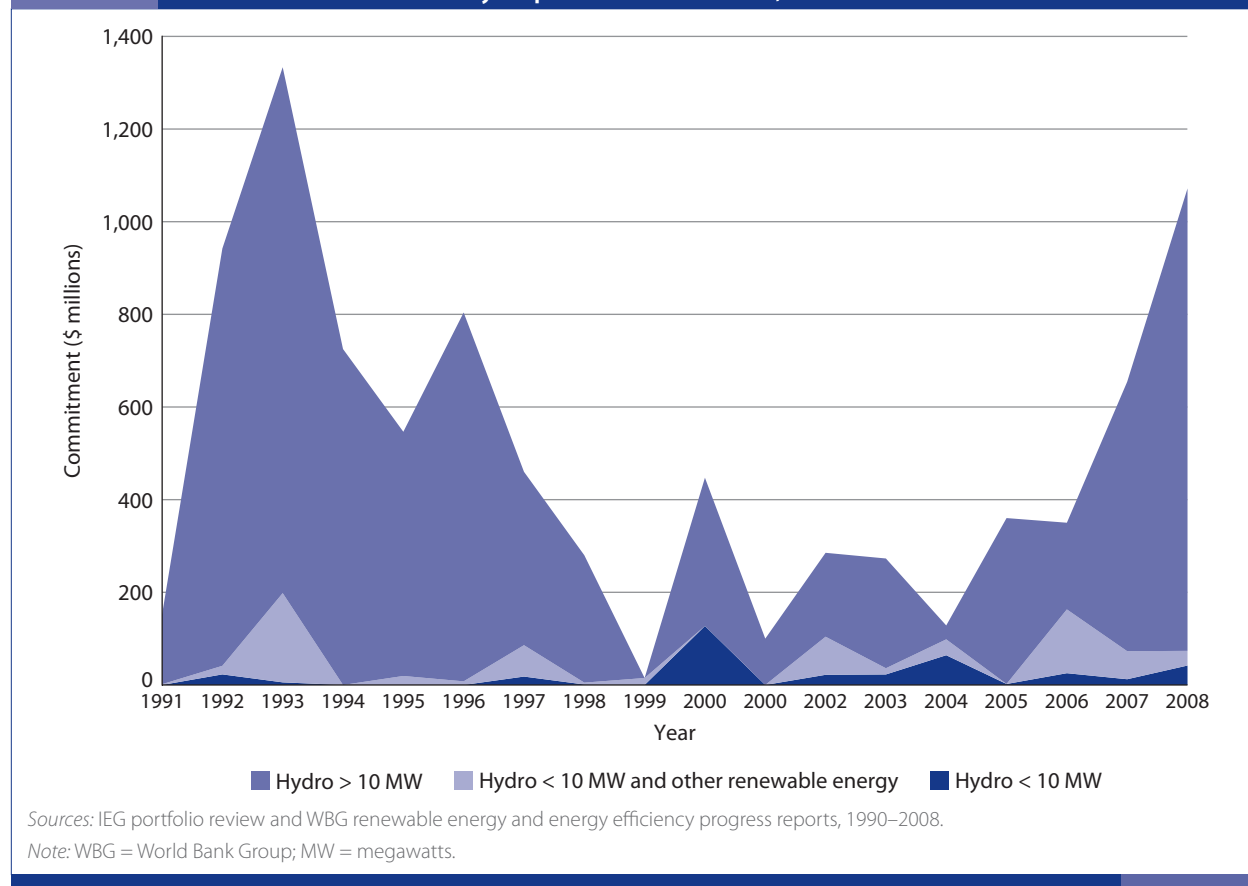
Figure 2.9 documents the decline and rise of hydropower in the WBG portfolio. During the 1990s, criticism of the environmental and social impacts of dams and hydropower led to the convening of the World Commission on Dams and a slowdown in related WBG commitments. The WBG endorsed most of the World Commission’s recommendations, and commitments rebounded after 2000. The WBG recently released a document outlining a vision of increased investment in hydropower, especially in Africa (World Bank 2009).

Table 2.6 shows the breakdown of recent investments by size and presence of storage. Large hydropower with storage (the most environmentally and socially sensitive category) constitutes about one-third of these commitments in volume; some of this is rehabilitation.

Regionally, Sub-Saharan Africa accounts for one-third of commitments overall, a quarter of the large hydropower projects with reservoirs, and about half of the micro and pico (ultra small) hydropower projects. Half of large hydro with reservoirs is in Europe and Central Asia.

Large hydropower with storage constitutes about one-third of World Bank hydropower commitments.

FIGURE 2.9 The Fall and Rise of WBG Hydropower Commitments, 1990–2008



Hydropower by size	All hydropower	>10 MW, with storage	>10 MW, run-of-river	1–10 MW	<1 MW
Guarantees ^a	453.0	203.1	249.9		
IBRD stand-alone	849.4	394.9	540.4	202.0	
IDA stand-alone	528.5	190.9	213.6	28.0	
IFC	358.7		351.6	7.1	
Total traditional financing	2,189.7	789.0	1,355.5	237.1	
IBRD-GEF-carbon finance blend					
IDA-GEF-carbon finance blend	72.9		72.9		
Total blended financing	72.9		72.9		
GEF stand-alone,	0.4			0.4	0.4
World Bank carbon finance	145.5	6.0	129.5	4.1	5.9
IFC carbon finance	33.7		28.7	14.0	
Total new financing	179.6	6.0	158.2	18.5	6.4
Total	2,442.2	794.9	1,586.6	255.7	6.4

Source: IEG.
Note: Unit of analysis is the project component. Excludes freestanding WBG analytic and advisory assistance, IFC advisory services, and special financing. GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation.
a. Guarantees include the World Bank and MIGA.

The number of small hydro projects (hydro < 10 MW) increased significantly after 2002. Prior to 2002, four projects were approved. Between 2002 and 2008, 46 projects were approved that targeted development of small hydropower facilities, of which 10 projects have specific measurable indicators for small hydropower investments. The 2003–08 portfolio consists mostly of active projects: eight are still under implementation, one was closed, and one was dropped.

Performance of WBG-supported hydropower

Forty-five closed Bank hydropower projects have been subject to desk evaluations by IEG; 11 of these have had field evaluations. Of the 45, 34 were connected to the power grid.¹¹

Two-thirds of hydropower projects were rated moderately satisfactory or better.

Overall, outcomes for two-thirds of the portfolio were rated moderately satisfactory and better, with better performance for projects approved after 1998. Outcome ratings are similar in both grid and off-grid projects.

World Bank performance in 35 of the projects was rated moderately satisfactory and better, as was borrower performance in 30 projects. All unsatisfactory ratings for Bank performance and borrower performance occurred in the projects approved between 1990 and 1998. Bank performance was rated unsatisfactory in small and large hydropower projects equally, whereas borrowers' failures were associated mainly with large hydropower projects (nine

large and four small projects with unsatisfactory ratings for borrower performance).

WBG-sponsored CDM hydropower projects have had lower capacity utilization than expected.

Unlike other WBG projects, CDM-registered carbon projects and recent IFC projects provide systematic and timely information on postconstruction performance. CDM projects report actual versus expected production of carbon offsets; this ratio will reflect in large part actual versus expected production of power. Relative to expectations, performance of WBG-sponsored CDM projects in producing carbon offsets was worse than that of other CDM sponsors. Only one of six of these WBG large hydropower plants achieved a yield more than 100 percent of expectations, versus 30 percent of non-WBG plants. Half of WBG

Approval year	Number rated moderately satisfactory or better	Number rated moderately unsatisfactory or worse
1991–97	23	12
1998–2006	8	2
Total	31	14

Source: IEG, based on WBG renewable energy and energy efficiency progress reports, 1990–2008 and IEG 2010d.

small-scale hydropower projects had yields of less than 60 percent, compared with 18 percent of non-WBG projects. IFC's Development Outcome Tracking System showed that four of six reporting projects exceeded planned production on average. One did not report a baseline.

A review of project evaluations points to several recurrent factors that affect project success (table C.4). Planning and execution of resettlement is a key factor for success or failure. Planning for water rights has been critical. In the Tanzania Power IV Project, failure to define water rights up front led to environmental problems and implementation delays; an Armenian project, in contrast, was able to extend water rights validity to a 40-year term. In several cases, lack of a regulatory framework or failure of the borrower to implement expected reforms was a factor in performance. In sum, and not surprisingly, thorough project preparation is critical to success.

Energy Access and Low-Carbon Development

A billion and a half people lack electricity. An IEG review (IEG 2008) showed that poor people place an extraordinarily high value on electricity. Even with their extremely limited income, people are willing to pay up to \$1/kWh to power lights, televisions, and cell phone chargers. Improving access to household electricity is particularly important for women, who often have the greater work burden for domestic tasks (box 2.4). Access is a critical development goal for both reducing poverty and fostering growth. How can low-carbon activities support energy access?

BOX 2.4 Gender and Low-Carbon Energy

An IEG evaluation of gender issues in World Bank investment projects from 2002 to 2008 (IEG 2010c) identified 890 (of 1,183) projects where gender was relevant. Nineteen of these were energy projects containing low-carbon components, primarily energy access expansion through grid power extension, off-grid hydropower, or SHS. These projects had a range of differential gender impacts, including labor savings for women from access to electric appliances, health benefits for women and girls from substituting electrical power for kerosene or wood fuel, and high vulnerability for female-headed households from reservoir hydropower resettlement policies. Project design documents were rated by degree of gender analysis, consultation, activities, and monitoring. Of the low-carbon energy projects, seven were rated low, five moderate, eight substantial, and none high for their treatment of these criteria.

Source: IEG.

Most increases in energy access will happen through expansion of the grid, rather than expansion of off-grid power. A World Bank study (World Bank 2010) notes that in most countries 80–95 percent of unserved communities are targeted to receive electricity supply through grid extension. Cost estimates of grid expansion vary widely; however, for all but the lowest density or most remote areas, the lower cost of grid-based generation tends to outweigh the high cost of transmission and distribution extension.

Though there are many barriers to electrification, key issues include the high costs of supplying rural and peri-urban households, a lack of appropriate incentives or financial capability for utilities, and a shortage of electricity generation relative to demand from existing customers (World Bank 2010). Some actions can address these barriers while also reducing carbon emissions.

Supply constraints can be alleviated through either generation increase (renewable or not) or energy efficiency. Efficiency improvements can be cheaper. Moreover, to meet an end user's demand, new generation has to allow for transmission losses. With technical losses of 11 percent,¹² a kWh saved is worth 1.11 kWh generated.

Though energy shortages have traditionally been alleviated largely through generation increases, energy efficiency can play a key role. For example, Bank projects in Vietnam have reduced supply shortages through a mix of transmission and distribution (T&D) capacity expansion and efficiency improvements, demand side management, and on-grid and off-grid renewable energy. Energy efficiency and demand-side management projects have led to a combined reduction in peak load of 1,997 MW at far lower cost than construction of new generation; at the same time this leads to lifetime emission reductions of 130 million tons. Technical losses fell from 15 percent in 2000 to 9 percent in 2009 because of Bank projects and other Vietnamese investments, easing the need for new power generation. In addition, distribution of CFLs has proved to be a highly effective tool in reducing peak demand to alleviate urgent supply constraints both in Vietnam and in Sub-Saharan Africa.

Energy efficiency can play a key role in alleviating power supply shortages and thus expanding access.

Most access improvements have been accomplished through grid expansion. Early pilot projects in Vietnam with rehabilitating micro-hydropower to increase off-grid access were initially successful and connected 5,000 households. But these projects were not expanded, in part because of greater-than-expected success in rapid grid expansion. In contrast, grid-expansion projects have provided access to power for roughly 2.5 million people. But with connection

costs for remaining unelectrified areas exceeding \$0.50/kWh because of small loads, off-grid supply may be the least cost alternative.

Off-Grid Renewable Energy: Solar Photovoltaics

This section focuses on SHS—historically the biggest recipient of WBG support for off-grid renewable energy and still prominent in the portfolio (table 2.5). SHSs provide individual rural households with modest levels of power primarily for lighting and television. SHSs can reduce carbon emissions by substituting for kerosene lamps and grid-charged batteries. Because they promise both rural access and GHG reductions, they have attracted substantial funding.

Since 1992, the WBG has contributed \$790 million to SHS components.

Barriers and interventions

The barriers to SHS are well established:

- *Cost and financing for consumers:* The cost of a 20-peak watt (Wp) system ranged from \$150 to \$490 in the portfolio. Although the operating cost per lumen (unit of illumination) is theoretically less than that of a kerosene lamp, the up-front cost is prohibitive for most rural poor without financing. And rural finance poses its own problems.
- *Financing for manufacturers and dealers:* SHS systems are assembled by small manufacturers that find it difficult to get capital.
- *Biased pricing policies:* In Sri Lanka, for instance, solar photovoltaic modules were initially subject to 35 percent import duties. In Indonesia, when the price of photovoltaic systems increased by 400 percent due to currency depreciation, the import price of kerosene and diesel only increased by 40 percent and 58 percent, respectively, thanks to government subsidies. In Uganda, solar purchases were subject to extra duties aimed at protecting a local battery company.



Photo by Dana Smillie, courtesy of the World Bank Photo Library.

Since 1992, the WBG has contributed \$790 million to SHS components in 33 Bank and 4 IFC projects in 34 countries. Virtually all had some degree of GEF support. The portfolio is concentrated in East Asia and the Pacific and Africa. The Middle East and North Africa is represented only by a \$1 million project in Morocco, despite the region's solar resource.

This section draws on a review of the 12 World Bank projects that contain an off-grid solar photovoltaic component and were closed or open and well documented, and that have an installation target greater than 10,000 SHSs (see table A.7).

- *Anticipation of grid connection:* Households much prefer the convenience and reliability of grid connections and will not invest large sums in SHS if connection to the grid is imminent. Ambiguous plans or too-optimistic promises on grid integration can discourage demand for SHS.
- *Poor quality—actual or perceived:* Uncertainty about SHS quality and reliability dampens consumer demand for these expensive investments; uncertainty about consumer demand dampens industry supply.
- *Geographic barriers:* Off-grid populations tend to be in areas of low population density with difficult terrain.

Sellers and microfinanciers find it costly to service these populations.

Against these barriers the WBG has deployed a number of instruments:

- Most projects employed *subsidies*. These subsidies were to buyers or renters, dealers or manufacturers, or winning concessionaires under a fee-for-service model. Subsidies were often 10–20 percent of cost, but ranged up to 60 percent. They aimed at making the systems more affordable and at expanding overall production and thus pushing the entire industry down the learning curve, resulting in sustained cost reductions. In Bolivia and China, dealer/manufacturer subsidies were contingent on meeting quality standards.
- *Consumer credits* addressed the financing barrier and were provided through three primary mechanisms: dealer extended credit, credit through local banks, and credit through microfinance institutions.
- *Investor financing* (beyond subsidies) was provided in some projects.
- *Technical assistance* and support for standards and certification addressed the quality barrier.

WBG-supported projects deployed subsidies and consumer credit.

Project outcomes

Active promotion of SHS now dates back two decades, to a time when solar modules (the main component of SHS) were much more expensive than they are now. Reviews looking over the first decade of that experience pointed to the persistence of price and credit as barriers (Martinot, Ramankutty, and Frank 2000; GEF 2004a; GEF 2004b). Disappointment in these outcomes has led the GEF—the main financier of these projects—to deemphasize them.

An IFC self-assessment (IFC 2007) was pessimistic also, concluding that without some level of subsidies, solar photovoltaic power in developing countries is often too expensive for the average rural consumer; that “the rural, off-grid, solar photovoltaic industry in emerging markets is a low-margin, high-risk business”; and that IFC has “been unable to significantly transform markets and create sustainable business as originally anticipated.”

However, emerging evidence from evolving World Bank experience paints a more positive picture—though still with the qualifications that SHS appears to be a small niche market rather than a rural panacea and is largely still dependent on subsidies.

All projects in the evaluation portfolio had the development objectives of (i) increasing access to electricity in rural areas in an environmentally sustainable manner and (ii) facilitating greater participation by the private sector in advancing the commercialization of photovoltaic technology. In addition, 4 of the 12 projects specifically spelled out the goal of fostering economic growth or improving the delivery of social services such as health and education through the provision of electricity services. The global environmental objective of the solar photovoltaic projects was to remove barriers to the adoption of emissions-reducing energy technologies.

Outcomes for four of the five evaluated projects with large SHS components were rated satisfactory.

Table 2.8 reports the rated outcomes of the five completed projects in the evaluation sample with large SHS components. With the exception of Indonesia—where the 1997 macroeconomic crisis crippled consumer demand—all the projects performed well against targets. But good measures of SHS longevity are lacking.¹³

TABLE 2.8 Rated Outcomes of Completed Projects with Large SHS Components

Project	Number of installed SHS		Total capacity of installed SHS (MWp)	
	Targets	Actual	Targets	Actual
China Renewable Energy Development Project	350,000	400,000	11	10
India Renewable Resources Development Project	NA		2.5 – 3	2.145
Indonesia SHSs	200,000 (appraisal) 70,000 (revised)	8,054	NA	
Sri Lanka Energy Services Delivery	30,000 (appraisal) 15,000 (revised)	21,000	NA	
Sri Lanka Renewable Energy for Rural Economic Development (RERED)	87,000 by 2009 (appraisal) 155,000 by 2011 (revised)	105,398 (as of June 30, 2009)		4.622

Sources: Implementation and Completion Reports and Sri Lanka RERED Statistics and Reports (<http://www.energyservices.lk/statistics/index.htm>).
Note: MWp = peak megawatts; SHS = solar home systems.

World Bank experience

Two factors accounted for the success of the projects in Bangladesh, Sri Lanka, and China. Consumer finance was crucial. In Sri Lanka's energy services delivery project, the SHS vendors and commercial banks were expected to provide financing but proved ill suited to deal with collecting payments from the highly decentralized off-grid customers, and the project languished. The project took off after shifting to a microfinance model.

The Bangladesh Renewable Energy for Rural Economic Development project also relied on well-functioning microfinance institutions. China's Renewable Energy Development Project (REDP) achieved success despite lack of financing arrangements in provinces where many clients were yak herders who could self-finance a system through sales of their animals.

Microfinance was a critical input for success in several projects.

The second factor was the use of output-based producer subsidies. The development of the Chinese industry is noteworthy, as it illustrates an effective set of mechanisms to promote manufacturing quality and capabilities. Demand-driven grants enabled companies to improve their technologies and financial management systems. Technology-neutral subsidies—contingent on achieving quality standards—served as an incentive to improve quality, provided small firms with capital for expansion, and were to some degree passed on to consumers, boosting demand. As a result, the SHS companies doubled their employment, tripled sales and service outlets from 266 to 721, and more than tripled sales. The inland city of Xining emerged as a manufacturing center and began to export products.

Quality-contingent output-based producer subsidies were important.

It is difficult to discern the impact of certification or labeling on consumer perception of quality and therefore on demand. China REDP supported the development of a "Golden Sun" quality label, but rural familiarity with the label appears to be low, and exporters seek internationally recognized certification.

Projects in Argentina, Bolivia, Indonesia, Mongolia, and Sri Lanka aimed to support the development of policy frameworks for off-grid electrification. The Sri Lanka effort was most clearly successful. In Sri Lanka, the energy service delivery project indirectly influenced the government to rationalize a photovoltaic module import tariff, which was reduced from 35 to 10 percent. Toward the end of the project, the government also introduced its new

rural electrification policy, which aims to promote sustainable market-based provision of rural service. In contrast, in China, India, and the Philippines, multiple competing programs for SHS promotion sometimes worked at cross purposes, with heavily subsidized programs undercutting the progress of more market-oriented ones.

IFC experience

IFC's attempts at promoting private sector development in the SHS market were generally less successful than the Bank's. A candid IFC review (IFC 2007) points to a lack of flexibility; this is consistent with internal evaluations and with the views of an industry participant and former client (Miller 2009). A \$41 million effort initiated in 2000, the Solar Development Group, comprised for-profit private equity finance and nonprofit technical assistance—in two arms that were intended to cooperate but failed to do so. The equity finance arm collapsed having disbursed only \$650,000, a victim of unrealistic expectations about industry profitability and rigid procedures. The technical assistance arm, more flexible and less demanding of returns, disbursed about \$2.2 million to 53 small companies spread across many countries, so that the overall impact was highly diluted. IFC noted also a failure to coordinate IFC activities with World Bank support for favorable renewable energy policies.

IFC's approach has been less flexible than the Bank's and has had less success.

A more recent IFC-GEF effort, the Photovoltaic Market Transformation Initiative, provided \$30 million to support photovoltaic enterprises in India, Kenya, and Morocco. Initially overly bureaucratic, it was restructured for more flexibility. It has been successful in India, where it has supported performance guarantees and higher-quality products, though initially it was poorly coordinated with the World Bank project. The Initiative has been less successful in Morocco and Kenya.

Impacts

A goal of these projects was to sustainably reduce the price of SHS and thereby increase access. In general, closed projects all observed reduction in the cost of photovoltaic systems. Under China REDP, photovoltaic system costs declined from about \$16/Wp to \$9/Wp. In Uganda, the photovoltaic system cost declined from \$20/Wp to \$12–17/Wp by the end of 2008. These declines probably reflect increased domestic competition. The programs are too small to have affected the global market for solar modules, where increased European demand drove down prices over the decade.

Projects have generally reduced the local cost of photovoltaic systems.

Overall, the closed projects have not made a significant contribution to the reduction of GHG emissions. This is a consequence of the target users' poverty and low energy consumption. In India, the avoided carbon emissions were estimated to be 94,000 tons over the lifetime of the photovoltaic subproject. In China, a rough extrapolation implies total CO₂ reductions on the order of 7,000 tons per year.

Evidence on these projects' poverty reduction impacts is spotty because of the lack of monitoring. In India, some traders reported a 50 percent increase in net income by using solar instead of kerosene lighting; income of some rural households increased by about 15–30 percent because of increased home industry output. SHSs also allowed longer study hours for children under better lighting conditions. In China, a 2007 end-user survey covering 1,203 households in 6 villages reported that 95 percent of SHS users claimed that the use of a photovoltaic system increased their incomes; 15 percent claimed that the increase was significant.

Project monitoring and evaluation needs to be strengthened, particularly regarding cost data, performance of installed systems, poverty impacts, and CO₂ savings.

Calculation of ERRs depends on technical assumptions about consumers' benefit from lighting and may not be comparable between projects. In Bolivia, Indonesia, the Philippines, and Sri Lanka, ERRs for the consumers' investment in SHS were calculated in the 27–47 percent range. For China, IEG estimated a phenomenal 115 percent ERR (World Bank 2010). These very high numbers are consistent with studies that show huge gains to rural electrification (IEG 2008) and could be higher in areas where grid connection is possible. However, the ERRs do not include the dynamic gains of industry technical progress and cost reductions for future consumers.

Overall, projects monitoring and evaluation needs to be further strengthened:

- Disaggregated cost data, such as assembly cost, installation cost, and financing cost were usually not monitored and reported, preventing assessment of the impact of industrial development on price.
- Performance of installed photovoltaic systems was not always monitored and reported. Monitoring systems are shut down when the project closes, inhibiting evaluation of the program's sustainability—the crucial question of whether consumers continue to purchase systems after the subsidy ends.
- Baseline and comparison group data are lacking, so it is difficult to assess impacts on poverty.

- Although reducing CO₂ emissions is a critical goal of most of the projects, actual CO₂ savings was not carefully monitored.

The Way Forward for Renewable Energy

Economic and GHG returns to renewable energy investment

Hydropower projects with high capacity factors and low costs per KW can be cost competitive with fossil fuel plants and also offer GHG reductions and other environmental benefits. Wind and other renewable energy typically offer significantly lower returns per dollar on both dimensions. But capacity factors make a large difference in returns. Renewable energy offers additional benefits of energy security (for fuel importing countries) and a possible basis for stimulating domestic manufacturing. But low-capacity-factor, high-cost renewable energy may not be advantageous for low-income countries.

SHSs can have extremely high economic returns, but they have relatively low carbon benefits.

SHSs supply power at high cost yet offer extremely high economic returns to off-grid households because of the households' large benefits from electricity access. However, the systems have relatively low carbon benefits. The economics of other kinds of off-grid renewables will be similar, because of low capacity factors and low usage of energy by poor rural people.

Overcoming barriers to adoption and diffusion

Middle-income countries are increasingly willing to pay premium prices for renewable energy because of its environmental and energy security benefits. World Bank policy advice and piloting has been helpful in China and Mexico in catalyzing large-scale installation of wind facilities. This is a relatively low-cost, potentially high-leverage, but uncertain line of intervention that may take years to bear fruit. It is through this kind of indirect catalysis, rather than investment in individual power plants, that the WBG can affect a large enough volume of investment to help these technologies make globally relevant advances in cost competitiveness.

WBG support has helped develop SHS manufacturing capacity.

World Bank support has helped develop manufacturing capacity for SHSs and reduce local prices in China, Sri Lanka, and Uganda. Markets are still reliant on subsidies, however, and are limited by the still-high prices of solar modules. Sustained declines in module cost, together with promotion

The World Bank has helped promote significant growth in renewable energy in Sri Lanka, through two IDA-GEF projects, beginning in 1997.

The largest impact was through catalyzing the growth of grid-connected, independently operated small hydropower plants. This was done by facilitating finance. A small power purchase agreement eliminated time-consuming, asymmetric negotiations between small companies and the electricity board. A market-based feed-in tariff, with a floor, ensured a minimum income. IDA funds were on-lent by private banks for durations of 7–9 years, as opposed to the usual 4. The government assumed the foreign exchange risk (and has borne the cost of a devaluation).

As a result, 153 MW of minihydro have been installed, generating 4.4 percent of grid-connected power (2008) and saving a claimed 550,000 tons of CO₂ per year. Sri Lanka has gained technical manufacturing expertise in the process and is now exporting turbines and engineering services.

The projects also supported the rapid growth of solar photovoltaic home systems, from near zero to 125,000 systems totaling 5.5 peak MW of capacity. Output-based subsidies (as in China's REDP) and specialized microfinance were key. Success was more modest for village hydro systems, supported through grants and loans, which installed 1.3 MW serving 4,696 households. And a wind project, designed to demonstrate commercial feasibility, performed below expectations and was not replicated. Recently, a new IFC project, PADGO, has begun to promote decentralized energy, including combined heat and power fueled by biomass.

Challenges for further expansion of renewable electricity include an inadequate grid; decreasing quality of remaining hydropower sites; wind sites that are remote and can support only small turbines; and an increasingly bureaucratic plant licensing process that now requires two years. Demand-side management and energy efficiency have also been less successful than hoped. However, a 30 percent increase in electricity tariffs in 2009 (that preserved lifeline tariffs) should increase the attractiveness of both renewable energy and energy efficiency.

Source: IEG background study.

of smaller systems (as in the Lighting Africa Project), could help with diffusion.

Long loan durations are an important stimulus to project bankability and are featured in IFC lending and Bank on-lending.

Long loan tenors are an important stimulus to project bankability and are a feature of IFC direct lending and on-lending by the World Bank. At current carbon prices, carbon finance has a very modest leverage on the financial viability of hydropower, wind, or geothermal projects but a profound effect on projects that involve the capture of methane.

Systems issues

As renewable energy expands, systems integration issues become critical. There is increasing use of strategic

environmental assessments to aid in optimizing hydropower sites, taking account of economics, environmental impacts, transmission needs, and integration of intermittent power sources. Spatial planning of this kind will become increasingly important to aid in integration of wind, biomass, solar, and other site-specific resources, especially as climate adaptation needs are factored in.

Learning and feedback

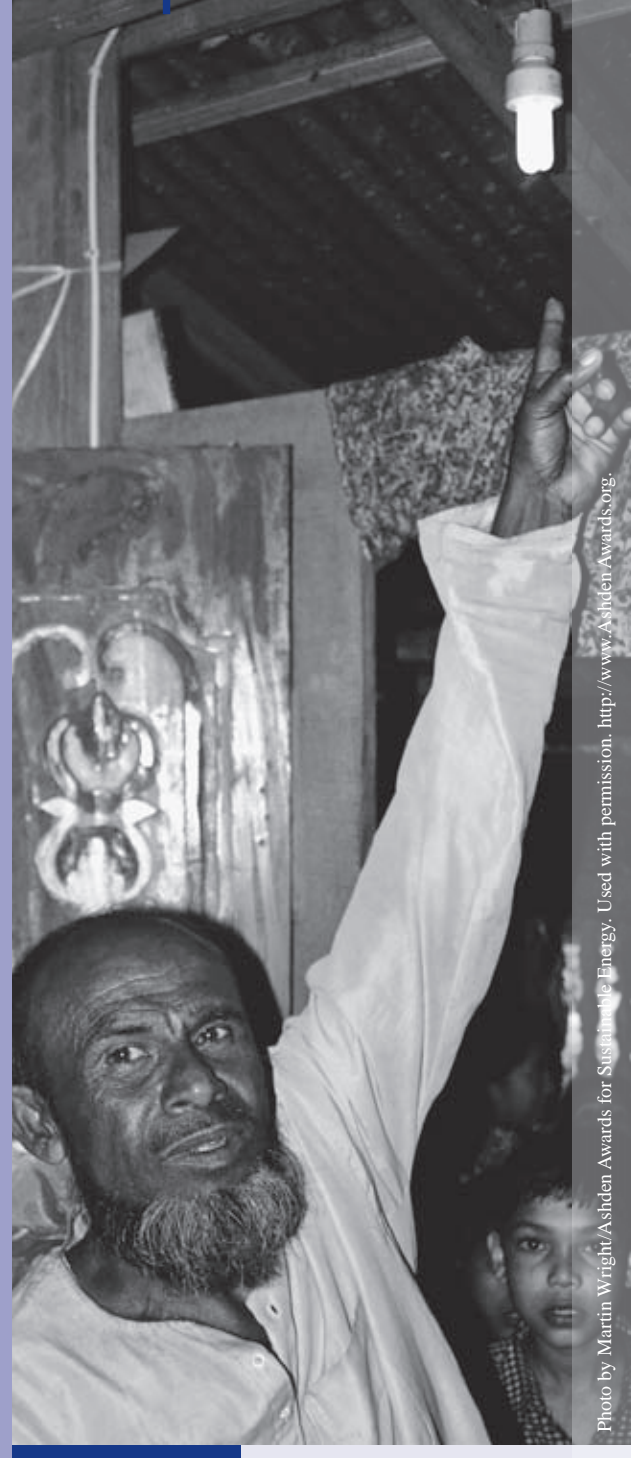
Systematic monitoring of output of grid-connected renewable energy can help explain why new types of projects are underperforming, so that design and operations of repeater projects can be improved.

Better monitoring of costs and impacts is needed to guide future investment portfolios. Actual long-term impacts of solar home systems are poorly measured—including how long they last.

Chapter 3

EVALUATION HIGHLIGHTS

- Efficient lighting may offer very high economic returns and significant GHG reductions.
- Reducing technical losses in transmission and distribution offers high returns and large scope for investment.
- There are large energy efficiency opportunities in the building sector, where market failures abound; this represents a largely untapped area for WBG intervention.
- Guarantees have stimulated lending by banks to enterprises with poor collateral but have not been transformative in reducing banks' risk aversion.
- By screening existing clients for cleaner production opportunities, IFC found projects with good projected returns but small absolute levels of energy and CO₂ savings.
- There remains a tremendous need to understand what works and what does not in this still-evolving field.



Energy Efficiency

The first phase in this evaluation series (IEG 2009) assessed projects related to demand-side efficiency policy and to energy pricing. It highlighted the importance of removing poorly targeted energy subsidies as a win-win policy that can promote energy efficiency, poverty reduction, fiscal balance, and GHG reductions.

Since then, the Bank has codirected a G20 study to examine policies to reduce energy subsidies (IEA and others 2010). The previous evaluation also urged increased attention for the intersection between efficiency investments and pricing reform. Such attention is now evident in the Vietnam Power Sector Development Policy Operation (2010).

Energy Efficiency in the First Phase Evaluation

District heating was one area of World Bank activity reviewed in the Phase I report. Concentrated mostly in Eastern Europe, this has been a large area of energy efficiency emphasis. Over the period 1991–2008, there were 41 projects with \$2.1 billion in commitments. Of the 25 closed projects, about three-quarters had outcomes that IEG rated moderately satisfactory or better. To a large extent these were “engineering” projects focusing on supply-side efficiency improvements. However, some included policy elements such as tariff reform. Some ongoing Chinese projects are combining supply-side interventions with promotion of far-reaching reforms that provide consumers with the means and incentive to reduce excessive energy use.

In its review, IEG found 34 projects initiated over 1996–2007 that had policy content that related (under a broad definition) to end-user efficiency. These included nine that supported the creation of appliance or building standards. Although the projects were successful in supporting adoption of codes, there was less attention over this period to sustained support for implementation and enforcement, and very little monitoring and evaluation of impacts. There were about a dozen projects that supported demand-side management, usually through a utility.

Complementing the earlier volume, this chapter reviews several energy efficiency business lines that are large in volume or have potential for scale-up: transmission and

distribution (T&D) loss reduction, financial intermediaries, direct IFC investments in industrial energy efficiency, and promotion of efficient light bulbs (table 3.1 puts this in the context of all low-carbon investments from 2003–08).

Using Financial Intermediaries to Overcome Barriers to Energy Efficiency Investments

In China, Eastern Europe, and Russia, a history of command economies and low energy prices had fostered industries and housing that were wasteful of energy. Starting in the 1990s, the World Bank and IFC moved in parallel to equip financial intermediaries to promote energy efficiency in these regions. These efforts were mostly supported by GEF and had GHG reduction as a goal. This section reviews 11 such projects (table C.4, which includes all but two of the energy efficiency financial intermediary projects initiated by 2005).¹

Diagnosis of barriers

The projects had similar *diagnoses* of energy efficiency barriers:

- Banks do not understand energy efficiency financing. In this view, banks either did not understand that the savings flow from energy efficiency improvements could back a loan or did not know how to appraise that flow or the exaggerated the risk of these loans.
- End users—factory or housing owners—do not understand their energy efficiency savings potential or how to realize it.

Although the World Bank and IFC had similar diagnoses of barriers to energy efficiency, they arrived at different prescriptions.

TABLE 3.1 Energy Efficiency Interventions by Type in the Low-Carbon Investment Portfolio 2003–08 (with overlap)

Type of energy efficiency	Component cost (millions)	Percent of low carbon	Number of components
District heating and combined heat and power	\$573	7.2	25
End user energy efficiency, government and municipal	\$484	6.1	22
End user efficiency: industrial energy efficiency	\$1,128	14.1	47
End user energy efficiency residential and commercial	\$572	7.2	40
End user efficiency: multiple or unspecified user types	\$370	4.6	19
Supply side efficiency: thermal power rehabilitation	\$656	8.2	15
Supply side efficiency: Reduced transmission, distribution or system losses	\$916	11.5	37
Supply side efficiency: other or unspecified	\$340	4.3	12
Energy efficiency in transport	\$23	0.3	2
Energy efficiency multiple, unspecified, or unknown	\$449	5.6	24

Source: World Bank.

Note: Individual components may appear in multiple categories, so column totals are not meaningful.

IFC and the World Bank arrived at different prescriptions. Both hoped for a transformative impact (see table 3.2). IFC focused on the presumed risk aversion and inexperience of commercial banks and therefore prescribed a combination of *technical assistance* and *loan guarantees*. Technical assistance would train banks to appraise and structure energy efficiency loans and to fill a pipeline of future projects. GEF-subsidized loan guarantees would act like training wheels. Once the banks realized that risks were low, the guarantees could be removed. Success of the participating banks would spark emulation, and energy efficiency lending would spread.

In China, the World Bank prescribed energy service companies (ESCOs) to overcome these barriers. ESCOs

would provide both finance and technical know-how to their clients (box 3.1). Because ESCOs were unknown in China and therefore highly risky, the Energy Conservation Project used GEF funds to help capitalize three companies to test and popularize the idea, which was expected to provoke spontaneous replication. Later, the Bank used GEF-supported loan guarantees to back ESCO financing, again with the presumption that this would be a temporary measure to overcome banks' unfamiliarity with energy efficiency finance. In Romania and Bulgaria, the Bank used GEF grants to set up dedicated, revolving energy efficiency funds as an alternative to banks and a complement to ESCOs, which had already arrived in Europe.

TABLE 3.2 IFC and World Bank Approaches to Energy Efficiency Financial Intermediation in China and Eastern Europe

	IFC	World Bank
China	Guarantees Technical assistance for banks	ESCO demonstration Technical assistance for ESCOs Guarantees for ESCOs
Eastern Europe	Guarantees Technical assistance for banks On-lending (Russia)	Dedicated energy funds Technical assistance for funds

Source: IEG.

Note: ESCO = energy service company.

BOX 3.1 ESCOs and Energy Performance Contracting

Pity the poor small factory owner. Busy running her business, she thinks there may be opportunities to save on energy expenses, but does not think it a good gamble to invest time and money in an energy audit. What if there are no savings? Or suppose the auditor recommends replacing old motors or boilers. Where will the proprietor, already at her borrowing limit, find funds? And how can she be sure that the investment will pay off?

Enter the ESCO. Part consultant and part banker, the ESCO offers to reduce the factory's energy costs by a specified amount, splitting the gains with the owner. To do this, the ESCO will finance, purchase, and install any required equipment, carrying the loan on its own balance sheet. The owner need merely collect the savings.

This arrangement is called energy performance contracting and is the canonical form of ESCO. It requires reliable enforcement of contracts in order to work, given the complicated interdependence of lender, ESCO, and client. Other, simpler, arrangements are also possible.

Source: IEG, based on Taylor and others 2008.

Prescription: Guarantees

The barrier diagnosis was partially flawed, so the guarantees were less transformative than hoped. The assumption was that banks practice project finance—in other words, they will finance a factory to set up a new assembly line, weighing the cost of the equipment against the return it provides. But, the diagnosis continued, the banks don't know how to appraise energy efficiency projects, which generate a cash flow from energy savings rather than from increased sales.

In reality, most banks in these countries simply do not practice project finance, because there is no way to ensure that they will get returns from that particular piece of equipment. They are concerned with getting repaid and therefore look beyond the project at borrowers' overall balance sheets and collateral. So for many banks the core constraint is their borrowers' lack of creditworthiness, not the novelty of energy efficiency. However, a better understanding of energy efficiency did help banks market loans to their more creditworthy customers. And the China Utility-Based Energy Efficiency project (CHUEE) has helped banks structure efficiency loans as project finance, putting savings into escrow accounts which substitute for fixed collateral.

In China, collateral requirements are onerous. Hence, guarantees were important for credit access by cash-strapped ESCOs and small and medium enterprises. Although Chinese banks welcomed the guarantees, they were not obviously critical to improved credit access by larger enterprises. In CHUEE, which catered to larger firms, 91 percent of a sample of borrowers said they could have financed their energy efficiency investment without the project and its guarantee, though perhaps more slowly (IEG 2010b).

In IFC's European projects, the guarantees, although attractively priced, were generally not appealing to banks for their small and medium enterprise (SME) or municipal

lending. These were familiar markets, and the banks were comfortable bearing the risk of lending to these clients. Guarantees were more successful with new or unconventional types of projects and borrowers, such as retrofitting apartment blocks by homeowner associations in Hungary and renewable energy projects in the Czech Republic, when the regulatory framework and feed-in tariffs were still untested and uncertain.

It is noteworthy that almost none of the guarantees have been called. This experience may convince IFC to become less risk averse. In the CHUEE project, the IFC's \$207 million guarantee was not at serious risk, buffered by a GEF-funded first loss guarantee. The first loss was much smaller in the case of Hungary's OTP Schools Energy Efficiency project (see next page).

Guarantees helped less creditworthy borrowers but did not trigger market transformation.

In sum, the guarantees were useful for less-creditworthy borrowers in underdeveloped financial markets. But they did not have a large transformative effect on reducing commercial banks' risk aversion and are likely to be a permanent rather than temporary measure.

Prescription: ESCOs

The Energy Conservation Project's introduction of ESCOs (called energy management companies, or EMCs, in China) had significant direct effects. The three pilot companies realized an average financial rate of return of 18 percent, with assets growing from \$20 million in 1999 to \$91 million in 2006. The total ERR (including benefits to the EMC's clients) was calculated by IEG at 50 percent without CO₂ benefits, or 58 percent with CO₂ at \$6/ton of CO₂. Total claimed energy and CO₂ savings were 6 million tons of coal equivalent and 18.6 million tons through 2006—below appraisal

estimates but still substantial. Note that these are unverified ex ante estimates.

The introduction of ESCOs had significant direct effects in China and spurred development of an energy management industry.

The project also spurred the development of an EMC industry. As pilots, the EMCs immediately encountered a regulatory obstacle: Should they be regulated as financial institutions, leasing companies, or sales outlets? The Bank and the government worked to address the ambiguities, facilitating entry of other EMCs. This is a good example of how pilot projects can reduce the costs of followers.

In addition, the EMCs participated in training programs and opened their doors to would-be domestic and foreign investors. GEF funding was crucial in motivating this openness to dissemination. In part because of these efforts and in part to an ASTAE training program, an industry association of EMCs was formed and grew to at least 400 member companies by 2007, with a core of 40–50 practicing energy performance contracting.

However, the ESCO prescription required adaptation in China, and it has limits. First, the Chinese ESCOs did not write contracts based on measured savings, a practice that requires a high degree of reliance on contract enforcement and on sophisticated measurement of outcomes (box 3.1). The three original EMCs have largely relied on agreed ex ante estimates of energy savings, or they simply became equipment leasing companies. Few of the emerging EMCs take a systemic approach to improving process efficiency, but rely instead on promoting specific kinds of energy efficiency equipment. Second, there are limits to the ability of ESCOs to provide financing. The original EMCs had the advantage of substantial capital at concessional terms. The new ones are generally small and even more credit-constrained than their clients.

Chinese ESCOs adopted a basic model of operation akin to equipment leasing.

In Hungary, the OTP Schools Project (OTP being the Hungarian bank involved) supports Caminus, an ESCO that won an umbrella contract for school heating and lighting upgrades. The umbrella contract is a noteworthy policy innovation, because it drastically reduced the transaction costs for small municipalities (they do not have to organize individual tenders) and engages economies of scale for the winning ESCO. Caminus finances all the investments except for the 20–25 percent paid from European Union grants and is therefore taking the credit risk for municipalities.

However, the scope of work does not include insulation, which means that potential cost and CO₂ savings may be untapped.

Prescription: Technical assistance

In Central Europe (Commercializing Energy Efficiency Finance Program) and Russia (Sustainable Energy Finance Program), IFC used donor funding to hire a large in-house team that provided free services to local banks; there is a move now to increase cost recovery. Banks that IEG interviewed confirmed that they benefited significantly from the technical assistance program, especially training on technologies and appraisal of energy efficiency projects. It is difficult to assess whether the services provided were cost-effective. (In some cases, projects are unable to track precisely the use of technical assistance resources.) Some banks have decided to build on and consolidate this learning by creating dedicated in-house units for energy efficiency projects. Staff cuts as a result of the financial crisis threaten the sustainability of these changes but may aid in diffusion of knowledge through the industry if staff are rehired elsewhere.

Banks benefited from IFC technical assistance.

Prescription: Information dissemination

The China Energy Conservation Project also sponsored an information center, developing energy efficiency case study examples and technical guidelines and building outreach networks. An internal evaluation found that 6.2 percent of a random sample of 10,000 enterprises attributed energy efficiency investment to the information center's influence. The claimed impact was 27 million tons of coal equivalent of energy and 71 million tons of CO₂. These are extraordinary numbers, dwarfing the Energy Management Company Association's direct impact. Likely, other factors were at work, including policy pressure for energy efficiency improvements. However, even if overestimated by a factor of 10, these impacts would represent a good return on the \$10 million invested in the centers.

Outcomes

Economic returns, energy savings, and emissions reductions. Impacts have varied substantially across projects. As noted, the Energy Conservation Project in China racked up high economic and carbon returns at the subproject and project level. For CHUEE, which has been analyzed in more depth, subproject and project level returns diverge. By June 2009, the guarantee program had supported \$512 million in loans for \$936 million in projects, associated with a claimed GHG reduction of 14 million tons. However, as noted earlier, CHUEE may

have had limited causal impact on these reductions. The large client firms enjoyed good credit and were responding in part to China's vigorous pursuit of energy efficiency goals in the Five-Year Plan. Still, if CHUEE counted all its project costs, but counted as beneficiaries only the minority of clients who said they had no other potential lender, CHUEE's overall ERR was 38 percent (about half of which was carbon emission reductions, valued at \$19/ton of CO₂).

Economic and financial returns from subprojects are not consistently monitored.

Economic and financial returns from subprojects are not consistently monitored across projects. The energy efficiency projects in Bulgaria and Romania, unlike the others, monitor ex post results. In Romania, where most projects were industrial, financial returns ranged from 15 to 87 percent. In Bulgaria, which had a more diverse portfolio, returns ranged from 13 to 37 percent. The Russian project (still in progress) reports a mean ratio of annual energy cost savings to project cost of 20 percent, but this value is problematic, reflecting an abstruse but crucial methodological issue.²

Projects with energy savings targets are falling short of those targets.

All the projects with energy savings targets are falling short of those targets, often by a large margin. Croatia stands at 3 percent, Bulgaria energy efficiency at 6 percent, and OTP at 19 percent. (Note, however, that these projects are still ongoing through 2010 or 2011, and final outcomes may differ as experience progresses and data are reexamined.) The shortfall is evident even after allowing for the low disbursement rate of some projects.

Appraisal of potential GHG savings appears to have used inconsistent and, in some cases, erroneous values relating CO₂ to energy. Reported achievements of CO₂ savings are roughly commensurate with actual energy savings, except for the Bulgaria project. There the implied CO₂ saving/energy saving ratio appears to be unusually high. Overall it is difficult to reconcile high financial rates of return with underachievement of energy targets. Further investigation into monitoring and appraisal methodologies is needed.

Post-project sustainability and catalytic impacts. The clearest case of *sustainability* is in Russia, where some participating banks have begun to make loans without IFC resources, using IFC's energy efficiency Calculator Tool. For Central Europe the case is less clear. Before IFC's Commercializing Energy Efficiency Finance Program started operation in 2003, there was no bank in markets like the Czech Republic, Hungary, or Slovakia

that specifically targeted energy efficiency or renewable energy financing. With significant input from the finance program's technical assistance team, two banks have created dedicated internal units and developed products specifically for the energy efficiency/renewable energy markets. With the expiration of the subsidized guarantee programs, however, some of the banks involved in the energy finance program have discontinued lending for street lighting and residential energy efficiency or have reverted to previous collateral requirements.

The *catalytic impact* of the WBG projects on the broader energy efficiency finance market is difficult to evaluate because of the impact of the financial crisis, because monitoring and evaluation was not generally set up to track diffusion, and because rising energy prices throughout the region (figure C.1) would be expected to encourage energy conservation regardless of WBG intervention. The Russia Sustainable Energy Finance Program does have as an indicator adoption of energy efficiency lending by nonpartner banks and reports three instances. Observers of Hungarian banking find it difficult to pinpoint diffusion impacts of the IFC projects.

In Russia, joint IFC-IBRD technical assistance and analytic work, including an enterprise survey, highlighted the tremendous scope for profitable energy efficiency in the Russian economy. This work estimated that up to 40 percent of energy consumption could be cost-effectively reduced. WBG analytic efforts provided key inputs to the Russian government as it drafted a new energy efficiency law, recently adopted. The impacts of the law will depend on yet-to-be-adopted implementation regulations.

Direct Investments in Energy Efficiency

IFC's energy efficiency emphasis has been on the use of financial intermediaries, but it also makes direct investments associated with energy efficiency. Often energy efficiency is incidental to plant modernization or expansion. In other cases, energy efficiency is the main goal, as in installation of waste-heat recovery equipment.

Mainstream investments

In 2005, IFC began to review projects to determine whether they could be claimed as having energy efficiency content. Over the period fiscal 2005–08, 48 such projects were identified. IFC assigned a notional proportion of each investment to energy efficiency. In total, \$392 million of IFC's \$1.96 billion investment (in projects valued at \$3.96 billion) was considered to be energy efficiency. Ten projects accounted for more than 80 percent of the notional energy efficiency investments.

IFC has supported some CO₂-intensive cement and steel companies in replacing obsolete, inefficient production

lines. Some of the companies involved emit more than 10 million tons of CO₂ annually—more than some countries—so efficiency gains could have global significance. Four cement projects replaced old wet process equipment with more efficient dry process production lines. Government policies, together with cost savings, motivated the phase-out of old facilities, and these companies likely had good access to credit, so IFC's additionality is not clear. Two investments in an Eastern European steel company supported replacement of open-hearth furnaces with modern blast furnaces. In this case, the combination of difficult credit, low energy prices, and an IFC environmental and social action plan makes it plausible to attribute the efficiency gains to IFC's intervention.

In other cases, the basis for allocating investment amounts to energy is unclear. Two investments, totaling \$55 million, supported airlines in modernizing their fleets. These investments were entirely classified as energy efficiency, although they conferred other benefits, such as safety, comfort, and reliability.

In many cases, it is not clear if IFC's direct investments have led to improvements in energy efficiency.

and CO₂ emissions, so it is impossible to quantify energy or GHG savings. Some of the projects were initiated before GHG monitoring was required. But even where required, compliance with monitoring is imperfect.

The cleaner production initiative

Approved in January 2007, the three-year, \$20 million Cleaner Production Lending Pilot is a proactive initiative to seek and promote energy, water, and materials efficiency opportunities within IFC's existing clientele. The program focused on clients with good credit standings and environmental performance, enabling IFC to significantly reduce loan preparation time and effort. Projects were identified either directly with clients or via optional donor-funded energy audits.

In 2009, the pilot was scaled up to a \$125 million, three-year Cleaner Production Lending Facility, covering all real sector investments. To complement the loan funds, a \$5 million Global Cleaner Production Facility (GEF-funded via the Earth Fund) will cofinance Cleaner Production audits. Clients will bear half the audit costs.

The \$20 million Cleaner Production Lending Pilot was fully committed to eight projects, with an average loan size much smaller than the IFC norm. Three of the projects employed the donor-funded energy audits; in other cases, the clients identified energy efficiency savings. The projects' projected



Photo by Gennadiy Ratushenko, courtesy of the World Bank Photo Library.

In one case, IFC invested in an American-owned distribution utility in an Eastern European country, with an explicit goal of reducing technical losses, which stood at 12.6 percent. Five years after the initial investment, the goal had not been achieved: technical losses had actually increased to 15 percent. Had the company reduced losses to 8 percent (a conservative target), it could have cut CO₂ emissions by 180 thousand tons per year.

Most of these ex post identified energy efficiency projects lack baseline and monitoring data on energy efficiency

returns to investment were 22–117 percent (with a median of 36 percent) and are projected to yield 1–19 kilograms of CO₂ per year per dollar invested (or roughly an additional 1–19 percent to the return on investment if carbon is valued at \$10/ton of CO₂), with carbon returns mostly proportional to financial ones.

Total annual CO₂ savings are estimated at 136,613 tons. But a single company accounted for half those savings. Thus, significant resources are devoted to small loans that yield CO₂ savings of just a few thousand tons of CO₂ per year. Ex post

measurement of achieved economic returns is lacking, undercutting the Lending Pilot's ambition to use program results to convince other clients to invest in cleaner production.

The Cleaner Production Lending Facility funded small loans with a median projected rate of return of 36 percent, but most had CO₂ savings of just a few thousand tons per year.

An early lesson from the audits was the necessity of cost-sharing. Initially, clients were only required to cover 10 percent of the cost but committed to reimburse the grant if audit recommendations were implemented. This created an incentive not to disclose implementation plans and not to borrow from IFC. After full cost sharing was implemented, the three sponsored audits successfully identified cost-saving measures with one- to four-year paybacks.

The audit costs were small relative to the client's projected returns. But the audit costs were relatively large compared to IFC's potential returns from lending. Hence, IFC-funded audits are not likely to be sustainable for small-scale projects in the absence of concessional funding, though the audits themselves are potentially cost-effective.



Transmission and Distribution

Electricity T&D projects provide a potentially cheaper alternative to construction of new generation in countries with high technical losses. They also offer major potential for reducing carbon emissions. Such projects can increase supply security and reduce outages and can be important for improving access. They can reduce carbon emissions by—

- Connecting renewable power to the grid
- Reducing technical losses (dissipation of electricity as waste heat)

- Reducing the illegal or unpaid consumption known as nontechnical losses (emissions are reduced if consumers, confronted with a bill for electricity, reduce their consumption).

Reducing losses

Losses vary widely across regions and countries because of utility performance. A survey of 12 African utilities found total loss rates ranging from 6 to 35.3 percent (Pinto 2010). In these utilities, transmission losses ranged from 3 to 6.6 percent, distribution losses ranged from 2.4 to 20.5 percent, and nontechnical losses ranged from 3.6 to 17.5 percent.

Technical losses in transmission and distribution remain high in many regions.

Technical losses can be reduced through direct investment in hardware and network management and by increasing the institutional capacity of utilities to plan, finance, and maintain their networks. Opportunities for very large economic returns from T&D projects exist largely because many power utilities have lacked the capacity, funds, and incentives to undertake optimal network management. Unless performance of utilities is improved, there is a risk that T&D projects may not yield their expected economic and emission reduction benefits.

Nontechnical losses are usually caused by a combination of faulty or inadequate metering, collusion between utility employees and power consumers, and theft. Nontechnical loss reduction entails collecting money from customers who were previously receiving power at no cost, provoking opposition from entrenched interest groups.

Advanced metering infrastructure technology allows meters to be read remotely (using mobile phone networks), which reduces much of the scope for collusion and theft. Significant reductions in the price of advanced metering infrastructure components has made their widespread adoption economically feasible (Antmann 2009). Preliminary evidence from Brazil, the Dominican Republic, and Honduras demonstrates their effectiveness in reducing nontechnical losses.

Advanced metering infrastructure technology has demonstrated effectiveness in reducing nontechnical losses.

Nontechnical losses are often ascribed to poor people, but a significant portion of those losses comes from major users, and targeting these users is often key to reducing losses. For example, a loss-reduction effort in North Delhi successfully reduced total losses from 53 percent in 2002 to

18.5 percent in 2008. This was done primarily by using advanced metering infrastructure for the 30,000 major consumers, who collectively represent 3 percent of the customers but 60 percent of the power sales (Antmann 2009).

WBG portfolio, 2003–08

The Bank has a long history of investment in T&D projects. Over 2003–08, the WBG committed \$3.45 billion to 44 T&D projects that are expected to lead to significant carbon reduction benefits or technical loss reductions, though emission reduction was not an explicit goal for many of them. (Table C.2 summarizes impacts and appendix D presents lessons from completed projects).

The Bank's portfolio demonstrates recognition of the importance of improving the financial state of utilities in order to improve long-term impacts. Among the low-carbon T&D projects, 60 percent addressed nontechnical losses, and 82 percent of projects that specifically aimed at loss reduction included nontechnical loss-reduction measures. Projects have been aimed at the regions with the highest power losses (particularly Europe and Central Asia and South Asia).

Projected economic gains from these projects are often large. Many projects calculate high ERRs on a large investment base (often 20–60 percent; see tables C.1 and C.2). Projected benefits are even higher if the project is expected to boost access or reduce outages. One project in the Dominican Republic projects a net present value of \$428 million on a \$122 million investment.

The projected economic gains from these projects are often very large, but the disparate methodologies used make it difficult to validate or compare projections.

Unfortunately, it is difficult to validate or compare these ex ante projections, because Bank projects do not use a common methodology when valuing loss reduction, outage reduction, or other benefits. It is not always apparent whether loss reduction forecasts come from formal engineering studies or are rough estimates. Many projections are contingent on assumptions that loss reductions will be sustained across many years after project completion, presuming successfully institutionalized change in maintenance and operations.

Efficient Light Bulbs

Electric lighting represents 19 percent of global electricity consumption (IEA 2006). In many developing countries, lighting is the largest use of power in the residential sector, particularly in the poorest countries, where households have few electrical appliances. For example, in Ethiopia,

lighting constitutes 74 percent of power consumption for a typical household that has electricity access (Maurer and Nonay 2009). Because lighting demand is concentrated in the early evening hours, utilities must build additional generation capacity that is only used during this period.

Switching from standard incandescent lamps to CFLs reduces energy consumption (saving fuel costs) and capacity costs while mitigating CO₂ emissions. CFLs draw only 20–30 percent as much power as equally bright incandescent lights and last much longer. Households benefit from lower energy consumption, and CFL adoption can pay for itself in 2–14 months. Utilities benefit from lower power sales (when generation cost exceeds supply cost) and from reduced capacity costs.

Replacement of all of Sub-Saharan Africa's incandescent lights would effectively boost power availability by 23 percent, at a fraction of the cost of peaking diesel generators.

A recent ESMAP review (ESMAP 2009) finds that a “representative” CFL program, under optimistic assumptions, would have a benefit-cost ratio of nearly 28:1, based on energy and capacity savings, or nearly 30:1 if CO₂ abatement were valued at \$10/ton. A Bank study for Sub-Saharan Africa (de Gouvello, Dayo, and Thioye 2008) estimated that regionwide replacement of all 476 million inefficient lights (60 percent of these are in South Africa) with CFLs would reduce peak power demand by 15,200 MW, representing about 23 percent of installed capacity for the region. Recent estimates of CFL bulk purchase projects (ESMAP 2009) suggest that one-shot replacement can be achieved at roughly \$2 per bulb. Although full phase-out for Africa could cost \$950 million, significant gains could be achieved with a much smaller investment targeting residential users or countries with high emission factors, expensive power, or supply shortages.

Barriers and interventions

Despite the large benefits, private households have been slow to adopt CFL technology. Where electricity prices are artificially low due to subsidies, consumers have low incentive to adopt. Other adoption barriers include the higher upfront price of CFL bulbs, distaste for the color or quality of the illumination, skepticism about the bulbs' lifespan, and poor consumer knowledge.

Although the potential benefits are large, households have been slow to adopt CFL technology.

Since the early 1990s, public entities, utilities, and development agencies have used several (overlapping) design features to encourage CFL adoption: subsidizing bulbs, using bulk procurement, imposing quality standards, offering certification, and mounting advertising campaigns.

WBG portfolio

Since 1994, the WBG has supported residential CFL programs in more than 20 countries; the Bank has covered some 50 million CFLs primarily through bulk distribution or market-based projects. Many projects have received GEF or carbon fund support, though many recent projects aimed at rapid crisis mitigation have been implemented without GEF assistance.

The WBG has supported residential CFL programs in more than 20 countries.

In the early 1990s, WBG-GEF projects supported CFL distribution in Jamaica, Mexico, Poland, and Thailand. In Poland, though CFL sales increased and significant power savings were attained, market transformation effects were

not fully sustained, as the project lacked effective mechanisms to sustain quality levels (GEF 2006a).

Based on results from these projects, IFC undertook the GEF-supported Efficient Lighting Initiative (ELI), which carried out market-based programs in Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines, and South Africa. ELI supported public education, targeted subsidies, demand-side management programs, and the development of standards and labeling for CFLs.

After a lull, there was a surge in World Bank projects in 2007–09. Many of these were emergency projects to address drought-induced hydropower shortages in Africa. Most of these new projects are bulk-purchase and distribution for residential CFLs. Bulk-purchase projects have become favored because of their ability to reduce unit costs of bulbs through bulk discounts, their substantial and immediate reductions in peak electricity demand, and the ability to access carbon financing.

Economic, CO₂, and environmental impacts

CFL project appraisals are generally back-of-the-envelope exercises that calculate savings based on assumed number of bulbs, wattage of new versus old bulbs, and hours used per bulb. These ex ante calculations suggest ERRs in the hundreds of percent together with more modest CO₂ savings.

Few of the WBG-supported projects have applied rigorous monitoring and evaluation.

Well-developed methodologies exist for monitoring these outcomes and calculating impacts, as a result of decades of demand-side management programs in developed countries (Vine and Fielding 2006). However, few WBG-supported projects to date have applied rigorous monitoring and evaluation methods. ELI mounted a large monitoring and evaluation effort, but long-term impact monitoring was not undertaken, and the interim results were never publicly released. Most other projects have undertaken limited ex-post monitoring, and few attempt to compare project versus control group areas. Hence, the impact assessments (table C.3) must be read with great caution.

Early projects claimed positive impacts but faced barriers to sustainability: commercial prices of CFLs remained high and quality often low. Yet in Sri Lanka, despite a high bulb failure rate, a subsidy demonstration project with 100,000 bulbs led to a successful follow-up where 511,000 bulbs were purchased at commercial rates. Survey results found that 58 percent of customers thought the utility's endorsement of CFLs was important or very important in determining their decision to purchase CFLs (SRC 1999).

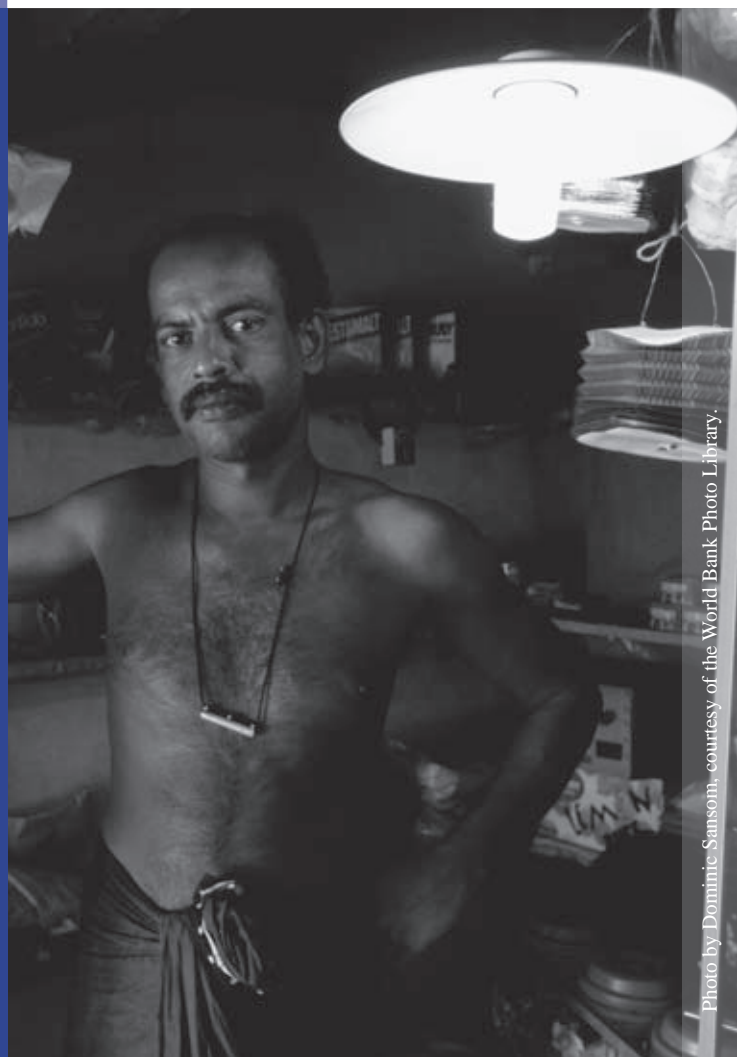


Photo by Dominic Sansom, courtesy of the World Bank Photo Library.

ELI deployed a variety of tools to encourage commercialized use of CFLs, combining limited-term subsidies, standards and labeling, public education, and targeted credit schemes. Although the credit schemes were generally unsuccessful, the \$15 million project claimed direct reductions of 2,590 GWh and 1.9 billion tons of CO₂. The project claims also to have catalyzed reductions in CFL prices. It is not possible to validate these claims—for instance, there are no statistics on CFL prices and diffusion in comparison countries—but the project would have a high return even if these impacts are overstated by a factor of 10.

In a follow-on project, the Bank and IFC, with GEF funding, commissioned the China Standard Certification Center to operate the ELI Quality Certification Institute, which develops quality standards and licenses manufacturers who comply to use the ELI label. Some Bank projects use ELI standards for procurement practices; so far the impact of ELI standards on commercial markets is unclear.

The best-documented completed Bank project was undertaken by Electricity of Vietnam over 2004–07, with GEF funding. The project included a CFL component that distributed 1 million bulbs to rural customers at a cost of \$1.8 million, along with other energy efficiency activities. Bulbs were purchased using bulk supply contracts at an average price of \$1.07 per lamp and sold to customers by Electricity of Vietnam at an average price of \$1.56 per lamp. In comparison, existing retail prices were \$2.00–3.00 per lamp. Many utilities lack incentive to participate in programs that reduce electricity sales, but Electricity of Viet Nam was strongly motivated because it is mandated to serve low-income and peak-hour customers at prices below its cost (average marginal revenue from power sales was 4.5 cents/kWh as opposed to average marginal cost of 8 cents/kWh).

The best-documented CFL project resulted in energy savings of 46 GWh per year at a cost of \$1.8 million.

An ex post evaluation (IIEC 2006) found a peak load reduction of 30.1 MW, energy savings of 45.9 GWh per year, and expected lifetime energy savings of 243 GWh. Average customer power bill savings were estimated to be 15.2 percent. Failure rates of CFLs were relatively low (0.5 percent), and the utility replaced failed lamps. A substantial subsequent rise in CFL sales was attributed to an accompanying public education and CFL promotion campaign. The benefits from increased private sales potentially exceed the benefits from the primary distribution campaign. Although this market transformation impact is difficult to validate, it is plausible given the extremely large increase (80 percent and 150 percent increases in first-year sales for the two largest sellers).

CFL projects have also been a cost-effective response to energy emergencies, saving both costs of providing additional capacity and the fuel cost of running diesel generators. For example, during a 2007 power crisis in Ethiopia, \$5 million was spent on 4.6 million CFLs, which were expected to save 315 GWh per year for 4 years. Meeting the same demand for 4 years using leased diesel generators would have cost \$20–\$115 million in leasing costs and \$152 million in fuel costs (EEPC 2009) and resulted in about 750,000 tons of additional CO₂ emissions.

Unlike incandescent lights, standard CFL bulbs contain a small amount of mercury (about 0.001–0.025 grams, compared to 0.5–3.0 grams in a mercury thermometer.³ By some calculations, use of incandescent bulbs triggers more mercury release into the atmosphere because of the mercury content of coal. Mercury concerns have not played a major part in CFL project design. These projects typically trigger environmental category B for safeguards,⁴ but on the basis of other, larger, power sector components. Most CFL projects do not explicitly mention mercury issues, but the most recent Bank CFL projects (Rwanda 2008, Senegal 2008, Benin 2009, and Mali 2009) incorporate designs for collection or disposal mechanisms. Bank projects in Ethiopia (2006, 2007) are studying CFL disposal options for Sub-Saharan Africa.

Coordination with policy reform

The first phase of this climate evaluation (IEG 2009) pointed to the potential to combine electricity pricing reform with promotion of CFLs and other efficiency devices as a way of cushioning the transition to environmentally and financially sustainable pricing. Although many recent energy projects include both CFL distribution and tariff reform (for example, in Benin, Cote d'Ivoire, Mali, and Togo), this has tended to occur because both CFLs and tariff reform are practical responses to power supply shortages. In these cases, CFLs have been “sold” as a peak load reduction tool, rather than as a tool to mitigate tariff increases. Thus the potential for policy coordination remains unexplored.

The potential for combining CFL distribution with tariff reforms remains largely unexplored.

Incentives for staff and managers

These projects offer high returns, but they may not be attractive to Bank staff and management in an environment that measures results by volume of disbursements. As an example, compare a \$5.7 million GEF-funded energy efficiency project in Vietnam that included a \$1.8 million component for a residential CFL component to a \$335 million hydropower generation project in Ethiopia, funded in

part with a \$198 million IDA credit. The hydropower plant contributes 35 times as much to a tally of Bank disbursements but costs the Bank only 3.8 times as much in preparation and supervision. Overall, the hydropower project cost 58 times as much as the energy efficiency project and 183 times as much as the CFL component. Yet it generated only about 20 times as much power and provided only about 4.5 times as much capacity. This is not to suggest these two particular projects were substitutes or were inappropriate. Rather it serves to illustrate the order of magnitude of Bank costs, client costs, and client benefits in energy efficiency and renewable projects; it also suggests why preparation of small energy efficiency projects has relied on trust funds rather than Bank budget.

The Way Forward for Energy Efficiency

Economic and GHG returns to energy efficiency investments

Efficient lighting may offer extraordinarily high economic returns, with substantial GHG reductions as a by-product. Promotion of efficient lighting may have large catalytic or demonstration effects. A concerted, multinational effort to pursue incandescent phase-out could lead to economies of scale in production and distribution. Such an effort might require considerable WBG staff time for preparation and coordination but relatively low loan or grant amounts. Reduction of transmission and distribution losses also offers apparently high returns and scope for large investments.

Scattered information from industrial energy efficiency intermediation projects suggests that SMEs can achieve attractive rates of return through retrofits. But there may also be high returns in large, greenfield companies. Many companies operate at the state of the art in efficiency, but not all do. A recent study in China found that large cement companies investing in new facilities failed to incorporate technologies that would have financial returns greater than 35 percent (not taking into account carbon benefits) (Price and others 2009). Globally, cement and steel account for 15 percent of energy-related GHG emissions, about three-quarters as much as coal burning, so this is an important target for improved efficiency.

Studies project large energy efficiency opportunities in the building sector, where market failures abound, representing a largely untapped area for WBG intervention.

Studies project large energy efficiency opportunities in the building sector, where market failures abound. Rapid urbanization during the coming decades will result in the construction of billions of square meters each year. Because

of market failures, these buildings are likely to be energy inefficient and carbon intensive, and they will stand for decades. At the same time, demand for energy-intensive appliances such as televisions, refrigerators, and air conditioners is growing rapidly. As noted in Phase I of this evaluation, there is large scope for supporting policies for building and appliance efficiency.

The WBG has modestly supported policy formulation but, with the notable exception of two Chinese projects, has not been deeply involved in implementation. There is considerable scope here for public-private coordination. The World Bank could support policy implementation, and IFC (following the precedent of ELI) could work with manufacturers to promote more efficient and cost-effective products and practices.

Overcoming barriers to adoption and diffusion

Many of the barriers to energy efficiency lending are in fact barriers to general lending: lack of liquidity, inability to make long loans, and inability to rely on contracts. Hence, guarantees have been useful not as a temporary device to overcome banks' unfamiliarity with energy efficiency, but rather the means to convince them to lend to enterprises with poor collateral. Future use of guarantees should be more tightly focused on these targets. Technical assistance does appear to have helped some banks identify and market energy efficiency lending opportunities.

Energy efficiency policies loom large as complements to finance. China's vigorous push for energy efficiency was a motivator for industrial investments. Hungary's innovations in municipal finance opened cost-saving, emissions-reducing opportunities. As noted in first phase of this evaluation, cost-reflective prices are important motivators for efficiency.

Growing but largely unevaluated experience with CFL distribution projects suggests that public policies can overcome household barriers to adoption. Carbon finance would be another possible mechanism to pay for light bulb distribution, because the carbon returns are large relative to CFL costs. Further analysis is needed to determine when a one-time subsidized distribution of CFLs is sufficient to trigger follow-on adoption and diffusion.

IFC could use its direct investments to promote energy efficiency at three levels. First, just as it has encouraged client banks to market energy efficiency solutions to their own clients, IFC itself could proactively seek new markets with large impacts. These could include, for instance, developers of large commercial buildings and residential developments that are interested in pursuing low-energy building concepts, including nascent proposals for "eco-cities."

Second, within its current client base, IFC could prioritize the attention of energy efficiency staff to projects with the

highest potential for savings. Currently, IFC has devoted staff attention to small loans offering only a few thousand tons per year of CO₂ savings, and in at least one case (the above-noted distribution utility) failing to follow up on a project offering energy and CO₂ savings a hundred times greater. IFC has just hired an expert in building energy efficiency—how should this expert’s scarce time be allocated for maximum impact? Third, IFC could encourage benchmarking of performance among its smaller direct clients and among clients of financial intermediaries, preparing standardized audit services and loan products for them.

Systems issues

Energy efficiency can offer a cost-effective alternative to new generation, but this may be overlooked in the absence of a view of the entire power system. Similarly, the congestion impacts of new generation on transmission can be overlooked. A systems view is important to address the degree to which energy efficiency provokes “snap-back”—increased consumption of electricity as its effective price drops.

Learning and feedback

Most of the financial intermediation projects had a rationale of promoting diffusion of financial technologies—that is, the techniques of appraising and structuring energy efficiency loans. However, this was most effective in China, where the Bank’s Energy Conservation Project (especially) and IFC’s CHUEE Program (to a lesser extent) sought to build networks and disseminate information throughout the financial and end-user industries. In contrast, most other projects did not create explicit channels for diffusion, and banks had little motivation for sharing their learning with competitors.

There remains a tremendous need to understand what works and what does not in the evolving field of energy efficiency.

There remains a tremendous need to understand what works and what does not in this still-evolving field. Financial returns to energy efficiency are poorly and inconsistently measured. A lack of monitoring information on the state of T&D losses weakens power planning and makes it more difficult to locate high-return investments. And there is a desperate need for applied operations research in efficient lighting programs to understand which consumer and producer barriers are most salient and which interventions are most effective.

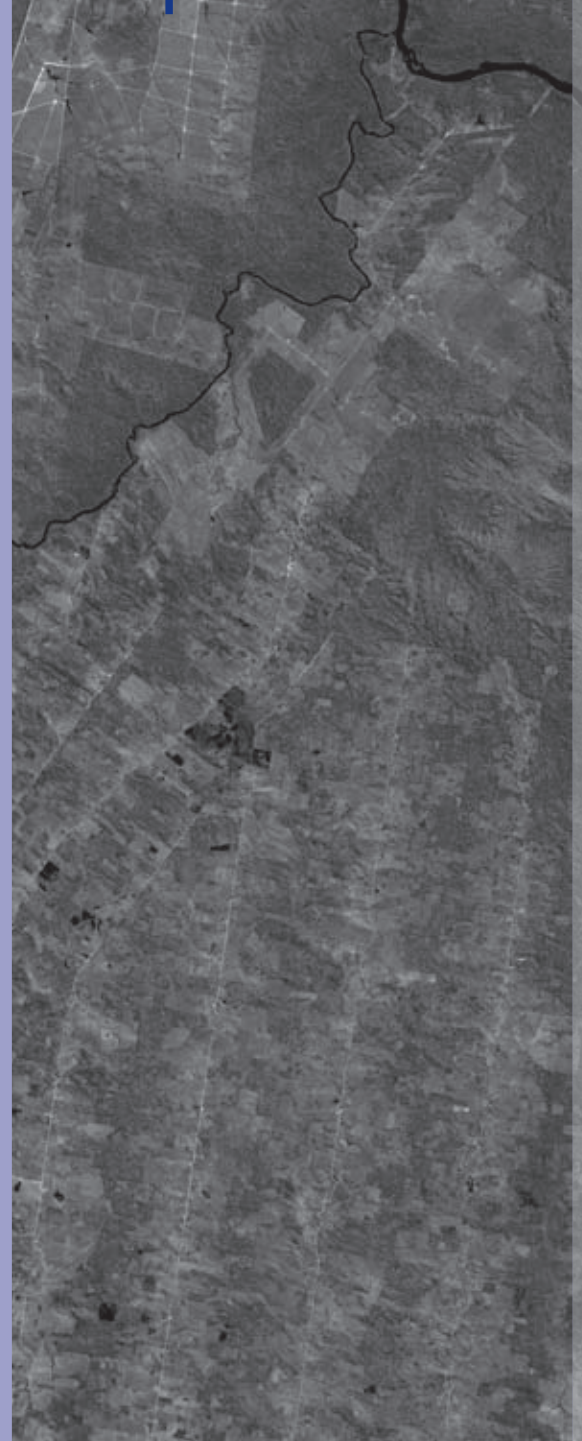
The first phase of this evaluation stressed the importance of developing indicators for energy efficiency to set targets and assess progress. Learning is critical, because energy efficiency promotion is less well understood than renewable energy promotion. However, current project-level methodologies are haphazardly applied, often lack ex post measurement, and are inconsistent in their treatment of projects that combine retrofits with capacity expansion.

The United Nations Industrial Development Organization, however, has documented that it is possible to set up information networks that facilitate benchmarking and sharing of information on efficiency performance. At the national level, several countries are beginning to assemble sectoral information on energy efficiency, as a recent ESMAP-sponsored workshop showed. “Bottom-up” indicators, for example, for particular industry sectors or for power distribution losses, would be more useful for the purposes discussed here than national level indicators.

Chapter 4

EVALUATION HIGHLIGHTS

- Bus rapid transit systems offer good returns in reduced travel time, congestion, and air pollution, with carbon cobenefits.
- Targeting, price-setting, and financial sustainability are major challenges for forest projects using payments for environmental services.
- The BioCarbon Fund has helped catalyze the forest carbon market but has had implementation problems.
- Protected areas have been effective in reducing tropical deforestation, especially where sustainable use is permitted; indigenous areas are even more effective.
- IFC investments in the Amazon did not catalyze deforestation, but neither did they catalyze widespread changes in industry practice.



Beyond Energy: Low-Carbon Paths in Cities and Forests

The futures of cities, urban transport, and growth are intertwined. Urban agglomerations have the potential to provide a high-productivity, integrated labor market if urban services, especially transportation, work efficiently. Once urban layouts have been established, they can persist for decades, even centuries, shaping circulation patterns (Shalizi and Lecocq 2009). So avoiding lock-in is important for urban efficiency (and lower emissions) in those countries that are still urbanizing.

Since the adoption of the SFDCC, the WBG has launched new analytic and collaborative activities to promote efficient cities, including the Eco2 Initiative and ESMAP's Energy Efficient Cities Initiative.

Urban Transit

This section examines bus rapid transit (BRT), for which there is a longer track record. Invented in the city of Curitiba, Brazil, in the 1960s, this is emerging as the single largest line of WBG action within urban transportation.

BRT refers to a range of options (FTA 2003). At a minimum, it involves moving buses out of mixed traffic into bus priority lanes or into exclusive bus lanes as a way to appeal to passengers who put a premium on time savings. At the high end, it includes bus rapid transit systems (BRTS). A low-budget version of a metro system, BRTS use articulated buses on dedicated roadways, allowing the system to move more people more quickly than traditional buses on shared, clogged roadways. The capital costs (per kilometer of line) of a BRT can be a quarter to a third of the cost of building a comparable tramway and 5–10 percent of the cost of a metro system. (Nonetheless, metros may be cost-effective in certain high-density locales, and the World Bank continues to support them.)

Transport, development, and climate

In the non-OECD countries, GHG emissions from transport nearly doubled from 1990 to 2006, and transport's share of emissions rose from 5.6 to 12.8 percent.¹ If these countries emulate developed countries, transport emissions will continue to grow rapidly. At the global level, within the

transport sector, the land transport subsector accounted for 85 percent of all energy consumed in 2009. To make a dent in CO₂ reduction in the transport sector, the primary focus will have to be on road transport, both within and between cities.

In already urbanized regions such as Latin America, public transport typically accounts for at least half of public trips. There is an opportunity for developing countries to maintain this high share for public transport if they can avoid the death spiral found in developed countries. In that spiral, a burgeoning middle class abandons poor-quality public transport for autos, imposing congestion and pollution costs on everyone. With ridership declining, public transit is forced to raise fares or further reduce quality, driving away more passengers, with a share declining to 10 or 20 percent.

Developing countries may be able to avoid the spiral of declining public transport quality, rising fares, and declining market share that some developed countries have experienced.

The consequences of this spiral are dire for developing country cities because of their lack of road capacity. In many developing countries, the circulation system in cities accounts for 10–20 percent of the urban area, in contrast to 35–50 percent in developed countries. Squeezing more cars onto limited roadways generates congestion and heightened CO₂ emissions.

The WBG urban transport portfolio (2003–08)

The IEG review of the overall transport portfolio (IEG 2007) noted that the number of urban transport operations is small relative to the scale of the problem. It suggested that the limited activity may reflect the complexity of these projects, but nonetheless it recommended that this subsector of activity should grow. Since then the WBG Transport Business Strategy for 2008–12 has identified climate change as one of its five strategic objectives.

Bus rapid transit projects, many with carbon objectives, multiplied at the Bank after 2002.

During 2003–08 there were 36 World Bank urban transport operations, versus 37 in the previous five-year period 1998–2002. However, average Bank commitments per year declined from \$713 to \$611 million. The decline in part reflects a complete lack of new operations in South Asia in 2003–08. However, a post-2008 upsurge may signal a partial reversal of trends.

During 2003–08, there was a clear shift toward BRT. There were 19 such operations (11 for full BRTS), compared with 6 in 1998–2002 (only one of which was for a BRTS). The new operations were concentrated in Latin America and East Asia.

Attention to carbon has been increasing. During 2003–08, 39 percent of the urban transport operations had formal

or informal² carbon reduction goals, versus 19 percent in the prereview period. As many as 10 operations in 2003–08 had components to monitor carbon reduction (compared to only 1 in the previous period), 6 of which involved GEF financing to develop the components.

Barriers and interventions to reducing congestion and CO₂ emissions

BRTS face a number of barriers:

- *Conflicting demand for road space.* Establishing dedicated bus lanes can displace other road users, creating resistance to the loss of circulation space and leading to spillover of traffic to neighboring roads. Demand management and parking restrictions are potential responses.
- *Institutional problems.* The real benefits of mass public transportation are only realized with a multicorridor trunk route system that is linked to a series of feeder routes. Scaling up to such a system puts a premium on coordinated planning in multi-jurisdictional metropolitan areas and on sustained long-term political commitment to routes and land use zoning.
- *Opposition by taxi and minivan owners.* BRT achieves pollution, congestion, and carbon emissions reductions largely by substituting for existing fleets of minibuses. Such fleets are highly polluting and unsafe but employ thousands of drivers, who tend to oppose change. This process has proven to be politically contentious in many cities; responses include finding ways to integrate the drivers into the new system or otherwise compensate them.



Photo by Curt Carnemark, courtesy of the World Bank Photo Library.

The challenges to bus rapid transit include competing demand for road space, lack of coordination between neighboring cities, and opposition by taxi and private minibus owners.

The BRT experience

Among WBG-supported programs, the BRTs that are most developed are those of Bogota and Mexico City. In both cases, the WBG worked with willing clients, who had already concluded that BRTS was a desirable alternative.

In Bogota (box 4.1), a sequence of learning-by-doing loans totaling \$887 million (together with non-Bank carbon revenues) supported expansion of BRT corridors and their integration into a citywide trunk and feeder system, with attention to bikeways and pedestrians. System expansion was complemented with serious demand-side measures, including doubling parking fees, boosting the gasoline tax, and restricting car travel during peak hours. Cooperatives were formed to offer employment to the former bus drivers as part of the new feeder routes. Companies participating in the new routes were required to scrap four to nine old buses for each new articulated bus added to the system.

BOX 4.1 The TransMilenio BRTS

Without an explicit goal to reduce CO₂ emissions, the World Bank has been financing urban transport projects in Bogota since the mid-1990s and has contributed to the development of Bogota's TransMilenio BRT system. One of the earliest programs of Bank support for a BRTS, this is an example of learning by doing.

Under the first Bank-funded Urban Transport Project, the World Bank helped finance traffic management systems along existing bus ways and connecting roads to improve the traffic throughput to an existing BRT corridor. This project also funded background studies that led to the development of a better parking policy for the city. According to the project completion report, this effort more than doubled average bus speeds, boosting them from an initial 12 kilometers per hour to 27 kilometers per hour post-project.

The second project, the \$130 million Bogota Urban Services, was designed to help implement the second corridor in the BRTS and promote nonmotorized traffic (an extensive network of bike paths). A third project, the \$757 million Integrated Mass Transit System, was designed to support the critical second (post-demonstration) phase of Bogota's BRTS as a citywide integrated trunk-and-feeder system with 14 additional corridors and an integrated fare system, and to introduce a number of transport demand-management initiatives. Most importantly, the Integrated Mass Transit System expanded BRTSs to five other cities, replicating the experience of Bogota but tailoring it to specific conditions of those selected cities.

By 2004, Bogota's BRTS already consisted of 58 kilometers of dedicated bus ways and 309 kilometers of feeder routes and moved more than 800,000 passengers per day. According to Wright (2004), carbon emissions reduction has been achieved through a combination of improved public transport and the introduction of complementary transport demand management policies to discourage the use of private vehicles and roadway space. The 20 percent increase in gasoline taxes, 100 percent increase in parking fees, and restriction on private car travel during peak hours are said to have reduced car traffic by 40 percent per day.

Wright and Fulton (2005) list the key factors contributing to emission reduction:

- Replacing four to five smaller buses with larger articulated buses and requiring the destruction of four to eight older buses for every new articulated vehicle introduced into the system; articulated buses are more fuel efficient per passenger-kilometer traveled.
- Increasing the vehicle load factor to approximately 80–90 percent by implementing global positioning system-controlled management of the fleet, allowing the optimization of demand and supply during peak and nonpeak hours.
- Enforcing emission standards, requiring buses to be EURO II emission level-compliant.
- Increasing the share of public transport ridership in total transit. By 2002, the share of private car and taxi trips in total trips was said to have been reduced from 19.7 to 17.5 percent and the share of public transit trips increased from 67 to 68 percent (Karekezi, Majaro, and Johnson 2003).

One of the main barriers to system expansion was resistance to expansion of the BRT from current bus owners—an issue endemic to BRT implementation. The two corridors of Phase I of the TransMilenio BRT were designed to meet only about 10 percent of the public transportation demand, with the remaining 90 percent being met

by conventional transport systems, in particular a number of small bus owners competing with each other for passengers. Hence, the first phase did not displace many bus owners. The subsequent phases (with an additional 14 corridors), however, were designed to increase the share of BRT in total public transit to 70 percent and could drastically reduce the role of the remaining small bus owners.

The solution to this has been to form cooperatives or holding companies that would employ many of the bus owners/drivers (the balance being placed in alternate jobs through financial transfers). The difficulties in implementing this solution are ongoing but declining.

A related problem has been the difficulty in enforcing the phase-out of old buses. This phase-out affects the expected reduction in externalities determined at appraisal—particularly GHG reductions. Despite a monitored scrapping program in which the low-quality minibuses were exchanged for higher-quality articulated buses at the prescribed exchange rate and their destruction supervised, the total number of minibuses in the city did not decline as expected. The inability to enforce regulations, such as licenses and routes for minibuses, resulted in new entrants and the use of secondhand mini-buses. It also generated congestion in other parts of the city. The hoped-for reduction in CO₂ emissions from scrapping buses will be frustrated if other old buses are pressed into service and increase their annual mileage.

Maintaining and increasing ridership is also a challenge. Gilbert (2008) points to contractual arrangements that necessitate raising fares when ridership projections are lower than anticipated. That creates a spiral of decreasing ridership caused by higher prices and leading to new rounds of price increases and the inability to ensure safety on the new lines, which also contributes to ridership loss. In addition, the cost differential between extending the BRTS and extending the metro is declining as the system expands into more difficult terrain. As a result of all of this, the middle class (whose rate of BRT usage is highest relative to the lower income and higher income groups) has started voicing support for new metro lines at the expense of the BRT network.

The Bogota experience has piqued global interest in BRTSs. The Bank and other donors have facilitated visits by officials from other countries to see the experiment in Bogota. In fact, many other countries are learning from this experience and are now designing or implementing their own systems. However, the program is not yet fully implemented, and it is too early to judge whether it will realize the full benefits anticipated from expansion to a multilane, citywide, integrated system.

Sources: Wright 2004, Gilbert 2008, TransMilenio PDD 2004.

However, even as the old buses are scrapped and their drivers assimilated into the system, it has been difficult to exclude new entrants who import additional second-hand buses. Although the system was initially successful in attracting riders, there are signs of an incipient rising fare/declining ridership cycle; concerns about passenger safety are also eroding ridership, and public sentiment is shifting toward new metro lines (Gilbert 2008). Overall, however, the system is viewed as having demonstrated BRTS feasibility, and the Bank has actively facilitated visits to the project by potential foreign emulators. Current projects seek to add eight more BRT lines to the Bogota system and replicate it in five other cities.

The most developed systems were initially successful, but the future is uncertain.

In Mexico City, the BRTS was largely financed domestically, but the World Bank had two catalytic interventions. First, a \$6 million GEF-funded Bank project supported institutional development for implementing the system. Second, a World Bank-financed carbon project arranged

for \$2.4 million in carbon credit purchase. This is a small portion of the total \$49.4 million project cost, but the proponents claim that the association with carbon has helped popularize the project. In addition, the project was responsible for developing the second CDM-approved methodology for assessing GHG reductions in public transport, opening the way for CDM finance of BRTS elsewhere.

Impacts

Dedicated bus lanes (precursors to BRTS) have been shown to increase travel speeds for bus passengers by 20–60 percent, based on completion reports (for example, from 21.4 to 30 kilometers per hour in the Liaoning project in China, 15.6 to 25 kilometers per hour in the Shijiazhuang project in China, and 15 to 22 kilometers per hour in the Dhaka project in Bangladesh). The Dhaka urban transport air-quality project also showed a dramatic drop in local air pollutants (31 percent decrease in PM₁₀, 59 percent in hydrocarbons, 28 percent in carbon monoxide) after three wheelers with highly polluting two-stroke engines were removed, generating \$25 million per annum in health benefits for the city.

Dedicated bus lanes have been shown to increase travel speeds.

In Bogota, CDM validation reports showed annual CO₂ savings rising from 56,000 tons of CO₂e in 2006 to 79,000 in 2009. Ridership increased from 346 to 449 million. The proportion of passengers attracted from private cars and taxis fell from 9.8 to 6.9 percent.

BRTs offer attractive economic returns in fuel and time savings, reduced congestion, and reduced air pollution.

In Mexico, the \$47 million project is estimated to yield annual noncarbon savings of \$15.42 million (Schipper and others 2009). About a third is from fuel and time savings of bus riders, and the remainder is external benefits from reduced air pollution, congestion, and fuel expenditure by others. Annual CO₂ reductions were measured at 39,870 tons of CO₂ for 2007–08. At current CO₂ prices, these benefits are small relative to the local economic benefits.

Conclusions

Based on limited evidence, BRTs offer attractive economic returns to cities as a whole in time savings, fuel savings, reduced pollution, and reduced congestion; the savings do not go directly to the implementing agency. The short-run reductions in GHG generate carbon credits that are modest in value compared to the direct local benefits. Single-line BRTs have little impact on overall urban CO₂ emissions—for instance, the reductions in Mexico city are less than 0.25 percent of urban emissions from transport (Schipper and others 2009). In other words, these investments make a lot of sense as development interventions with CO₂ cobenefits; they would never be chosen solely as means to reduce CO₂.

In the medium run, there are likely to be declining returns as the number of corridors increases within a city; but cumulative emissions reductions for the system as a whole could increase, to 250,000–400,000 tons of CO₂e per year. Long-term impacts could differ substantially; BRTs could be a contributing component in the construction of efficient cities with low carbon footprints, if they are able to retain their share of passenger trips. Demand-side management will be an important part of such a scenario.

Efficient transport planning will require a systems view for planning and monitoring. Installation of a BRT corridor causes ripples throughout the entire transport network as people change trip patterns and vehicles enter the system. Indirect impacts could magnify or counteract the corridor-level benefits; these need to be anticipated and tracked. Although CDM projects have the tremendous benefit of tracking ridership and fuel use, they typically do not

monitor systemwide travel patterns. This requires systemwide travel surveys, which are expensive but informative.

As the World Bank embarks on sponsoring BRTs around the world, it should take the opportunity to promote harmonized monitoring of impacts. The Clean Technology Fund or other concessional funds could be used to mount regular, consistent travel surveys. This would allow correct measurement of impacts and could stimulate south-south sharing of experience and drawing of lessons.

Forests

Deforestation accounts for roughly one-fifth to one-sixth of human-caused GHG emissions. Emissions result as forests are cleared and burned to make way for farms and ranches and to a lesser extent from damage caused by careless loggers. Most emissions are from tropical moist forests, where deforestation rates are high and biomass is dense.

At CO₂ values of \$10–\$20 per ton, forests are worth much more as living carbon storage than as sites for farms or for cattle ranches. Forests have additional value as havens for biodiversity, and they play a role in regulating water flows. Nevertheless, forests are cut. Where land and forest tenure is well defined, landowners face strong incentives to liquidate standing forests (rather than patiently harvest them over rotations of 30–100 years) and replace them with cash crops, cattle, or fast-growing trees. In many forests, tenure is poorly defined, and people may use deforestation as a mechanism to claim land as the approach of roads or markets causes it to appreciate in value (Chomitz 2007).

Forests can be worth more as living carbon storage than as sites for farms or cattle ranches.

In principle, landholders or nations would reduce deforestation if they were compensated for the local and global benefits their forests provide. This has motivated the REDD agenda, an element of ongoing negotiations on the international climate regime. REDD seeks to mobilize global funds to reward developing countries for reducing emissions. Countries would use these funds to implement programs and policies to promote sustainable land use.

How, exactly, would that work? Although the forest carbon agenda is new, the forest conservation and management agenda is not, and World Bank experience provides some parallels for potential future REDD actions.

After briefly reviewing the World Bank forest strategy and portfolio, this section reviews three kinds of projects that may offer lessons for REDD. By far the largest set of projects with an explicit goal of forest conservation is *protected area projects*. A novel approach that closely resembles REDD is *payment for environmental services*, a category of projects that

include the forest carbon projects of the *BioCarbon Fund*. Finally, the durability and acceptability of forest conservation may depend on the sustainable intensification of agriculture, to provide the food, timber, and jobs that motivate deforestation in the first place. IFC has supported *agribusiness at the forest frontier* with the goal of encouraging sustainability.

The Bank's 1991 Forest Strategy mainly focused on environmental issues, particularly protecting tropical forests.

The Bank's forest strategy and portfolio

The Bank's 1991 Forest Strategy recognized the role that forests could play in poverty reduction and the importance of policy reforms in containing deforestation. However, it mainly focused on environmental issues, particularly protecting tropical moist forests. It reflected rising international concern about the rate of tropical deforestation through adopting a “do no harm” approach of not financing commercial logging in primary tropical moist forests. Yet as the revised strategy attests, this emphasis on safeguarding forests did little to help countries actively manage their natural forests, especially in the tropics, and left the Bank scant opportunity to harness the poverty-reduction potential of forests. Termed a “chilling effect” by the IEG (2000) forest strategy review, the strategy and associated safeguards prevented Bank staff from engaging the sector in proactive ways to improve economic and environmental management of tropical forests.

The 2002 Strategy refocused around poverty reduction, economic management, and environmental protection, expanding to all forest areas.

The revised 2002 Strategy expanded the Bank's forest policy to include all forest areas; it refocused the strategy around three pillars of engagement aligned with the Bank's mission: poverty reduction, economic management (including governance), and protection of environmental services and values. The revised strategy also recognized that the 1991 Strategy did not clearly define implementation mechanisms, but rather set out a menu of approaches that could be pursued.

To harness the potential of forests to reduce poverty, the revised strategy recommended strengthening the rights of forest-dependent people—especially marginalized groups—by promoting community forest management and agroforestry. To achieve progress on the second pillar, the integration

of forests into sustainable economic development, the Bank would help governments improve forest governance by assisting with legal and institutional reforms and encouraging investments that catalyze production of forest products.

The protection of local and global environmental services and values, the third pillar, would be achieved by continuing to support the creation and expansion of protected areas, improving forest management outside these areas, and developing options to build markets and finance for international public goods such as biodiversity and carbon sequestration, that would include payments for forest ecosystem and environmental services.

A forest portfolio review conducted for this study found that investment lending in forests has declined since the adoption of the 2002 Forest Strategy (see figure 4.1). The portfolio composition has changed, with a shift from investment projects to Development Policy Loans³ and increased prominence of GEF-funded projects with global environmental goals.

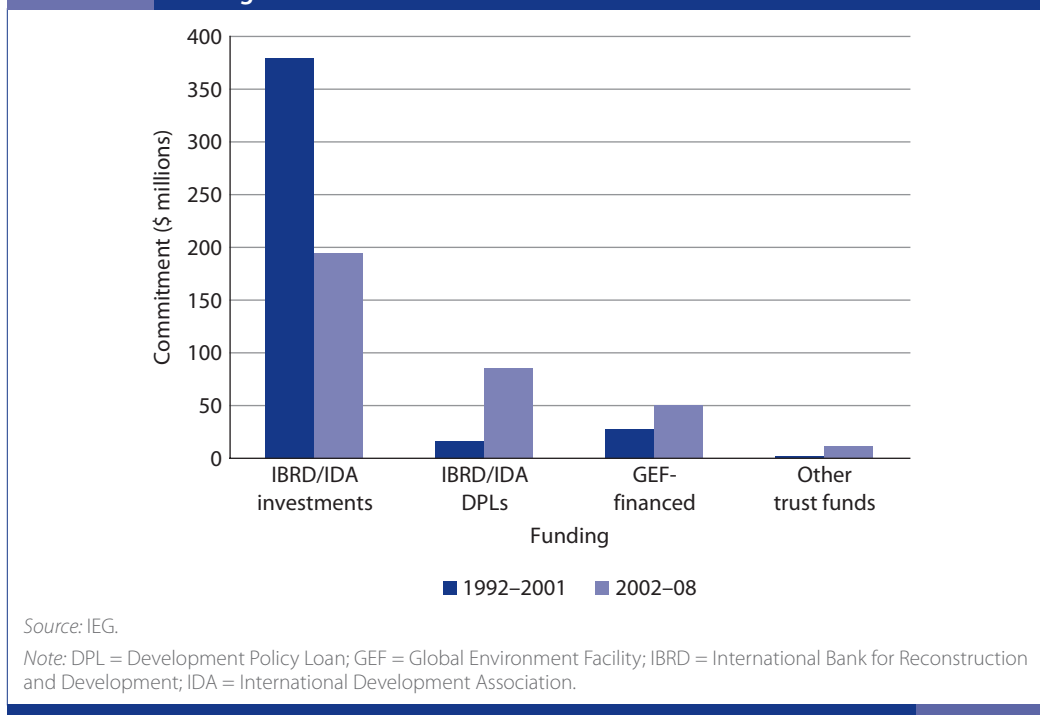
Investment lending in forests has declined since adoption of the 2002 policy.

Of the 124 forest-related projects in the 2002–08 portfolio, 46 had objectives or components related to protected areas, and 10 had connections with payment for environmental services. Of the 17 projects for which forests were designated as the leading sector, 11 contained components related to community forest management.

Payment for environmental services

The World Bank has supported roughly a dozen projects over the past decade that have incorporated some form of payment for environmental services (PES) scheme, mainly in Africa and Latin America and the Caribbean. PES schemes reward landholders for growing or conserving forests, which provide services such as watershed protection and carbon storage. Payment is based on compliance with agreed conditions. Because the forest holder is typically not able to exclude particular beneficiaries, funds are typically raised through a levy on beneficiaries, or through taxation, though there are also voluntary payments and market-based schemes. PES schemes could be one model for implementation of REDD at the national level.

PES schemes provide one model for implementation of REDD at the national level.

FIGURE 4.1 Average Annual Forest Commitments

Costa Rica has led the way in the design and piloting of market-based instruments to enhance the provision of forest environmental services. The World Bank has been a partner in this effort since the mid-1990s. By the end of the second phase of Bank support for Costa Rica's PES program, the country will have put in place some 288,000 hectares of land with environmental service contracts (equal to approximately 5.6 percent of Costa Rica's land area), half of which will be financed by funding from service users. The program showed that PES schemes could be accomplished at relatively low administrative costs. A GEF-commissioned independent review (Hartshorn, Ferraro and Spergel 2005) found that the program had achieved its output goals. But it also found that the program had not set up a monitoring program adequate to determine impacts.

The need for sustainable, long-term financing mechanisms is one of the main lessons that has emerged from the piloting of PES systems in Latin America. In Costa Rica, the bulk of funding for the PES program comes from an earmarked fuel tax subject to political decision making; most of the payments are for limited duration, leaving no incentive for continued forest care. New financing mechanisms are needed to increase the long-term sustainability of the program. For instance, the second phase of Bank support for the PES program in Costa Rica involves a water tariff that is expected to generate \$5 million a year in support of watershed conservation.

Specifying whom to pay, and how much, is a major challenge for these programs. The economic logic of the programs requires rewarding landholders according to the services they

provide. This runs into scientific and political difficulties. First, the services themselves may be poorly understood and measured. A strong folk belief holds that forests generate water, while in fact forests typically are net consumers of water.

Second, cost-effectiveness would require targeting payments toward forestholders most likely to be dissuaded from deforestation, with payment levels tied to the expected benefits of conservation. This may conflict with notions of equity that favor uniform payment rates (as occurred in Mexico and Costa Rica) and favors payments to owners who are not inclined to deforest. Third, there is pressure to target PES payments to poor people, thus combining social and environmental goals. However, poor people may own relatively little forest, and the transactions cost of dealing with many smallholders is a barrier to including them.

Targeting and price-setting are major challenges for PES programs.

Econometric analyses of the early experience of the Costa Rica and Mexico programs found that they were disproportionately targeted toward lands with little risk of deforestation. In the first four rounds of the Mexican program, 52–72 percent of PES contracts were in forests in the bottom two quintiles of deforestation risk. However, 72–83 percent were located in communities in the two highest quintiles of economic marginality (Muñoz-Piña and others 2008).

However, one study (Alix-Garcia, Shapiro, and Sims 2010) found that the program may have reduced the probability of deforestation by about 10 percentage points. An analysis

for Costa Rica for the period 2000–05 found that only 0.4 percent of targeted landholdings would have experienced deforestation in the absence of the program; similar findings were found for earlier periods (Sánchez-Azofeifa and others 2007; Pfaff and others 2009). Sills and others (2008) find that PES recipients did not reduce deforestation, but increased reforestation.⁴ It is possible that the PES scheme worked at a political level rather than at the plot level, by reinforcing decisions to stiffen penalties for deforestation and to market Costa Rica as an ecological tourist destination. Costa Rica's deforestation rate declined to very low levels by the late 1990s.

Early programs targeted lands with little risk of deforestation, but program designs have since improved.

In both countries, ongoing World Bank–supported programs are contributing to better targeting. One lesson learned has been the need to incorporate better up-front design for monitoring and evaluation in PES programs to allow more timely and reliable impact analysis. The Regional Silvopastoral Project (see box 4.2) is an exemplary use of

experimental determination of the impact of alternative payment schemes and agroforestry approaches on carbon, biodiversity, and farm profits.⁵

BioCarbon Fund

Launched in 2004, the BioCarbon Fund provides carbon finance for projects that sequester or conserve GHGs in forests and agro- and other ecosystems. The BioCarbon Fund is mostly oriented to forest projects creditable under the Kyoto Protocol: afforestation and reforestation. But it also pays for credits generated from reduced deforestation and from soil carbon, which are not recognized under Kyoto. It is thus a prototype of REDD and other post-Kyoto proposed systems.

The BioCarbon Fund has helped catalyze the forest carbon market.

The BioCarbon Fund has helped catalyze the forest carbon market by contributing to the development of 3 of the 12 approved afforestation/reforestation methodologies. The BioCarbon Fund accounts for 5 of the 13 forestry projects registered with the CDM to date.

BOX 4.2 The Silvopastoral Project: A Successful Demonstration

The GEF/IBRD Regional Integrated Silvopastoral Approaches to Ecosystem Management Project (2002–08)—implemented in Colombia, Costa Rica, and Nicaragua—was designed to test the effects of payment schemes on the adoption of conservation practices on cattle farms. The project, the outcome of which IEG rated as highly satisfactory, identified a range of technical approaches in each country and tested four main categories of silvopastoral systems: forest plantations with livestock grazing; live fencing, wind protection shields, biological corridors, and shade for animals; managed succession within silvopastoral systems; and intensive systems for cattle and other animal species.

The implementation of these systems resulted in a large body of learning, including 70 reports, refereed journal articles, and books about how to induce farmers to adopt biodiversity-friendly, carbon-fixing land uses. In some cases, technical assistance and credit are sufficient. In other cases, short-term payments are needed to cover farmers' initial investment costs, but not thereafter. However, land use changes that represent an ongoing opportunity cost for farmers require mid- to long-term payments for the environmental services being produced; those services could include watershed protection or secondary forest recovery in degraded pastures.

Different combinations of silvopastoral practices have proven to yield varying internal rates of return; economic analysis conducted in Esparaza, Costa Rica, revealed rates from 14 percent for a system with natural pasture and a fodder bank to 37 percent for a system with improved pasture and low tree density. Based on the attractiveness of a system to an individual farmer, some farmers may be willing to adopt certain systems even in the absence of short-term PES incentives.

Lines of credit for scaled-up silvopastoral system implementation are now being made available through Costa Rica's Cattle Ranchers Association, Nicaragua's Local Development Fund, and the Ministry of Agriculture in Colombia. However, it is unlikely that most farmers will be able to afford the high initial costs of introducing a new land use system or that credit will be able to be tapped across all farm households across varying silvopastoral applications. Additional and recurrent finance will be especially needed to promote investments in silvopastoral systems that generate a high level of public environmental services compared to a more attractive private rate of return.

Source: IEG.

The BioCarbon Fund has signed emissions reduction purchase agreements (carbon offset purchase agreements) with 19 projects, originally for a total of \$26 million. Focusing on poor and rural communities, the fund's first tranche is 25 percent invested in Africa. This is a far higher proportion than the African share of other carbon funds at the Bank or of the CDM as a whole. In its first phase, the fund invested heavily in plantations and community reforestation (representing 34 and 31 percent of the technical distribution of the portfolio, respectively), in addition to other activities such as environmental restoration, assisted regeneration, and agroforestry.

The Fund has struggled at the project level with implementation issues that are also encountered in the World Bank's forest operations. However, it has built a comprehensive monitoring system, allowing closer scrutiny of performance than is possible for many noncarbon projects. As of June 2009, 12 of 19 tranche 1 projects were expected to deliver less than half of contracted emissions reductions. In five of the projects, the contracted amount had already been revised downward.

The BioCarbon Fund has underdelivered carbon reductions.

There are several reasons for underdelivery. In Costa Rica and Honduras, suitable CDM-eligible land was grossly overestimated, and carbon payments were not competitive with other land uses; thus, these projects were scaled back by 80 percent or more. Inadequate up-front financing constrained planting area in several projects. The project implementer's capacity has been low in several cases, one factor behind low seedling survival rates in some projects. Unexpectedly bad weather has hampered projects in China and Kenya.

Given these risks, the Bank has increased supervision to try to improve expected delivery from the portfolio. But average supervision budgets for these projects already exceed the average for the PCF, which has much larger projects.

Preliminary reports show success in the Humbo Assisted Natural Regeneration Project in Ethiopia, the first large-scale African forestry project to be registered with the CDM. This project has adapted techniques demonstrated in West Africa to promote natural regeneration of woodlands and has restored more than 2,700 hectares of degraded land. The regeneration project has reportedly resulted in increased production of honey, fruit, and fodder. Further study is needed to assess the economics of the project: the labor costs, the impacts on income, and the generation of local hydrological and biodiversity benefits.

The Forest Carbon Partnership Facility is designed to pilot approaches that might be used in a future REDD regime.

A follow-on to the BioCarbon Fund, the Forest Carbon Partnership Facility is designed to pilot approaches that might be used in a future REDD regime. It has supported the development of readiness plans, broadly outlining plans for accomplishing and measuring deforestation reduction, in 37 forested countries. It will eventually purchase emissions reductions from countries with approved plans. Investments to implement the plans will be funded via the Climate Investment Fund, a separate facility.

Protected areas

The World Bank, combined with finance from GEF, has made a significant contribution to creating and strengthening protected areas worldwide. According to the GEF Secretariat, GEF assistance—since it began operations in 1991—has supported more than 1,600 protected areas covering 360 million hectares (GEF 2009). Protected areas now cover more than a quarter of the remaining tropical forest, an area equivalent to Argentina and Bolivia combined (Nelson and Chomitz 2009).

The World Bank, together with GEF, has made a significant contribution to the creation and strengthening of protected areas worldwide.

This review identified a population of 114 World Bank protected area projects, approved between 1988 and 2000, that are located in humid tropical forests. (With high deforestation rates and high biomass, these forests account most forest carbon emissions.) Seventy-four percent of these projects have been rated satisfactory by IEG (receiving an outcome rating of moderately satisfactory or higher); however, these ratings do not necessarily reflect the effectiveness of the protected area sited, because the protected area in many cases is a component of a larger project. Likewise, although only 56 percent of this portfolio was rated sustainable (likely or highly likely or an equivalent thereof), these risk ratings are composite ratings affecting the project as a whole.

In fact, despite 20 years of effort in creating protected areas, systematic information is lacking on their impact on biodiversity, on carbon storage, and on the welfare of people who live in and around them. Hence, there is also no reliable information on what external and internal factors are conducive to positive impacts.

After 20 years of effort, systematic information is still lacking on the impact of protected areas on biodiversity, carbon storage, and the welfare of forest-dependent people.

Limited information is available from the Bank’s World Wildlife Fund Management Effectiveness Tracking Tool, a simple checklist that describes management elements but lacks outcome measures. For projects financed partly or fully with GEF funding, the GEF Secretariat requires tracking reports at inception, mid-term, and completion. Compliance with the latter two submissions is imperfect, and the Bank does not compile Management Effectiveness Tracking Tool reports from its projects. The latest overall evaluation of the GEF (GEF Evaluation Office 2010), recognized the limitation of the tool and called for greater reinforcement of it by including indicators for progress toward impact and integrating these systems into the overall results based management system of the fifth replenishment of the GEF.

IEG reviewed 34 protected area projects in forest ecosystems (approved between fiscal 2006 and 2008) for this study and found severe limitations in monitoring. Only six of the projects included indicators that could track the financial sustainability of the targeted protected area—indicators such as revenue generation, park income, personnel budgets, or fund-related information. And only two projects included baseline measurements of vegetation cover and species count, although quantitative targets (usually in percent terms) for increased cover and greater species resilience are often targets set in protected area projects.

In the absence of good information, controversy persists about the effectiveness of protected areas. Some deride protected areas as ineffectual “paper parks.” Others fear,

to the contrary, that these areas are *too* effective, excluding local people from access to land and forest resources.

As part of this evaluation, Nelson and Chomitz (2009) sought to fill the evaluation gap by assessing the global impact of all pre-2000 tropical forest protected areas on deforestation over 2000–08. They used spatial data on the location of protected areas and of forest fires, an indicator of deforestation, and controlled for potentially confounding influences such as terrain and remoteness.

Protected areas have been effective in reducing tropical deforestation, especially where sustainable use is permitted; indigenous areas have been even more effective.

They found that protected areas were on average effective in reducing deforestation (table 4.1). Multiple-use protected areas—those that permitted some forms of sustainable use by local populations—were at least as effective as strictly protected areas. Areas that had been returned to indigenous control were most effective of all. Similar results were found in a sample restricted to World Bank-supported projects. These effects have been obscured in studies which did not allow for the possibility that some protected areas are preferentially sited in regions of low deforestation pressure (because there are no politically powerful claimants on the land) or high pressure (because of the perceived importance of conservation).

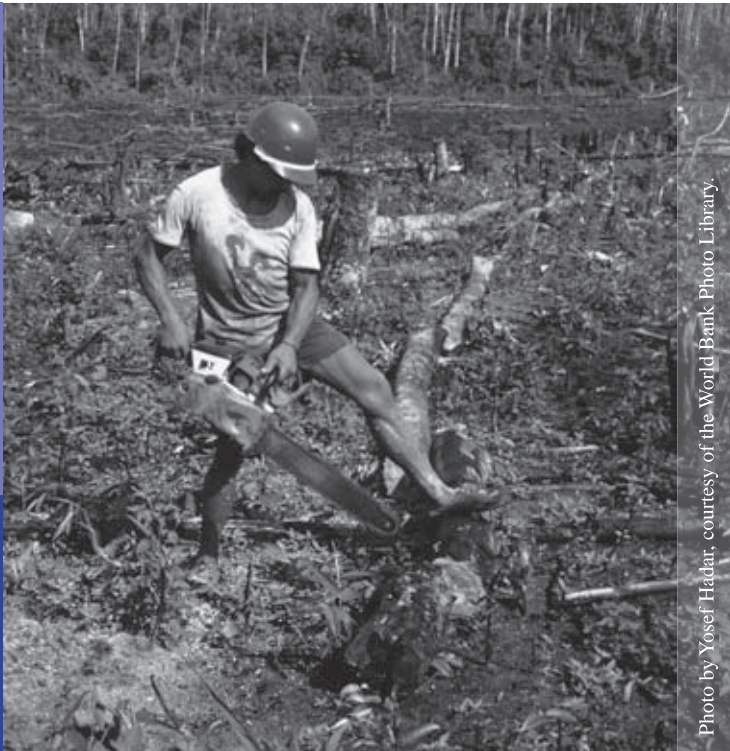
In Costa Rica and Thailand, protected areas have reduced poverty rates.

A recent study (Andam and others 2010) that also used controlled comparisons shows that protected areas have reduced local poverty rates in Costa Rica and Thailand. Again, this impact had been obscured by the tendency for protected areas to be located in impoverished regions.

TABLE 4.1 Impact of Protected Areas in Tropical Forests on Forest Fire Incidence

Area	Mean fire incidence	Mean reduction from strict protected areas	Mean reduction from multi-use protected areas	Mean reduction from indigenous areas
Latin America and the Caribbean	7.4	2.7–4.3	4.8–6.4	16.3–16.5
		3.8–7.7	6.2–7.5	12.7–12.8
Africa	6.1	1.0–1.3	(0.1)–3.0	Not applicable
		4.4–4.5	<i>Not calculated</i>	
Asia	5.5	1.7–2.0	4.3–5.9	Not applicable
		2.9–3.1	6.7–5.1	

Source: Nelson and Chomitz 2009.
Note: Table reports percentage point reduction in forest fire incidence, a proxy for deforestation over the entire period 2000–08. Figures in italics are for protected areas established 1990–2000; in plain text, all pre-2000 protected areas.



Agribusiness at the forest frontier

Deforestation in the Brazilian Amazon is largely driven by conversion to pasture and soy. Over the period 2002–07, IFC made three loans in the Brazilian Amazon: two to a soy processor (Amaggi) and one to a beef processor (Bertin). The projects aimed to demonstrate sustainable agribusiness practices in the sector by building clients’ environmental management capacity. Both loans attempted a “law abidance” strategy—that is, to bring the respective firms and their suppliers into compliance with Brazilian environmental, social, and land tenure legislation, thereby reducing deforestation in the Amazon.

Under the IFC loan, the soybean processor committed to ensuring that all soybeans grown on its farms and all soybeans purchased from prefinanced suppliers meet Brazilian and IFC environmental and social regulations. With the beef company, IFC sought to ensure compliance with Brazilian legislation for all Bertin suppliers, as well as to develop a chain of custody system to track animals throughout the supply chain.

IFC loans to agriprocessors in the Brazilian Amazon attempted to bring firms and suppliers into compliance with Brazilian environmental law.

The law abidance/chain of custody strategy, if successful, would ensure that IFC was not directly associated with deforestation. And, with the right conditions, it might have a market transformation effect. If the companies could

demonstrate that chain-of-custody tracing was reliable and feasible, and that verifiably sustainably produced products command a market premium, other agriprocessors might “green” their own supply chain. This could drive unsustainable producers out of business.

But the conditions for this scenario are stringent. The processors need to be able to trace the purchases to the point of origin—which is difficult because cows and soy can be “laundered.” Then the processors have to verify that the originating farms are in compliance with the law, a task normally undertaken by government. To motivate these actions, the processors would have to face a market in which a significant proportion of buyers will pay a premium for sustainably produced goods. And it has to be possible to sustainably intensify production on farms and ranches that comply with the law. If any of these conditions fails, new investments at the forest frontier could end up simply increasing pressure on the forest.

Outcomes. IFC and Amaggi succeeded in ensuring that no new deforestation occurred on the company’s own farms or on those of prefinanced suppliers. The company used a combination of satellite imagery, digital mapping, and field visits to verify the behavior of those suppliers. Development of this sophisticated monitoring system served the firm’s own quality control and fiduciary purposes in addition to satisfying IFC requirements. However, a significant proportion of the company’s soy purchases were from the third parties that were outside the conditions of the loan agreement and for which Amaggi had no capacity to identify the farm of origin.

IFC’s agribusiness investments did not catalyze deforestation, but neither did they catalyze widespread changes in industry practices.

Little was accomplished under the environmental covenants of the agreement with the beef producer. Bertin had agreed to develop an environmentally sustainable supply chain, including 100 percent traceability of its cattle from farm to final product, and to make 600 suppliers compliant with labor, land acquisition, and environmental legislation. Although some progress was made with ranches receiving direct support from IFC advisory services, many suppliers were noncompliant. The company also purchased slaughterhouses close to the Amazon biome in breach of IFC’s requirements, without first ensuring the sustainability of their supply chains. This noncompliance with IFC’s social and environmental standards was in effect when IFC decided to disengage from the project.

IFC wagered its reputation that these loans would tame, rather than encourage, deforestation. On one hand, both

borrowers have demonstrated the ability to raise funding far in excess of that provided by IFC, so IFC's financing per se was not catalytic of deforestation. On the other hand, neither did IFC catalyze the kind of widespread change in industry practice that would redeem its endorsement of soy and beef production at the forest frontier.

Alternative approaches to ensuring supplier compliance with environmental rules. IFC's strategy was to hold buyers responsible for the legality of their supply chain, tracing the chain of custody to the original producer and verifying that producer's compliance with the law. Without significantly strengthened supporting institutions, this strategy was unviable. First, without effective institutions and infrastructure to create traceability, non-compliant farmers could potentially launder their sales through "complying" farms. Second, being "out of compliance" was difficult to define. Cases of land invasion, rural violence, and forced labor in the Amazon remain in legal limbo for decades. Third, an effective, comprehensive georeferenced land registry was required to enforce the requirement that landholders keep 80 percent of their property under forest cover (the legal forest reserve). But no such registry exists. And finally, the commitment of the beef purchasers lacked credibility.

Although IFC's strategy had limited success in the Amazon, alternative strategies have shown more success. These rely on a combination of external pressure on buyers and the use of simple but geographically comprehensive approaches to monitoring compliance.

The Soy Moratorium and government enforcement to restrict deforestation for cattle development have shown more success in reducing deforestation pressures

Soy. In the soy sector, industry groups announced in July 2006 a moratorium on the purchase of soybeans planted in the Amazon in areas deforested after that date. This closely followed Greenpeace's report "Eating up the Amazon" (Greenpeace 2006) and its subsequent international campaign. Industry and nongovernmental organizations joined to implement the Soy Moratorium, which continues to date. This monitoring system uses existing remote sensing data from the Brazilian Space Agency, supplemented by aerial flyovers.

The success of the Soy Moratorium is based on three factors. It is a policy of zero new deforestation, which bypasses the question of the Legal Reserve and land ownership and therefore is simple to monitor. Second, as an industrywide action, it avoids leakage and achieves economies of scale in monitoring. Third, Greenpeace's participation as an independent monitor lends credibility to the enterprise.

Beef. In June 2008, Greenpeace launched Slaughtering the Amazon, an international campaign exposing the marketing of beef and leather products from illegally deforested Amazonian areas. Shortly thereafter, the federal prosecutor of Pará and the Brazilian Environmental Agency brought action against 21 ranches and more than 13 slaughterhouses that purchased cattle from these ranches, including IFC's client. Following warnings that they would be subject to prosecution if they continued to purchase from these slaughterhouses, 35 supermarkets and wholesalers suspended contracts with the offending meat processors. Subsequently, four meat processors (including the client) agreed not to purchase cattle from ranches that are embargoed by the Brazilian Environmental Agency or that engage in unlicensed new deforestation in the next two years.

Success in the beef sector is being won through a strategy that depends heavily on government enforcement and the comprehensive use of remote sensing and georeferencing technologies. In February 2008, the national monetary council in Brazil began embargoing the economic use of lands illegally deforested, as well as making all agents in the productive chain co-responsible for deforestation from these areas. The Brazilian Environmental Agency published a "dirty list" consisting of municipalities in which most illegal deforestation is occurring and an Internet site listing properties embargoed due to deforestation.

In addition, the 2008 resolution required that all farmers wishing to receive credit in the Amazon biome present documents (issued by the state environmental agencies) demonstrating compliance with Brazilian environmental legislation. Mato Grosso and Pará have begun to create rural environmental cadastres that register land for environmental compliance purposes, sidestepping the complex issue of regularizing ownership.

Finally, the Brazilian government has built on an existing cattle-tracking system to control the spread of hoof-and-mouth disease. Environmental compliance of landholders is now also tracked, incorporating the deforestation

monitoring system. The cattle-tracking system has been modified to track “lots” of animals rather than individuals. Throughout, the quasi-independent public prosecutor has been an important catalyst of action.

Deforestation has fallen steadily from 25,000 square kilometers in 2003 to 7,000 square kilometers in 2009; deforestation from September 2009 to February 2010 fell more than 50 percent relative to the same months in the previous year. It is too early to tell the degree to which this is due to enhanced enforcement versus a decline in beef and soy prices.

Conclusions

If the REDD agenda succeeds, countries, donors, and investors will put up massive funds in hopes of conserving forests and fostering sustainable land management in a socially acceptable way. Guidance is needed for these large, novel, and complex ventures, which will take many years to implement. Unfortunately, the Bank’s long experience in relevant areas is not well documented. However, some lessons emerge from this review.

Protected area creation has been effective, on average, in reducing deforestation. Creation of large protected areas in remote areas where deforestation is currently low has been a farsighted strategy that could reduce future deforestation as roads and markets expand. Evidence suggests that sustainable-use protected areas are compatible with reduced deforestation and that indigenous areas (at least in Latin America) are extremely effective in preventing deforestation. Together with recent findings that protected areas may reduce local poverty, this points to the compatibility of REDD with sustainable development and suggests greater attention on the maintenance and expansion of protected and sustainable use forest areas is necessary.

Payment for environmental services schemes could constitute one element of a REDD strategy, appropriate for

areas where land and forest tenure is well defined. Project experience shows that countries can manage the logistics of enrolling, monitoring, and paying service providers. Ensuring sustainable finance has been a problem, but REDD may solve this. More challenging is devising targeting mechanisms and payment schedules that are socially and politically acceptable as well as cost-effective in providing carbon storage and other environmental services.

Chain-of-custody tracing was an inefficient way to monitor environmental compliance: if trees are what you care about, it is cheaper to watch the forest than to follow the cows on their long journey to the market.

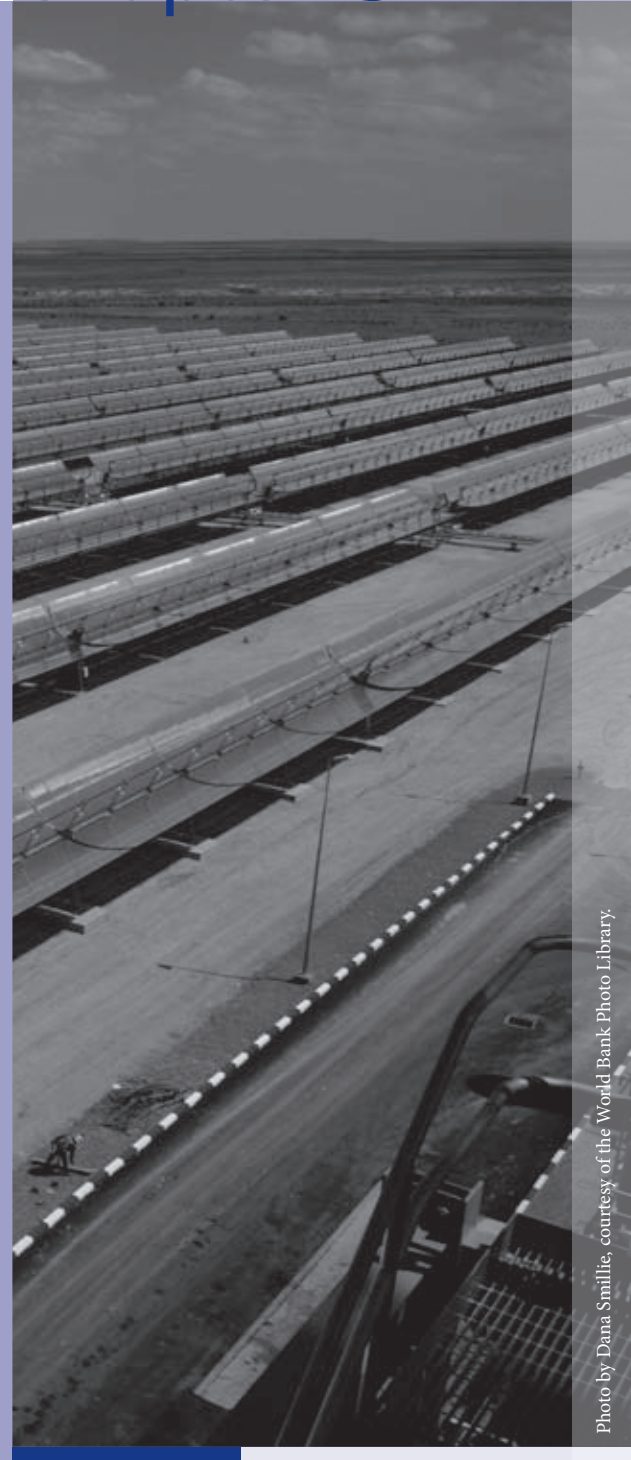
Promotion of sustainably intensified agriculture is the flip side of forest conservation. If more forest is to be conserved, farms, ranches and tree plantations must be intensified on existing, perhaps degraded lands, to meet the demand that is driving deforestation. Chain-of-custody certification of forest-competing products has been seen as a way of shifting private sector incentives to sustainability, without relying on often-ineffective government enforcement. But a private-sector-only strategy is also problematic, and that chain-of-custody tracing is difficult and expensive.

A combination of nongovernmental organization-triggered pressure on buyers, an independent governmental advocate for environmental enforcement, and government sanctions has been effective. A key technical feature has been the use of wide-area remote sensing rather than chain-of-custody tracing. If trees are the focus of conservation, it is cheaper to watch the forest than to follow the cows and beans on their long journey to market. This experience could have important implications for palm oil, timber, and other markets.

Chapter 5

EVALUATION HIGHLIGHTS

- Over 2003–08, almost all WBG support for coal has been in IBRD countries.
- WBG support for coal power had no impact on technology *choice*; in one case it may have accelerated *diffusion* of more efficient technology.
- Rehabilitation of old coal plants proved more difficult than anticipated.
- Technology transfer projects succeeded only when they planned well for demonstration, learning, and diffusion.
- Private recipients of technology transfer are reluctant to share technology with competitors.
- The World Bank's Carbon Finance Unit was important in catalyzing the emergence of the carbon market.
- The World Bank has largely not realized synergies between operations and carbon finance.
- A sequence of mostly unsuccessful GEF-financed, IFC-implemented projects has supported small-scale renewable energy enterprises.
- The Bank moved into pilot areas of the carbon market as planned, but did not exit established parts of the market.



Special Topics

WBG stakeholders are polarized about the organization's role in supporting coal-fired power plants. Coal is the most CO₂-polluting of fuels and a major contributor to climate change. Environmental nongovernmental organizations argue forcefully for the WBG to devote its resources and moral authority to finding alternatives. But some developing countries see no affordable alternative to power their aspirations for growth. Without the WBG's support for coal, "it is the cheaper, dirtier type of coal plants that will proliferate," argues its chief economist.¹

Efficiency in Coal-Fired Generation

In response, the SFDCC sets out criteria for WBG support for coal-based generation. The WBG can support client countries in developing new coal power projects if it contributes to energy security, reduced power shortages, or increased access; if it is least cost, taking environmental impacts into account; if it uses best "appropriate available technology"; and if no donor financing is available for lower-emission alternatives.

To assess the costs and benefits of the WBG's involvement with coal power, this chapter of the evaluation examines five of the six greenfield or rehabilitation coal power plants in the 2003–08 portfolio² and addresses the following questions:

- Were there alternatives that were both lower cost and less GHG intensive?
- Did WBG involvement improve efficiency or reduce pollution at the plant level?
- Does the intervention promote or retard diffusion of higher efficiency technologies?

Global context and the WBG's role in power sector finance

Barring revolutionary technological developments, coal will be in use through mid-century and beyond. International Energy Agency projections (OECD-IEA 2009) show that under a scenario where the world meets a stringent 450 ppm goal for atmospheric CO₂, coal will still provide 7,300 terawatt hours (TWh) in 2030 (24 percent of global generation), down from 8,200 TWh in 2007 (42 percent). Even in this 450 ppm scenario, coal generation in non-OECD countries will be higher in absolute terms in 2030 (5,608 TWh) than in 2007 (4,194 TWh). The Massachusetts Institute of Technology Future of Coal study (MIT 2007) projected that in an

active mitigation scenario, energy from coal over 2000–50 grows 12 percent in the United States, declines 11 percent in China, and grows about 30 percent elsewhere. Coal plants have a typical lifespan of 40 years, and many existing plants are decades old. Thus even stringent climate scenarios foresee new coal plants as part of the mix.

The WBG is too small to have a large direct impact on global power plant construction. New power plants (across all fuels) with 607 GW capacity became operational over 2003–08 in countries eligible for Bank borrowing (IDA/IBRD/Blend), but WBG-supported projects approved over the period contribute only 28 GW.³ Total 2003–08 WBG commitments of \$5,768 million constitute, as an order of magnitude, less than 1 percent of the cost of capacity installed in borrower countries over this period.

The WBG is too small to have a large direct impact on global power plant construction, but it has a significant role in new generation in the poorest countries.

The WBG does play a significant role in new generation in the poorest countries. New generation installed in IDA countries over 2003–08 was 21.8 GW, whereas new generation planned in these countries with some WBG involvement was 6.2 GW, or 29 percent. However, over 2003–08, WBG support for coal-fired generation was much more prominent outside IDA countries (figure 2.6).

Over 2003–08, almost all WBG support for coal has been outside IDA countries.

In sum, substantial developing world investment in coal appears to be inevitable over the coming half century.

Consequently, the efficiency with which new or renovated plants burn coal will affect global CO₂ emissions. The scale of that investment for non-IDA countries dwarfs the WBG's financial resources, so any significant WBG influence on coal investment or efficiency would have to be primarily via other channels, including policy, technical assistance, and demonstration effects.

Assessment of WBG support for five coal plants

In Turkey, the World Bank offered support for the rehabilitation of the Afsin-Elbistan A thermal power plant to remedy power supply shortages. The plant runs on lignite coal, which is plentiful in Turkey but CO₂ intensive. The plant's thermal efficiency fell from its design rate of 37 percent to 27 percent as a result of poor operations. Rehabilitation seemed an obvious, cost-effective way to boost power supply. One would expect CO₂ reduction as a side benefit, though this was not a project objective. However, this project was cancelled after two efforts at procurement failed to attract qualified bids, an indication that rehabilitation can be complicated.

Power generation from natural gas—a lower-carbon alternative—would have been economically competitive with the rehabilitation project, if planning had attached a shadow price to the local air pollution damages from coal use. A shadow price of \$5/ton of CO₂ would also have made gas cheaper; this may possibly be monetizable depending on Turkey's role in a future climate regime. However, energy security considerations might put a strong premium on diversification away from gas.

In Kosovo, IDA provided a grant totaling \$10.5 million in technical assistance to help bring in new investments in the energy sector and attract private investors to develop Kosovo's lignite mines and increase capacity for lignite-fired power generation. Kosovo's 11.5 billion ton reserve of easily accessible lignite constitutes one of this poor country's main assets, for both internal consumption and export as electricity. The technical assistance was broad, including an assessment of carbon mitigation options (including options to leave space for a carbon capture and storage plant) as well as policies for promoting renewable energy in the country. The economic analysis for the new plant included costs of decreased air quality from plant emissions of air pollutants. A systemwide analysis indicated that a new lignite-based plant in Kosovo is the least-cost option even

when carbon prices (or carbon credits) are of the order of €10/ton of CO₂.

MIGA has issued guarantees for the construction of a 660-MW lignite coal power plant in Bulgaria against risks of expropriation, war, and civil disturbance. The new plant is designed to meet European Union environmental standards and replaces 500 MW of older, more polluting capacity (MIGA 2008). MIGA claims that its support was essential for the project to mobilize long-term commercial bank financing. Alternative sources of power for Bulgaria include nuclear, which has lower conventional pollutants and would potentially allow Bulgaria to sell CO₂ allowances. Nuclear has, however, costs of debated magnitude, related to safety and waste disposal.

IFC invested \$8 million as equity in the 660-MW Lanco Amarkantak coal-based power plant project in Chhattisgarh, India. IFC's investment is a small portion of the overall cost of the project, which is expected to be about \$578 million. The financial closure for both units was achieved by September 2006—prior to IFC's approval of equity support in June 2007.

IFC's support played a marginal role in improving the social impact assessment from the power plant and improved the environmental design standards of the plant. The plant's design efficiency and GHG emissions are at business-as-usual levels, and IFC cannot be credited with supporting any technological improvements. The environmental impact analysis discusses the possibility of cofiring the plant with biomass, which would reduce net emissions. Given IFC's relatively small investment, it remains to be seen whether any of the proposed social and environmental improvements will be implemented.

In April 2008, the IFC Board approved a \$450 million debt investment in the Tata Mundra Ultra Mega Power Plant in Gujarat, India. The 4-GW project is IFC's largest coal-fired project and IFC's largest financing to date. The Indian government promoted the development of this plant as critical in meeting the power needs of a number of Indian states through transmission of power on regional and national grids. The plant is currently under construction.

IFC's support for this project probably resulted in improved design standards for environmental performance. IFC did not have a role in the technology choice, as the Indian government preselected the supercritical technology.

However, to the extent that the plant displaced subcritical coal plants, it may result in emissions reductions of about 10 percent—significant, but far less than the 40 percent differential relative to the existing coal fleet average that IFC cites in the project’s Environmental and Social Review.

It is likely that IFC’s funding was required for the plant to secure financing, and its successful closure has helped reduce doubts within the domestic banking industry about the viability of such large competitively bid projects. Thus it is plausible that the project may help catalyze the Indian power sector’s movement away from subcritical to more efficient supercritical technologies. This provides a clear demonstration of the WBG dilemma: the investment has supported what will be one of the largest point sources of CO₂ on the planet, but may well have reduced them incrementally compared to a scenario without IFC involvement.

Appendix tables E.1 and E.2 summarize the five cases.

The WBG had little direct impact on technology choice. Kosovo was the only case in which the WBG supported ex ante planning, but a definitive technology recommendation was not made. In the other cases, technology was largely or entirely predetermined by project sponsors before WBG involvement. Hence, the main potential channel of WBG involvement was through the decision on whether to support the project—and whether that decision was critical to the fate of the project. This was likely in the case of Tata Mundra and possible for Maritza. There was no impact in the cases of Lanco (which would have taken place anyway) or the Afsin-Elbistan A thermal power plant in Turkey.

The WBG has little direct impact on technology choices.

Did the WBG explore cost-effective alternatives to these plants? (All these plants were appraised before the SFDC. However, the IFC plants were subject to Performance Standard 3, which requires investigation of alternatives.) The best case is that of Kosovo. The Kosovo analysis and the related southeast Europe analyses explicitly considered damages from local air pollution and the systemwide impacts of a shadow price on CO₂.

Nonetheless, a recent World Bank study points to very low electricity tariffs in Kosovo, and high rates of nonpayment by customers, with the result that “35–60 percent of the total final energy consumption in households is technically or economically lost” (Renner and others 2009). Technical losses alone are estimated at 18 percent. So there could be cost-effective ways to reduce excess demand, in part through increased technical efficiency or by boosting prices and collections to financially sustainable levels. In the case of India, the government reports that overall transmis-

sion and distribution system losses are 27 percent (though lower in the areas served by the plant under construction). The scope for efficiency improvements in India appears to be large and likely insufficiently tapped.

Kosovo and southeast Europe analyses demonstrate an approach for considering damages from local air pollution and incorporating the shadow price of CO₂.

Do plant-level efficiency improvements, such as those arguably achieved in India, promote or undermine systemwide levels of energy intensity and CO₂ intensity? It is difficult to answer this question quantitatively, but the channels of impact can be sketched out and in some cases the level of impact indicated.

First, as seen in the case of the Indian power plant, WBG support could help reduce perceived risk of a new technology in a new setting, catalyzing its adoption and reducing CO₂ emissions against a business-as-usual scenario at some plants. Second, such support could in theory reduce the price of coal power relative to gas or hydropower. This could induce a country to shift, at the margin, to greater investment in coal, counteracting the new technology’s efficiency gains.

However, this risk appears to be implausible in the case of a shifts to supercritical, ultrasupercritical, or Integrated Gasification Combined Cycle coal technologies. These technologies save fuel costs relative to subcritical coal, but have higher capital costs and so, on balance, produce power at about the same cost. Promotion of these technologies would therefore be expected to reduce emissions but not to appreciably induce shifts from gas or hydropower to coal.

Most difficult to assess is the symbolic or leadership impact of the WBG in supporting or disengaging from coal power. However, there are analogies in other sectors. The WBG has supported global phase-out of leaded gasoline, prohibition of project support for tobacco, and phase-out of gas flaring and venting. The leaded gasoline phase-out has had considerable success. Tobacco and lead control offer large domestic benefits, facilitating acceptance of the WBG role. The gas flaring initiative also potentially offers domestic benefits and has nominal support from many country partners.

Does the WBG have a compelling role in support for making coal power plants more efficient? It is clear that “retail” WBG support makes little difference, one way or the other, to global generating capacity because of the vast scale involved. It is conceivable that such support might be essential to particular low-income countries with poor credit and no alternative power sources. It is conceivable also that support for regulatory changes or pilots that promote efficient coal

technologies could accelerate diffusion of those technologies within particular middle-income countries, possibly with high leverage in reducing CO₂ emissions. Recently approved World Bank projects to rehabilitate Chinese and Indian coal generators use this rationale.

Choices at the country level—whether financed by the WBG or not—would be illuminated by systemwide analyses of expansion options. Such assessments would consider efficiency options, assign costs to domestic pollution, and explore different shadow prices for CO₂. Such analyses would clearly show when there are no domestically affordable alternatives to coal power and would help to defuse controversy. This approach is consistent with that of the SFDCC, but with an emphasis of the additionality of WBG support in effecting poverty reduction or technology diffusion benefits.

Decisions about coal should use systemwide analyses that consider efficiency alternatives, local pollution costs, and shadow prices of CO₂.

Technology Promotion and Transfer

Great hopes are pinned on technology, a cornerstone of both the Bali Action Plan and the SFDCC. Developing countries hope not only to acquire hardware—such as wind turbines and solar panels—but also to gain the capability to manufacture and innovate, sparking industrial growth.

At the global level, new technologies are conventionally understood to follow a path from laboratory research, through piloting and technical demonstration, to commercial demonstration, and finally widespread deployment and diffusion, with continual improvements and innovations along the way. With increasing cumulative production, firms learn and costs decline, tracing a learning or experience curve. This reflects the solution of technical problems and the advantage of economies of scale (box 5.1).

At the global level, technology costs decline with increasing production.

There is debate about where to draw the line between public and private support and between coordination and competition. There is general agreement, however, that expensive basic research, such as that underpinning nuclear fusion, must be government supported. Public sponsorship of pilot or demonstration plants, with data provided to all in the industry, also makes sense as a public good. The existence of a declining cost curve suggests that there are increasing returns to concentrating resources in a few technologies—a “big push” could produce a competitive product. However, many worry that public sector groups are ill equipped to pick winners in this manner.

There is debate about where in the technology development cycle to draw the line between public and private support.

Similarly, there has been a vigorous debate about the role of intellectual property rights (IPRs) in energy and climate technologies. What is the proper balance between rewarding innovators and accelerating access to new ideas? A growing literature on this topic notes that patents, or even trade secrets, are only one facet of technology transfer and typically represent only a small proportion of energy technology costs. Possibly more important are transfer of tacit knowledge and learning by doing.

Complementing the *global* technology development cycle is the process through which technologies *diffuse across and within nations*. The WBG has been active in this technology transfer process. It encompasses *piloting*, where globally available technologies are tested against and adapted to local conditions; *demonstration*, to convince producers, investors, and users of the technology’s reliability and cost

BOX 5.1 Technology Learning (or Experience) Curves

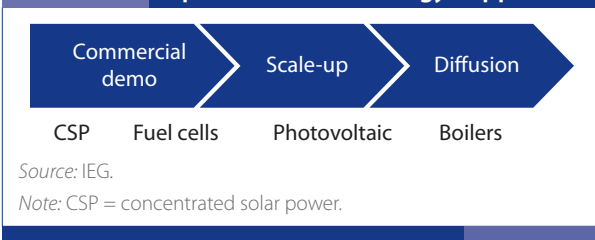
Many studies have shown that manufacturing costs decline with an industry’s cumulative production. The reasons include debugging and refinement of processes and economies of scale.

Learning rates are expressed as the percentage decline in unit costs with each doubling of cumulative industry production. According to a review by Neij (2008), learning rates in renewable energy range from 2.5 percent for geothermal and 5 percent for biofuel to 15 percent for wind and 20 percent for solar photovoltaics.

These statistical results are useful for summarizing experience, but they do not tell us *how* learning works. Costs can decline as a result of true learning as manufacturers tune their equipment and procedures, research and development, economies of scale, or increased competition among producers or component suppliers. The rate of cost decline is not predetermined, but can be influenced through these different channels.

Source: Neij 2008.

FIGURE 5.1 Spectrum of Technology Support



effectiveness; and *diffusion and scale-up*, to reduce local costs toward the global minimum and to help stimulate supply and demand.

WBG support for technology transfer can help reduce local costs towards global levels.

To bring concrete experience to these sometimes abstract debates, we review here some of the largest and most prominent examples of WBG support for energy technology promotion and transfer, across the spectrum from upstream to downstream. These are roughly depicted along an upstream-downstream spectrum in figure 5.1.

However, this evaluation uses the term “technology” to refer any kind of know-how or innovation that can advance development and GHG mitigation. For instance, ESCOs, chain-of-custody tracing of beef, and BRTs all qualify as technologies.

The concentrating solar power experience

In 1997, the GEF approved the first of four World Bank-executed projects designed to accelerate the diffusion of concentrated solar power (CSP). CSP, which uses focused sunlight to drive a steam turbine or heat engine, is attractive to the developing world. It can take advantage of high levels of insolation in arid and semi-arid areas such as northern Africa, the Middle East, western India, southern Africa, and northeastern Brazil. It is steadier than wind power, providing power throughout the day and even into the night, using molten salt to store heat. And it is based on relatively low-tech components—mirrors and pipes—potentially within the manufacturing capabilities of many developing countries.

An effort to accelerate concentrated solar power technology bogged down.

Yet this effort to accelerate technology bogged down. After 13 years, 2 of the projects are finally under construction, 1 is out for bid, and the last was cancelled. What are the lessons of that 13-year experience for WBG technology policy?

In 1996, the GEF’s Scientific and Technical Advisory Panel identified CSP as a promising target for technology promotion under the GEF’s new Operational Program 7 (OP7). At the time, although a subsidized CSP plant had been operating in the United States since the 1980s, no new plant had been constructed anywhere since 1991; the technology’s high cost was unsupportable, especially as electricity deregulation progressed. Support for CSP was in line with the goal of OP7, that “through learning and economies of scale, the leveled energy costs (of renewable technologies) will decline to commercially competitive levels” (GEF 2003).

In April 1997, the GEF approved a grant of \$47 million to India for a CSP project and subsequently approved requests for projects in Egypt, Mexico, and Morocco. The projects went to the Bank for development and execution. The India project was dropped; the others proceeded slowly.

A fundamental source of project delay was a mismatch between project goals and design. The projects’ intent was to drive the technology down the learning curve. However, the total planned capacity of 120 MW was only a fraction of the amount needed to yield real cost reductions. Moreover, a learning goal would have been more efficiently served by clustering the plants in the same country or region. This would have allowed manufacturers and developers to more easily assemble the necessary skills and build manufacturing for components in large quantity locally—activities that can help drive costs down more quickly.

Project delays were in part due to mismatch between project goals and design.

From the host countries’ viewpoint, these plants were an unproven and potentially unreliable source of power. To address host countries’ concerns about power reliability, the plants were designed as hybrids, incorporating much larger gas-fired generators. This greatly complicated project design and procurement. In India, it proved economically infeasible to build a gas pipeline to the project, which was dropped.

Bidding the hybrids was problematic. An integrated approach to project contracting carried the risk that there would be little competition or that contractors would be unwilling to guarantee performance of the novel system. The alternative approach—separate contracts for gas, solar, and for systems integration—is complex to manage and could lead to disputes in the case of poor performance. Both approaches have now been employed. A retrospective on this experience, when complete, could provide useful guidance for future WBG work on integrated systems—for instance, in potential work on carbon capture and storage.

A second issue, inherent to any advanced technology project, has to do with cost uncertainty and paucity of suppliers. When a technology is new, there will be few experienced suppliers, and cost information will be uncertain and closely held by those few. In the case of the GEF-Bank CSP projects, initial cost estimates were grossly underestimated. Actual bids came in well above the estimates, but the GEF grant amounts were already fixed. Hence the size of the CSP plants had to be scaled back, a process that incurred renegotiation and delay. In addition, procurement staff had to wrestle with the problem of few qualified bidders. Although procurement rules exist for this circumstance, its relative novelty led to a cautious and protracted process.

A further obstacle was the Bank's initial insistence that the CSP plants be operated by private sector independent power producers (IPPs). There was great enthusiasm for IPPs in the Bank at the time, but they were not present in the CSP host countries even for traditional power plants. The IPP requirement thus complicated a technological innovation by overlaying an institutional one. Moreover, the IPP approach held no attractions for the state utilities, whose cooperation was essential.

During the long gestation period of the three surviving projects, much changed at GEF and in the power industry at large. Disenchanted with OP7, the GEF eliminated it. Meanwhile, CSP experienced a renaissance, driven by a Spanish policy of generous feed-in tariffs and renewed interest in the United States. (The GEF projects, according to some industry observers, may have helped maintain interest in CSP in the meantime.) Costs appear to have declined, and several different technologies became available.

Buoyed by these changes and the advent of the Clean Technology Fund, and subjected to vigorous external criticism for prioritizing coal over CSP, the WBG is planning a \$750 million investment in a \$5.6 billion, 900-MW set of CSP projects in Algeria, Egypt, Morocco, Jordan, and Tunisia. A project is also planned for South Africa. Unlike the modest original investment, these new projects would potentially increase cumulative global capacity by a significant proportion and would be geographically concentrated. So there is a greater potential for advancing the global learning curve. The imminent completion of the CSP projects in Morocco and Egypt may help inspire interest in and support for the wider new venture.

China Efficient Industrial Boiler Project

In the early 1990s, GEF-funded World Bank-Chinese analysis (NEPA and others 1994) found that industrial boilers consumed 350 million tons of coal annually (more than the power sector) and accounted for 30 percent of China's energy-related CO₂ emissions. The boilers were also responsible for a large proportion of health-damaging urban

air pollution and crop-damaging acid rain. The report suggested that better boiler designs could yield 10–20 percent efficiency gains.

Consequently, a 1997 GEF-funded, Bank-executed project sought to spur Chinese capacity to build efficient industrial boilers, complementing government efficiency policies. The project's objectives were to reduce GHG emissions and local air pollution through the development and deployment of "affordable, energy-efficient and cleaner" boilers through design and policy reform. Most of the \$32 million grant was spent on acquiring technology (IPRs) for new or upgraded boiler designs and auxiliary equipment (such as grates) and transferring the technology to domestic manufacturers.

Procurement was protracted and difficult because few companies were interested in selling the technology.

Two problems were encountered during implementation. Both related to the project's strategy of picking winners, that is, precisely specifying the boiler types to be transferred. First, procurement was protracted and difficult. A combination of small contracts, tightly specified technologies, and a two-step (technical/financial) bidding process, together with concerns about IPR security, deterred participation by foreign technology suppliers. Only one package had multiple bidders, and two had none. Then, "once contracts were awarded, contract negotiations proved difficult in some cases, due to difficulties in meeting commercial terms and performance criteria using Chinese coals. Coupled with misunderstandings concerning Chinese and international contracting procedures, all of these factors contributed to delays in finalizing technology transfer contracts" (World Bank 2004). This process delayed implementation by at least two years. Meanwhile, evolving environmental regulations banned the deployment of some of the smaller boilers selected for the project.

The project concluded in 2004. A follow-up survey commissioned for this evaluation found that the beneficiary companies produced a total of 7,414 tons per hour of new boilers in 2009, accounting for 3.3 percent of the national market against an anticipated 35 percent.

A 1997 project transferred technology licenses for efficient industrial boilers to Chinese manufacturers.

Firms had divergent experiences. Two companies were highly successful in producing and marketing the new boilers. These well-run companies invested in their own research and development, improving the designs and keeping costs nearly competitive with the older, less-efficient

boilers. They also launched effective marketing campaigns. In contrast, the other six companies abandoned or deemphasized the new boilers, for a variety of reasons. They were less able to keep costs down, and customers were not willing to pay a 20 percent premium for the new boilers, being distrustful of the promised three-year payback. As noted, the markets were increasingly restricted by environmental rules. And finally, some companies found more lucrative markets, such as waste heat recovery, in a rapidly changing market.

Two successful technology recipients improved the designs and reduced costs; six others abandoned or deemphasized the boilers.

At appraisal, the project's intention was that "[t]echnologies that are proven to be technically and commercially successful will be disseminated to other boiler producers in China" (World Bank 1996), a key avenue of technology diffusion. However, an IEG survey found that none of the manufacturers deliberately licensed or retransferred their technologies to other firms, fearing competition. The most successful firm reported the existence of unauthorized copies of their designs, so some informal diffusion may have occurred, but the quantity and efficiency of the copies are not known.

Data are lacking on the performance of the auxiliary equipment manufacturers. However, one of the grate manufacturers has been successful, because the new grates are not much more expensive than traditional ones but offer significant fuel savings.

None of the manufacturers licensed or retransferred their technologies to other firms, limiting the overall impact.

Meanwhile, the government has imposed new mandatory standards for boilers, effective 2010, that are somewhat less stringent than the boiler project's design standards.

Renewable Energy Development Project

The Chinese REDP (1999–2008) provides an interesting counterpoint to the Efficient Boiler Project. Another large technology transfer project, REDP emphasized support for domestic research and development and manufacturing competence rather than licensing of foreign IPRs. With \$40 million from an IBRD loan and a GEF grant, the project focused primarily on establishing a sustainable market for rural solar home systems (SHS). It aimed to do so by overcoming barriers to commercialization: inexperience of local manufacturers, poor quality products, and high market prices.

REDP spurred manufacturer capabilities through quality-contingent output subsidies.

REDP used a combination of technical assistance, incentives, and subsidies to boost the capabilities of the small-scale SHS manufacturers. SHS manufacture is a relatively low-tech assembly business carried out in small workshops. A nascent industry already existed, including spin-offs of a former government research institute in Xining. But manufacturing costs were high and SHS reliability low.

REDP offered a \$1.50/Wp subsidy for manufacturing, contingent on meeting quality standards including component quality. To help companies meet those standards, it provided partial funding for company proposals to improve financial management, quality control, and marketing practices, and to adapt and develop technologies. The technologies involved were modest but crucial. For instance, some companies developed improved charge controllers—the apparatus that prevents batteries from being overcharged and is thus essential for SHS life and performance. These were adapted to operating conditions typical of the high plateaus where customers lived.

The project resulted in lower costs for larger systems, growth of firms in size and competence, and improved technology.

The combination of financing, incentives, and technical assistance was effective.

- *SHS costs declined for larger systems.* The project improved firms' quality control, reducing wastage; may have contributed to greater scale economies at the firm level; and reduced mark-ups as competition increased.
- *Firms grew.* Employment in monitored companies more than doubled over 2002–07, and sales increased 363 percent.
- *Firms became more competent, and quality improved.* All but two of the 17 participating firms received ISO 9001 certification. Seventy-four component suppliers were REDP certified.
- *Technology improved.* The technology improvement program supported 197 proposals, with an average grant of \$17,500. The project reported that among 81 audited projects, 95 percent achieved their objectives.

As in the case of the Efficient Boiler Project, project-supported technologies became proprietary and were not shared among companies. This might spur technological competition but may sacrifice opportunities for industry-wide advancement. The REDP model is now being applied to the more expensive and technologically sophisticated

goal of promoting wind turbine improvements, under the China Renewable Energy Scale-Up Project.

IFC support for technology transfer and deployment

Over the past 15 years, IFC has mounted a number of initiatives to invest equity, technical assistance, or both in start-up or early-stage clean technology ventures. Mostly funded by the GEF, these initiatives have targeted both precommercial and commercial technologies. These high-risk ventures have fit uneasily within IFC's generally conservative, risk-averse culture and indeed many have had a disappointing record.

A sequence of mostly unsuccessful projects, financed by GEF and implemented by IFC, has supported high-risk, small-scale renewable energy enterprises.

A sequence of mostly unsuccessful GEF-financed projects has supported small-scale renewable energy enterprises. These include the following:

- *The IFC-GEF Small and Medium Enterprise Program.* In 1995, a \$20 million initiative funded by GEF to increase the markets of SMEs in the areas of climate change mitigation. The program provided loans of \$500,000 to \$1 million to various intermediaries and private companies for on-lending to SMEs. Though the program was not designed specifically to target the solar photovoltaic sector, it included six solar photovoltaic-related investments. Although solar photovoltaic proved to be too risky for most financial intermediaries, the SME program was able to place funds in other technologies and sectors.
- *Renewable Energy and Energy Efficiency Fund.* In 1997, this fund was designed to place equity and debt investments in projects using renewable energy and energy efficiency technologies. But it had difficulty developing a project pipeline, failing to meet modest targets. Developed as a consortium, the division of responsibility among participant companies was unclear. Having made only one investment, the project was restructured in 2006 and folded into the Sustainable Energy Facility (see below).
- *Photovoltaic Market Transformation Initiative.* In 1998, IFC launched the \$30 million Photovoltaic Market Transformation Initiative to provide concessional finance and grants. The program was designed to accelerate the sustainable commercialization and financial viability of solar photovoltaic technology in India, Kenya, and Morocco. Early Initiative efforts took too long to materialize and required extensive documentation that proved to be too burdensome for small investments. In addition, the photovoltaic SMEs were operating with thin margins. The project was restructured in 2004 and aimed at industry-level rather than project-level capacity building. Results have been poor in Kenya and Morocco (IFC 2007). In India, the



emphasis has shifted from SHSs to support for manufacturing of solar modules.

- In 2001, IFC loaned \$1 million to a private company to invest in sustainable energy SMEs, especially those that offered electricity to unelectrified households, provided back-up energy sources to companies, or lacked access to financing and technical advice. The company fully disbursed the \$1 million loan to eight sustainable energy SMEs in Latin America and Africa to finance investments in fixed assets and working capital. Projects funded include solar water heaters, photovoltaic power, natural gas power, hydropower, and energy efficiency improvements.
- *The Solar Development Group,* a \$41 million initiative funded by IFC and GEF, was initiated in 1999 with the goal of increasing the delivery of SHS to rural households in developing countries. The group was comprised of two separate entities: Solar Development Capital, a private equity fund for private solar photovoltaic and solar photovoltaic-related businesses, and the Solar Development Foundation, a nonprofit entity that provided grants for business development assistance. The Foundation raised \$12 million and disbursed \$2.2 million in technical assistance to 63 projects. Solar Development Capital disbursed only \$660,000 and was liquidated (IFC 2007). Overall, the project did little to meet the objective of accelerating the growth of solar photovoltaic installations and closed in 2004.
- *Environmental Opportunities Facility.* In 2002, IFC established this facility to provide catalytic funding for innovative ventures with the potential to increase environmental sustainability and the need to overcome

significant barriers, such as entering new markets and applying new technologies and new business models. The facility provided technical assistance grants and investment funding to projects with significant environmental benefits or projects that led to cleaner production. As of 2009, only 4 projects have been committed, and 25 received technical assistance grants. High cost, low buy-in from bilateral donors, unfocused strategy, and resource limitations led to under achievements in placing funds. As a pilot facility, the program aimed to demonstrate the viability of early-stage cleaner production projects. However, case studies and dissemination workshops appear to have had little impact on technology diffusion.

- *Sustainable Energy Facility with E&Co.* In 2005, IFC established the Sustainable Energy Facility Project. The project consists of \$14 million of investment capital and up to an additional \$ 2.6 million for technical assistance and capacity building. Based on a mid-term self-evaluation, this facility appears to have learned the lessons of its predecessors, incorporating greater flexibility in technology and attention to making sure products are demanded by markets. Like some of its predecessors it combines technical assistance and investment, taking a quasi-venture capital approach.

One of IFC's furthest ventures into upstream technologies is its GEF-supported Fuel Cell Initiative, initiated in 2001. The pilot phase was expected to support three companies with different fuel cell technologies and help increase their supply of fuel cells, reduce their manufacturing and installation costs, and demonstrate the viability of the technology. The target market was backup and remote-location power for telecom companies. The program was supposed to close in December 2008, but to date only about 85 systems have been installed, against a target of 400. There was no demand for the remote-location fuel cell.

In sum, IFC's GEF-funded projects seem to have suffered from a persistent set of design flaws. They have often supported companies with the double handicap of inexperienced management and technology that is not locally familiar. They have supported products that are too advanced or expensive for the target market. And they have sometimes presumed overoptimistically that providing technology to specific firms would lead to spontaneous diffusion of that technology.

IFC's GEF projects have suffered from persistent design flaws.

There are, however, indications of a fresh approach that recognizes these past shortcomings. A new initiative on early-stage clean-tech venture capital is led by staff who were involved in IFC's high-risk but ultimately high-return investments in African telecom. The new approach seeks to support experienced management in adopting technologies

that are proven elsewhere in the world; it is prepared to take some risks for prospectively high returns. At the same time, an investment in one of the developing world's first large grid-connected solar photovoltaic power plants also stresses working with a well-qualified company, and the project provides for the construction of a "knowledge platform" to share project results.

A fresh approach emphasizes transfer of well-proven technologies and creation of knowledge platforms to share results.

Demonstration and piloting in recent low-carbon energy projects

Technology transfer can occur through piloting and demonstration. Existing technologies face new challenges when put in a new context. For instance, biomass technologies may require technical, logistical, contractual, and regulatory adjustments to adapt to a novel location with untried feedstock. An effective pilot project will have a coherent logical framework for demonstration. So, for instance, if the goal was to demonstrate the technical and financial viability of a biomass technology so as to induce spontaneous replication, the project should specify the technical and financial indicators that will be collected at the plant level, the target audience, how the results will be communicated, and how uptake of the technology will be tracked.

Recently initiated pilot projects had good plans for monitoring internal project outcomes.

To gauge the extent and practice of such projects, IEG did a desk survey of low-carbon energy projects over 2007–09 for this evaluation. It found 21 projects that contained either pilot or demonstration in their project objectives, with total commitments of roughly \$1.4 billion (see table H.1). Eleven of these projects were GEF supported; eight had solely GEF support. Nearly all project designs contained good plans for monitoring internal project outcomes, but only eight projects displayed a strong logical framework for demonstration; few project designs contained any measurement of external demonstration effects. Although the three carbon finance project designs included excellent internal outcome measures (through the CDM), they lacked a coherent mechanism for demonstration and contained no measurement of demonstration impacts.

Only 8 of 21 projects had strong logical frameworks for demonstration, and few contained any measurement of external demonstration effects.

Conclusions

The WBG's efforts to promote technologies have often foundered. There is a recurrent set of factors in these failures:

- The projects often did not set out a clear logical framework linking interventions to technological progress. Efforts to support upstream technologies have been far too small by themselves to advance those technologies along a global learning curve.
- New technologies inherently have few suppliers and poorly known costs. The World Bank's procurement system is not well adapted for these situations.
- A combination of inexperienced entrepreneurs and unfamiliar technology constitutes a double set of hurdles. REDP, however, shows that it is possible to address both challenges.
- "Demonstration" projects fail if private companies, understandably, want to keep technologies proprietary.

Successful projects, in contrast, planned well for demonstration, learning, and diffusion. REDP supported technological progress in many competing firms, stimulating the industry's growth. The Energy Conservation Project introduced the institutional technology of energy performance contracting and arranged for beneficiary firms to participate in demonstration, while they adapted the practice to local conditions. It also disseminated 75 specific techniques for industrial energy conservation.

The Regional Silvopastoral Project rigorously documented and publicized its achievements in boosting farm productivity and sustainability, which facilitated scale-up. There are signs that some of these lessons are being incorporated in new efforts. The GEF Evaluation Office cites a United Nations Development Programme energy efficiency project that was carefully designed for replication and successfully did that (NCSTE 2009).

Successful projects planned well for demonstration, learning, and diffusion.

Technology transfer projects face a number of barriers and disincentives. Smaller (more pilot-like) projects may have disproportionately high costs of preparing and supervising, including effective design and monitoring of diffusion impacts. Borrowers—and country directors—may perceive (correctly or not) that these projects are risky. Projects that involve less-commercial technologies may run into procurement issues beyond the expertise of most staff. Projects may also involve complex issues of intellectual property rights.

Should the WBG support the development of technologies proprietary to individual companies? Under what circumstances should publicly supported technologies be provided open source, as a public good, to an entire industry?

Technology transfer projects face a number of barriers and disincentives.

Addressing these barriers requires a host of instruments. The prominence of GEF and donor funding points to concessional funds as one way to overcome borrower risk aversion and to support higher preparation and supervision costs. Staff and management incentives need to be addressed—at the very least, by ensuring that pilot and demonstration projects are assessed as pilots, with recognition of the benefit of informative "failures." The WBG should consider setting up a physical or virtual technology unit as a resource for project teams. The unit could provide advice on procurement, IPRs, diffusion mechanisms, and monitoring. It could also advise on the advantages and risks of engaging with less-mature technologies.

The WBG should be cautious about trying to advance technologies at the global level. It has little direct experience with upstream technology development. There is, however, an a priori argument for research and development support for technologies that reduce poverty and are easy to replicate—meaning that there is little private sector interest in them. These might include, for instance, farming techniques such as biochar (which increase soil fertility and sequester carbon), improved cookstoves, and techniques for reducing urban heat island effects.

To make a global difference at the scale-up stage—push a technology down the cost curve at the global level—the scale of intervention needs to be large relative to cumulative global production. For instance, WBG and Clean Technology Fund resources are large enough, if leveraged, to significantly increase the global capacity of CSP but are small compared to the global investment needed to advance carbon capture and storage. And such efforts require weighing the relative merits of a purely country-based approach with one based on global procurement. For example, there are potential advantages and disadvantages of a single global tender for CSP plants (resulting in a standardized design, with economies of scale and competition) versus a series of separate smaller tenders in different countries (developing more technology paths, but not moving far along each one).

These choices involve some degree of "picking winners," which requires balancing risks against rewards. If the WBG gets involved in these activities, it needs to develop (or coordinate with others) a clear technology map with goals and exit criteria.

Carbon Finance at the WBG

The UNFCCC, to which virtually all countries subscribe, has the goal of stabilizing atmospheric GHGs to head off dangerous climate impacts. The carbon market, a creation

of the Kyoto Protocol, is supposed to reduce the cost of achieving that goal, making it easier for countries to agree on what to do and how to pay for it. It does this by requiring developed countries to limit their emissions, but allowing them to meet that limit by paying to reduce emissions (buying carbon credits) abroad rather than at home. Developing countries face no caps but can sell carbon offsets—reductions of emissions compared with emission levels from doing business as usual.

There are cheaper opportunities to reduce emissions in transition and developing countries than in developed ones.

The carbon market, inspired by successful market-based schemes to reduce acid rain, was attractive for several reasons. The atmosphere does not care where the CO₂ comes from—the impact on climate change is the same. Compared with developed countries, transition and developing countries have cheaper opportunities to reduce emissions, the former through replacing a legacy of energy-wasting infrastructure and industry and the latter by installing efficient

new equipment to meet rapidly growing energy demands. The carbon market can provide money and technology for developing country infrastructure. Because carbon credits are a priced commodity, developing countries can realize profits if they can produce them cheaply. Having a price on carbon emissions may motivate research and development for low-carbon technologies. Finally, some view the carbon market as a more reliable means of raising funds from developed countries (which are historically responsible for current levels of GHGs) than the competing alternative: direct annual appropriations from those countries' individual national budgets.

In contrast, the carbon market faces significant practical obstacles. The logic of the system requires that emissions reductions must represent a new, additional effort so that the developed country's extra emissions are exactly offset by reductions elsewhere. Otherwise, buyers and sellers might collude and claim bogus carbon credits, and total emissions would increase. To prevent this, an elaborate project-by-project validation system has been set up under the auspices of the CDM to certify the additionality of carbon credits (box 5.2).

BOX 5.2 Carbon Offsets—A Peculiar Commodity

Carbon offsets are a peculiar commodity. They are defined as the difference between the number of tons of GHG you emit and the number of tons you would have emitted had you not been paid not to emit them. In an idealized example, the offer of carbon payments might induce a utility to build a geothermal power plant (with no emissions) rather than a cheaper diesel plant (which would have emitted 100,000 tons per year). The offset would then be 100,000 tons per year.

Actual emissions can be measured with instruments, but quantifying counterfactual, business-as-usual emissions is difficult. Both sellers and buyers have an incentive to claim offsets for a project that they were going to do anyway—projects that are not “additional.” But if many people did this, then these bogus offsets would be used by purchasers to increase their emissions above agreed limits, frustrating the goal of the Kyoto Protocol.

This is the heart of the additionality dilemma. The CDM has set up an elaborate system for determining additionality for each proposed project. The project proponent must argue that carbon funding is critical to project bankability or helps to overcome other kinds of barriers. Methodologies for demonstrating additionality are developed at some cost by the first people to undertake a specific kind of project. Then, if approved by the CDM, that methodology is available to others, accelerating project approval. The CDM uses private third-party verifiers to validate additionality claims and to verify annual reports of emissions reductions.

In sum, the carbon offset commodity is in effect an impact evaluation, and an elaborate institutional mechanism has been set up to conduct that evaluation. Few other development projects attract the same degree of scrutiny on impacts.

However, the additionality screening process has been widely criticized as ponderous, costly, and ineffective. Environmentalists press for stricter screening, investors for more streamlined procedures. The current system may combine the worst of both worlds: high transaction cost with substantial nonadditionality. A growing consensus views determination of additionality as quixotic at the project level. An alternative would be to set up technology-specific crediting rules, creating a system akin to a feed-in tariff premium for renewable energy or energy efficiency, with higher credits for less-competitive technologies.

Source: IEG.

TABLE 5.1 Carbon Funds at the World Bank

Fund	Year established	Currency	Capital	% Private
Kyoto Funds				
Prototype Carbon Fund	2000	\$	219.80	57.6
Danish Carbon Fund	2005	€	90.00	78.0
Community Development Carbon Fund	2003	\$	128.60	45.1
Spanish Carbon Fund Tranche 1/Tranche 2	2005/2008	€	220/70	22.7
BioCarbon Fund Tranche 1	2004	\$	53.80	51.0
Umbrella Carbon Facility	2006	€	799.1 ^a	75.0
Netherlands CDM Facility	2002	\$	—	0.0
BioCarbon Fund Tranche 2	2007	\$	38.10	47.0
Netherlands European Carbon Facility	2004	\$	—	0.0
Carbon Fund for Europe	2007	€	50.00	20.0
Italian Carbon Fund	2004	\$	155.60	30.2
New facilities				
Forest Carbon Partnership Facility	2008	\$	155.00	3.2
Carbon Partnership Facility				

Source: World Bank data.

Note: — = not publicly available.

a. Includes €224.54 million total participation of Prototype Carbon Fund, Netherlands CDM Facility, Italian Carbon Fund, Danish Carbon Fund, and Spanish Carbon Fund.

Carbon funds at the WBG

The World Bank carbon funds were conceived when the Kyoto Protocol was under discussion and the concept of carbon markets was being explored. The WBG's carbon funds were intended as a “proof of concept” for the carbon market and as a pilot device for testing practical approaches to the novel challenges of defining, creating, and trading the carbon commodity, and integrating it with development goals. Building on a precursor program, Activities Implemented Jointly, the Bank began consultations on carbon in 1997. The first carbon fund was approved in 1999 and launched in 2000. It was followed by several more (table 5.1).

By May 2010, the World Bank's Carbon Finance Unit (CFU) had \$2.358 billion under management and signed purchase agreements for a total of 228 million tons of CO₂ of carbon credits, with total value of \$1.84 billion (implying an average price of \$8.07 per ton). Pipeline projects represented, notionally, an additional 53 million tons worth \$208 million. However, not all tons may be delivered before Kyoto-driven carbon market provisions expire in 2012;

In May 2010, the World Bank's Carbon Finance Unit had \$2.358 billion under management and purchase agreements for carbon credits worth \$1.84 billion.

the carbon funds allow for some post-2012 purchase, but the market is limited.⁴

Since 2002, IFC has managed carbon funds on behalf of the Netherlands government. The funds have contracted to buy \$135 million in carbon credits from more than 40 projects. In addition, IFC has marketed a carbon delivery guarantee, booking guarantees for 2.2 million certified emission reductions (CERs) in three projects.

MIGA insured a landfill gas project against breach of contract, including governmental failure to honor the CDM-related Letter of Approval. There has been no a replication of this CDM-related insurance provision to date.

Goals and operation of the funds

The World Bank carbon funds are trust funds managed by the Bank's CFU. The participants are developed countries and companies seeking to acquire carbon credits to fulfill their obligations under the Kyoto Protocol. The CFU solicits carbon project proposals from the general public and writes purchase agreements for selected projects' emissions reductions. Typically it pays for offsets on delivery, with limited up-front payments.

The CFU and its operations are entirely funded by the participants, rather than through the Bank's own budget. Although CFU staff act as “deal managers,” the CFU engages regional Bank staff for project preparation. The CFU has grown large, with 68 staff and 72 consultants.

Catalytic or demonstration impacts were stressed in the publicly stated goals of the Prototype Carbon Fund.

Catalytic or demonstration impacts were stressed in the publicly stated goals of the Prototype Carbon Fund (PCF) (World Bank 2001):

1. Show how project-based greenhouse gas emission reduction transactions can promote and contribute to sustainable development and lower the cost of compliance with the Kyoto Protocol.
2. Provide the parties to the UNFCCC, the private sector, and other interested parties with an opportunity to learn by doing in the development of policies, rules, and business processes for the achievement of emission reductions under Joint Implementation and the CDM.
3. Demonstrate how the World Bank can work in partnership with the public and private sector to mobilize new resources for its borrowing member countries while it addresses global environmental problems through market-based mechanisms.

In 2005, the Bank's Board endorsed a revised approach to carbon finance, with three general objectives:

- “To ensure that carbon finance contributes to sustainable development
- To assist in building, sustaining, and expanding the international market for carbon emission reductions
- To further strengthen the capacity of developing countries to benefit from the emerging market for emission reduction credits” (World Bank 2006).

In 2005, the Bank Board endorsed a revised approach that articulated more specific goals for the CFU.

In addition, there were specific goals:

- Continue to align carbon finance more closely with poverty alleviation and locally sustainable development, ensuring that smaller, poorer countries benefit from carbon market development.
- Expand the technology frontiers of the carbon market to ensure that carbon finance and carbon trade support energy infrastructure and technology transfer.
- Expand the Bank's role in helping developing countries develop and market portfolios of carbon assets directly to OECD buyers, as a “lead buyer” that helps develop a project but purchases only a fraction of its emission reductions.

- Ensure that there is a value added from carbon purchase, for instance, through the application of Bank safeguards.
- Achieve greater integration of carbon finance into the mainstream of Bank lending operations.
- Reach out to other international finance institutions and entities.
- Improve pipeline of carbon finance projects.

Inherent tensions among the various strategic and fiduciary goals have been resolved in part through differentiation of funds.

In addition to these overarching goals, the CFU wanted to fully use its funds on behalf of participants, to support sustainable development in client countries, and to ensure an equitable division of benefits between participants and host countries.

There are inherent tensions among the various strategic and fiduciary goals:

- *Demonstration versus volume.* Demonstration or pilot projects tend to be risky and demanding in preparation. Under UNFCCC regulations, first-of-a-kind projects require large fixed costs in methodology development. If, as is likely, these demonstration projects are small, the preparation cost per ton of CO₂ will be high. So there is a trade-off between demonstration (which benefits a global community) and maximization of carbon credits (which benefits fund participants and recipient projects).
- *Established versus less-established country locations.* This is the same kind of trade-off. “Frontier” projects in countries with less CDM experience are costlier to prepare but promote the geographic growth of the carbon market to poorer countries.
- *Stringent versus less-stringent additionality determination.* As was recognized from the outset of the CDM, both buyers and sellers benefit from lax baselines—that is, funding of projects that are not really additional. But additionality is difficult to determine, and screening for additionality has led to burdensome bureaucratic procedures. So for the CFU there is a potential tension between setting high standards for additionality demonstration and maximizing carbon credit transaction volumes.
- *High versus low CO₂ price; agent of buyers or sellers.* In the early years of the PCF, the carbon market was very thin or nonexistent. Without an objective means of price discovery, determination of a “fair” price was a challenge for the PCF.

These conflicting pressures were resolved in part through differentiation of funds. The PCF was launched as a

demonstration initiative. The Community Development Carbon Fund and the BioCarbon Fund have strong, explicit demonstration goals. The other Kyoto Funds are strongly oriented toward helping developed countries secure carbon credits for compliance purpose. The newer initiatives, the Carbon Partnership Facility and Forest Carbon Partnership Facility, return to the pioneering mode in seeking to demonstrate novel kinds of carbon transactions not yet recognized under Kyoto.

The new facilities also feature equal representation of donor and host countries in fund governance. In contrast, earlier funds were governed by a committee of the participants (donors), though in consultation with host countries.

Catalytic impact on the carbon market

The CFU played an important role in catalyzing the emergence of the market. Although there had been earlier carbon transactions (including Costa Rica's pioneering sale of forest carbon credits), observers point to the PCF's early mobilization of funds and private sector investors as galvanizing the realization that carbon markets were workable. The PCF invested heavily in developing monitoring and verification tools and in the legal apparatus for transacting offsets, which were diffused among practitioners in the emerging market.

The CFU was important in catalyzing the emergence of the carbon market and active in developing methodologies for carbon offset measurement.

The CFU was active in developing methodologies for carbon offset measurement, though not uniquely so. As noted in box 5.2, development of a validation methodology is a kind of public good: it cuts the development time, risk, and cost for all subsequent projects that use the same technology. In the first five rounds of the CDM's Methodological Panel, the WBG was responsible for 12 of the 44 submitted methodologies and for 6 of the 22 that were approved.

Altogether, for large scale energy and transport technologies, the CFU has been involved in the preparation of 45 methodologies, of which 16 were eventually approved. Those methodologies have been used so far in registered energy and transport projects that are expected to produce 137 million tons CO₂e, or about 10 percent of the CDM total for these categories. The CFU has also proposed most of the accepted forestry methodologies, though there have been few other users of these and many small-scale methodologies. Current work on the Forest Carbon Partnership Facility and Carbon Partnership Facility aims at facilitating the development of radically new approaches to the carbon market that work at scales much larger than site-specific projects.

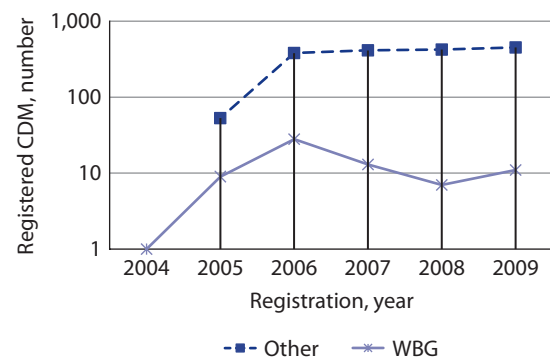
From the beginning, there was concern about whether the Bank's carbon funds would spur private sector participation or crowd it out—especially given the Bank's perceived clout. UNFCCC statistics show that, using registered projects or tons as a measure, the Bank's market share rapidly dwindled (figure 5.2). There was a surge of project registrations when the Kyoto Protocol came into force in 2005, so that by 2005 the World Bank comprised only a small share of the market. That being so, one could question the relevance of the 2005 goal of helping countries to market carbon credits, as a vibrant market was already emerging at the time.

The World Bank's market share of CDM projects dwindled rapidly over time as a vibrant market emerged.

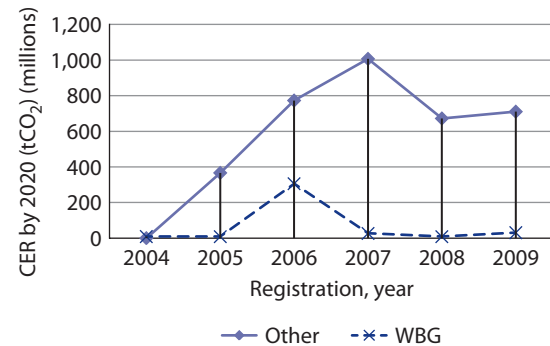
One way to assess the CFU's demonstration effect on additionality is to compare its relative success in securing CDM registration. Registration is a measure of a project's quality, including its stringency in determining additionality. The CFU's ratio of problematic to registered projects is smaller than that of the CDM at large (table 5.2).

FIGURE 5.2 World Bank Share of CDM Projects and Tons Registered

Panel A. Registered projects (log scale)



Panel B: CERs registered



Source: Calculated by IEG based on IGES Oct 2009, IGES as of October 2009.

Note: CDM = Clean Development Mechanism; CER = certified emission reduction.

TABLE 5.2 Comparative Success at Registration of CDM Projects, WBG versus Other Sponsors and Purchasers

	WBG	Other
Registered projects, Oct 2009	69	1,765
Ratio of rejected to registered	0	0.07
Ratio of validation negative, terminated or withdrawn to registered	0.26	0.34
Ratio of in process to registered	0.65	1.58

Source: IEG tabulation, UNEP Risoe center as of October 2009.
Note: CDM = Clean Development Mechanism; WBG = World Bank Group.

The CFU has been more successful in securing CDM registration than other non-WBG applicants.

However, like previous observers, this evaluation finds that the size and timing of carbon credit purchases is far too small, in many cases, to plausibly constitute a make-or-break influence on the decision to undertake a project. Instead, carbon funds constitute a mild additional inducement to investors that, statistically over the set of projects involved, may have contributed to some additional reductions.

Poverty focus

As noted, the 2005 objectives called for ensuring that smaller, poorer countries benefited from the carbon market. This was inherently difficult, because these countries have very low levels of energy-related emissions to abate, but their deforestation and agriculture-related emissions are ineligible under Kyoto rules.

This mission was carried out largely by the BioCarbon Fund and Community Development Carbon Fund, which comprise 8 percent of the overall portfolio. These have placed 39 percent of their purchases in low-income countries, as opposed to 0.3 percent for the other carbon funds (table 5.3). However, these demonstration-oriented funds experienced high preparation and supervision costs, along with implementation problems. Outside the low-income countries, some projects (such as Jepirachi Wind Farm) provided benefits to indigenous or low-income communities.

The BioCarbon Fund and Community Development Carbon Fund put 39 percent of their purchases in low-income countries; the other funds put 0.3 percent into low-income countries.

TABLE 5.3 Carbon Projects with Signed Purchase Agreements

	PCF	CDCF	BioCarbon Fund	National + umbrella	Total
Total project cost, ^a (\$ millions)	975	781	265	5,246	7,266
ERPA volume, million tons CO ₂ e	23	9	7	168	208
Total volume, million tons CO ₂ e	60	17	70	515	663
ERPA tons breakdown by country group (%)					
China	34	15	12	84	73
Jl (transition countries)	13	0	0	5	5
Low income	2	42	35	0	3
Lower middle income	25	41	38	6	11
Upper middle income	26	3	14	5	8
Total	100	100	100	100	100
Total tons breakdown by country group (%)					
China	55	10	3	81	69
Jl (transition countries)	10	0	0	7	7
Low income	1	49	74	0	9
Lower middle income	12	36	21	5	8
Upper middle income	22	5	2	5	7
Total	100	100	100	100	100

Source: World Bank CFU data.

Note: CDCF = Community Development Carbon Fund; CO₂e = carbon dioxide equivalent; ERPA = emissions reduction purchase agreement; PCF = Prototype Carbon Fund. Totals are not exact due to rounding.

a. "Total project cost" refers to the investment cost of establishing the project, not to the purchase amount of carbon offsets.

Impacts on technology transfer

The 2005 goals called for the CFU to “expand the technology frontiers of the carbon market to ensure that carbon finance and carbon trade supports energy infrastructure and technology transfer.” Energy technology constitutes a minority of total CERs under contract. The largest energy subsectors are hydropower at 6 percent of the overall post-2004 portfolio, landfill gas (6 percent), energy efficiency (4 percent), and methane avoidance (3 percent). Biomass, geothermal, and wind are about 1 percent each.

The degree of emphasis on technology transfer varies. The CFU has had an active role in the diffusion of landfill gas technology. The Jepirachi Wind Farm Project was the first grid-connected wind farm in Colombia; its operation provided useful lessons on adapting turbine operations to the coastal region’s distinctive climate conditions (Pinilla, Rodriguez, and Trujillo 2009). In contrast, hydropower was already well established in Chile and China before the Bank’s carbon projects arrived in those countries.

CDM project proponents must note technology transfer in their project design document. Seres and Haites (2008) reviewed these documents for all CDM projects in the pipeline as of June 2008. IEG reviewed the categorization of the 59 WBG-sponsored projects in their database. Nineteen specifically mentioned technology transfer, a slightly smaller proportion than the 36 percent in the overall sample. Of the 19, there were 6 landfill gas, 5 wind, 4 energy efficiency, 2 biogas, and 2 industrial gas projects. Eight cases involved equipment transfer only, 7 knowledge only, and 4 equipment and knowledge. Nepal was the only low-income country in this group.

Almost two-thirds of the CERs under contract were for Chinese reductions of HFC-23, a highly potent, industrially generated GHG. HFC-23 is a by-product of refrigerant production and can be abated at very low cost. This purchase generated a large pulse of offsets at a time when there was increasing pressure on the Bank to deliver them. Globally, HFC-23-based offsets accounted for half of all CERs validated in 2006, enabling the creation of a secondary market and allowing CER-short companies to meet immediate carbon obligations.

Almost two-thirds of carbon offset purchases were for Chinese reductions of HFC-23, a by-product of refrigerant production.

However, HFC-23 offsets provoked concerns. As permitted by the CDM, the refrigerant companies realized a large profit on these transactions, subsequently taxed by China at a 65 percent rate for development purposes.⁵ However, critics say that carbon finance was unnecessary and inefficient for this purpose, suggesting that the industries could

have borne the cost or simply have been reimbursed for it, analogously to the Montreal Protocol⁶ (Wara and Victor 2008). There was also concern that companies might enter the refrigerant business merely to profit from HFC-23 destruction, because destroying the by-product pays more than creating the refrigerant. For this reason, UNFCCC rules were put in place to exclude new entrants from claiming emissions reductions.⁷

Implementation and benefits

For most projects, the production of carbon offsets is proportional to the production of local benefits such as electricity or regrown forest volume. CDM monitoring reports allow comparison of planned versus actual issuance of offsets. Looking at CDM-wide statistics, biogas, methane recovery, cement, and transportation have performed far below expectations; for other technologies, there is wide dispersion in planned versus actual performance.

Chapter 2 discussed the performance of the 12 WBG carbon-financed hydropower projects for which formal monitoring information is available. Information is available also on 12 other WBG carbon projects (table A.6). Two landfill gas projects have fared very poorly, with issuance yields below 10 percent of planned levels (see box 2.2 on why landfill gas plans were too optimistic). Four other projects had yields below 65 percent. The remainder performed as designed or better. Internal tracking of BioCarbon Fund projects shows that reforestation and afforestation are proceeding more slowly than anticipated.

Biogas, methane recovery, cement, and transportation have performed below expectations, and for other technologies there is wide dispersion in planned versus actual performance.

Integration with Bank activities

The World Bank has largely not realized synergies between operations and carbon finance in the Kyoto Funds. Only 10 of the 108 agreements are associated with Bank operations. For the operational part of the Bank, mainstreaming of carbon finance is seen as too much trouble, because of the time and hassle of arranging for project registration. In contrast, four proposed operations under the Carbon Partnership Facility are grounded in existing Bank projects.

Knowledge transfer and capacity building

The carbon funds have supported CF Assist, a capacity-building program that advises countries on carbon regulation, sponsors a range of training, helps identify carbon projects, and sponsors carbon trade fairs and expos. The annual carbon trade fair has been cited as an important contribution to information diffusion. Over 2006–09,

CF Assist provided training to 6,225 people, more than a quarter in Sub-Saharan Africa, and helped in the preparation of 300 projects, about half of which were in the Philippines and Uzbekistan.

Conclusions

The World Bank's CFU has played an important role in opening an entirely new field of environmental finance, popularizing the idea of carbon markets and contributing to the institutional infrastructure of the market. Depending on the outcome of international negotiations, this could evolve into a major financial vehicle for supporting development and climate mitigation. Higher carbon prices will be necessary, though, to effect widespread transformation of energy technologies.

The 2005 exit strategy did not function smoothly; the Bank moved into pilot areas of the carbon market as planned but did not exit established parts of the market.

Constrained by the strictures of the Kyoto Protocol, the CFU has spent much of its creative energy grappling with the perplexities of establishing additionality and dealing with the CDM apparatus. The additionality and impact of its own actions are mixed. It has contributed to the diffusion of some technologies, such as landfill gas, and supported first-of-kind technology investments in some countries. The BioCarbon Fund and the Community Development Carbon Fund have supported novel small-scale, rural, and forestry projects—and found in the process that this is difficult to do.

In contrast, much of the CFU's support for energy technologies has gone to projects where its financial leverage was

relatively small. CFU staff claim that the cachet of involvement with the Bank's carbon fund has attracted investors to Bank-supported projects. To the extent that this is true, there may be other, less complicated ways to put the WBG's prestige to use.

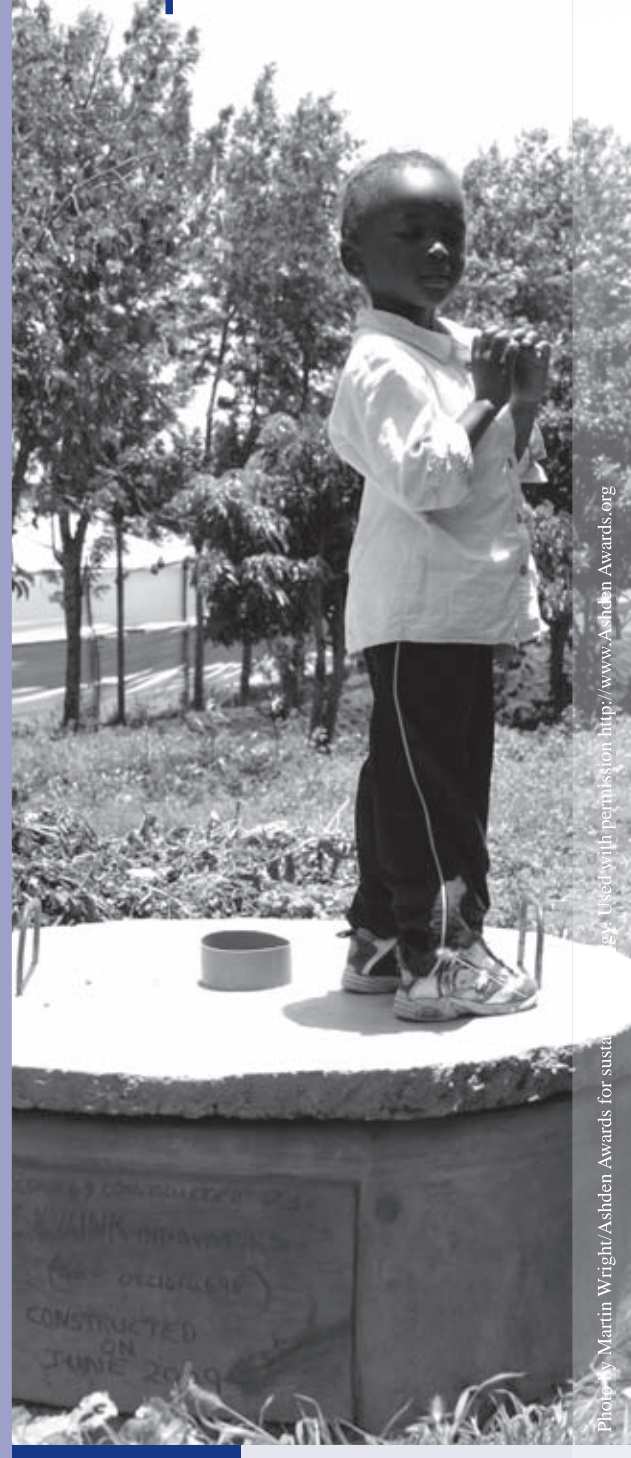
The CFU has spent much of its creative energy grappling with the perplexities of establishing additionality and dealing with the CDM apparatus.

On market exit, the 2005 Strategy statement put it this way:

To the degree that carbon markets thrive, the Bank will exit from the carbon market. The Bank as trustee of carbon funds will increasingly be able to act as the “buyer of last resort” and transition from being a ‘buyer’ of carbon assets to helping its clients countries position themselves as sellers. If risk and uncertainty declines in certain countries and for certain technologies, the Bank's carbon funds will be no longer needed as the Bank's participation becomes, over time, no longer necessary to help create viable projects and to manage risks for buyers and sellers. This, in effect, constitutes a built-in exit approach for the Bank from the lower-risk part of the carbon market (World Bank 2006).

This exit strategy has not functioned smoothly. Although the Bank did indeed move into higher-risk, pilot areas of the carbon market, it continued to build up its lower-risk Kyoto-oriented business after that market was already thriving. It then became clear that the bottleneck was not market demand for offsets, but creative, high-leverage ways to use those funds for sustainable development. This would have suggested greater emphasis on the supply side of the market.

Chapter 6



Conclusions and Recommendations

Economic life and GHG emissions have been closely intertwined. This evaluation has traced some of the most important parts of that large and complex knot, assessing the impacts of WBG attempts to disentangle the threads. Table 6.1 summarizes the sectoral findings. This chapter draws conclusions that cross-cut those diverse sectors and presents recommendations.

The Congruence of Mitigation and Development

GHG mitigation directly contributes to development and poverty reduction. But it does so by managing long-term risks at the global level. Thus, countries are rightly concerned about potential trade-offs between long-term, globally shared benefits and short-term, local benefits.

IEG finds that there are many important areas of action that combine significant global benefits with high local ones. Figure 6.1 plots indicative estimates of the local economic returns and global mitigation returns of some of the interventions discussed in this evaluation. These estimates must be taken with extreme caution, as they are based on possibly overoptimistic appraisals or on sometimes inconsistent or poorly documented monitoring reports.

But this evaluation suggests that energy efficiency and BRT offer local ERRs that exceed most development projects, with GHG as a significant side benefit. At current valuations of carbon reduction, the domestic benefits are much larger than the carbon benefits. There was insufficient information to compute returns to forest interventions, but there are large deforestation reductions (and therefore large emissions reductions) from forest protection projects, especially where local sustainable use is allowed, and even greater reductions from the establishment or maintenance of indigenous forest areas. This suggests a combination of social, biodiversity, and carbon gains from these projects.

A Systems View Is Essential

As emphasized in Phase I of this evaluation (IEG 2009), a systems view is often necessary to assess interventions' impacts and to appraise alternatives. A narrow project-level focus can fail to account for positive or negative indirect effects, fail to identify important complementary efforts,

and become mired in controversy uninformed by a consideration of alternatives.

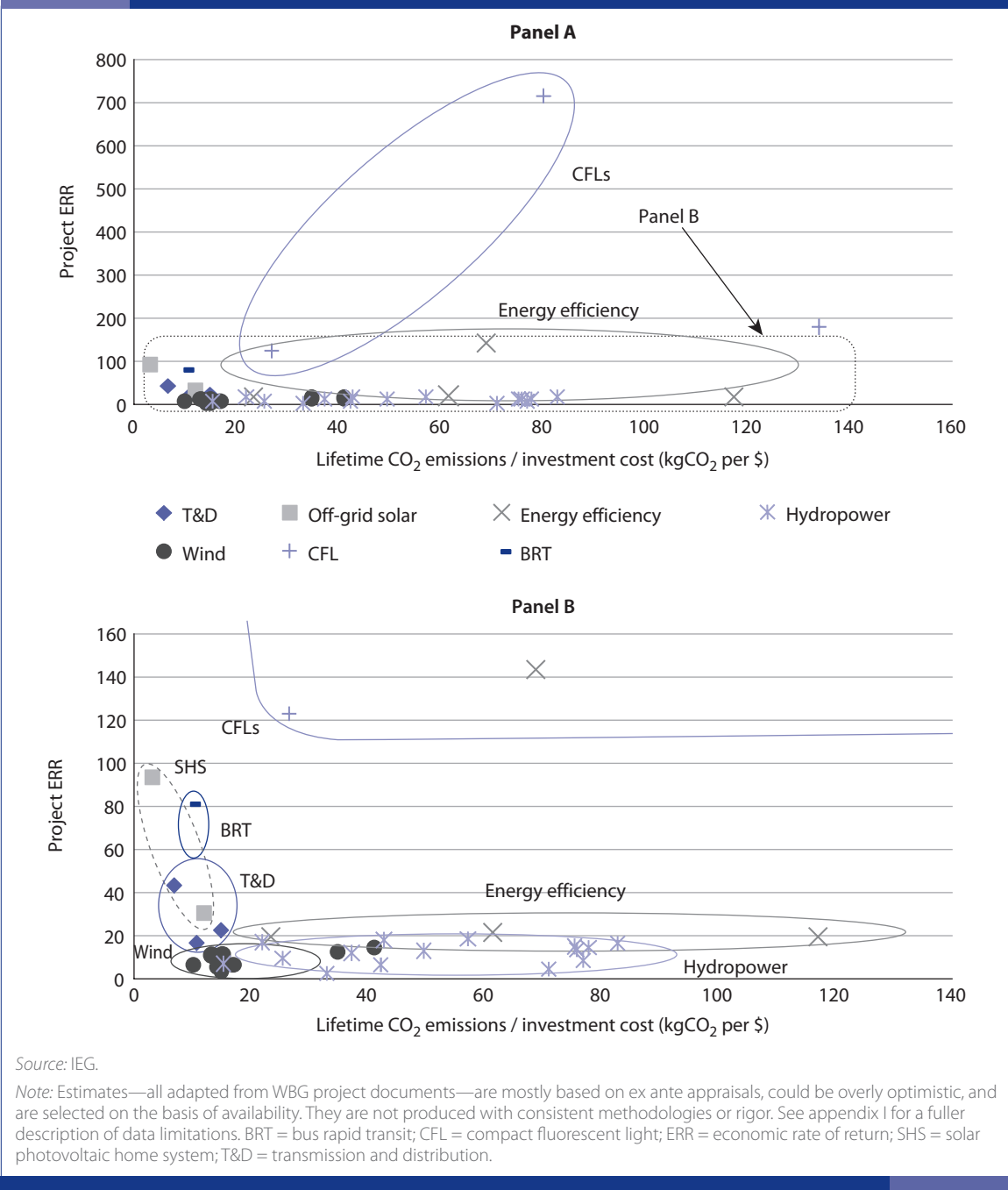
For instance, the WBG's involvement in coal projects has been a lightning rod for debate. If there were an international agreement that clearly set out how to achieve the UNFCCC goal of climate stabilization, with assigned roles and responsibilities, such a debate would not be necessary. In the existing vacuum, the SFDCC set out criteria that would restrict support to cases that are least cost, that optimize energy efficiency options, and for which no financeable low-carbon alternative exists.

A study for Kosovo illustrates a way to apply these criteria. It employs a systemwide model to show that even in the presence of €10/ton of CO₂ charges or credits, and taking account of the damages from air pollution, it would still be advantageous for Kosovo to build a large coal plant, while closing smaller, older ones. However, it is essential that such models incorporate the scope for efficiency improvements as an alternative to new power generation and consider higher levels of carbon payment.

Similarly, assessment of the costs and benefits of large hydropower plants should be made in the context of a systems model that identifies the advantages and disadvantages of different sites (as in the Nile Equatorial Lake Strategic Environmental Assessment). The model should also consider the social and environmental impacts of alternative modes of power provision.

In the area of forests and land use, forest conservation needs to be accompanied by sustainable agricultural intensification. Increased agricultural profitability by itself could motivate added deforestation; increased forest protection in one area could deflect pressures to another in the absence of a compensating supply of food, timber, and jobs. Likewise, the benefits of improved urban transit can be quickly eroded as cars expand into freed-up roadways;

FIGURE 6.1 Economic and Carbon Returns to Investments



a comprehensive system of transport demand management is necessary for sustained gains.

Recommendations

The WBG’s resources are small compared with the capital cost of providing low-carbon energy to developing and transition economies—to say nothing of broader development needs. To make a difference for the planet, the WBG needs to leverage its resources as far as possible. It can do this through four interlinked lines of action:

- **Support favorable policies** (discussed at length in Phase I of this evaluation with respect to energy pricing and efficiency policies, and reiterated here in connection with renewable energy policies).
- **Be a venture capitalist for technical, financial, and institutional innovations** (in short, for fostering technology transfer) by identifying innovations that have potentially high returns, using a cycle of piloting and demonstration to test, adapt, upscale, and diffuse these technologies to wider and wider audiences

- *Scale up high-impact investments* for solutions that work.
- *Use feedback and learning as a source of value for the WBG and its clients.*

The first point, with associated recommendations, was treated in Phase I. The other two are discussed here.

Be a venture capitalist of technologies, broadly understood

In both the public and private spheres, the WBG can support the transfer, adaptation, piloting and demonstration of innovative technologies, policies, and financial practices—as it has, for instance, with energy service companies, bus rapid transit, solar photovoltaic systems, and agroforestry. As in the case of private investments, these demonstrations carry risks but can offer high returns. What counts for clients, the WBG, and the world, however, is the return on the portfolio in development, poverty reduction, and GHG mitigation. The vision is to prepare a pipeline of development solutions that can be pursued on a large scale by the WBG and other funders, as climate finance expands.

A first challenge is to accept some prudent risks in pursuit of a high-return portfolio. For World Bank clients, this means using GEF or other concessional funds to support the earliest and riskiest ventures. Risk is further mitigated by starting small and staging successively larger pilots and demonstrations, from test site to province to nation. With increasing experience and comfort, the scale expands and the risk declines. For WBG staff and managers, it is important that demonstration and pilot projects' objectives be framed in terms of learning. For instance, if the project's goal is to test the financial viability of an innovation and the test shows convincingly that it is not viable, it should be considered a successful project.

But a more fundamental change in incentives may be necessary. In IFC, for instance, a venture capital team has secured a niche within IFC's generally conservative and risk-averse culture. This could be inspirational for the World Bank.

A second challenge is to design projects effectively for leaning and diffusion. Pilot or demonstration projects must have a clear notion of what is being demonstrated, to whom, and how; demonstration should be formulated as a goal and appropriately measured. For instance, the Regional Silvopastoral Project used experimental techniques to rigorously document the private gains from some kinds of agroforestry, and industry groups used this information to get government support to scale up. But some projects failed to recognize that private firms are reluctant to share proprietary information. So, for instance, the beneficiaries of technology licenses in the Efficient Boiler Project did not share their boiler designs with competitors. In contrast, pilot ESCOs in the Energy Conservation Project were obliged

to share their experience with others, and the model diffused rapidly.

In sum, the social networks and information mechanisms for demonstration and diffusion should be as important in project design as the hardware being demonstrated. So, too, is the capacity building, which is an integral part of technology transfer. The distinctive features of pilot, demonstration, and technology transfer projects argue for additional support for preparation and supervision in funding and on-call expertise.

There is a clear case and large scope for WBG involvement in technology transfer at the national level. The case is less clear for WBG involvement in new technology development at the global level. Candidate technologies would be those where WBG support could make an appreciable difference to the global market, helping to push costs down. Of special interest are technologies that are beneficial for poor people and difficult to protect from copying (and therefore attract little private research and development)—for instance, in agriculture and land use. The proposed new WBG effort to support concentrated solar power is a plausible area of support because a large proportion of the suitable resource is located in client countries, the technology is suitable for manufacture in client countries, and the proposed effort is large enough to globally push the industry along the cost curve.

Specifically:

- The World Bank and IFC should create incentives and mobilize resources to support effective pilot, demonstration, and technology transfer projects that have a clear logic of demonstration and diffusion. This will include mobilizing GEF and other concessional funds to mitigate World Bank borrower risk, reshaping incentives for staff and managers, providing adequate resources for the design and supervision of complex projects, and making available specialized expertise in technology transfer and procurement through a real or virtual technology unit.

Scale up high-impact investments

In the process of scaling up, the WBG can work with clients to choose the sectors and instruments that offer the greatest return on investment. This evaluation finds that the WBG could place more emphasis on energy efficiency. It is generally cheaper than renewable energy and has fewer potential negative environmental impacts. If coordinated with grid expansion, it can be an important contributor to energy access. It plays a prominent role in the 2010–30 time-slice of most long-term climate stabilization scenarios. And it is applicable to all countries—it is the poorest who can least afford inefficiency. There are many aspects of energy efficiency that are in need of further piloting, but there are ample candidates for scale up.

Specifically, the WBG could:

- Place greater emphasis on large-scale energy efficiency scale-up, as measured by savings in energy and reduced need for new power plants. This includes support for efficient lighting and for exploration of the scope for accelerating the global phase-out of incandescent light bulbs. It includes continued and expanded support for reductions in T&D losses. And it includes proactive search by IFC for large-scale, catalytic investments in energy efficiency. There is scope to coordinate World Bank support for demand-side energy efficiency policies with IFC support for more efficient manufacturing and more efficient products.

The WBG should, wherever possible, help clients find cleaner, domestically available alternatives to coal power. As is clear from the findings here and in Phase I, no-regrets alternatives can include energy efficiency, hydropower, and natural gas. Moreover, the WBG faces strategic choices in staffing and programming between building up expertise in “sunrise” sectors of broad applicability (energy efficiency, land use management for carbon, energy systems planning) versus “sunset” sectors (coal power).

But should the WBG completely forswear coal? Consider, as an analogy, the 1991 Forest Strategy’s ban on commercial logging in primary moist tropical forests. IEG’s review (IEG 2000) found that the strategy prevented Bank staff from engaging the sector in proactive ways to improve economic and environmental management of tropical forests. The ban was rescinded in the 2002 Strategy, without triggering logging investments. Analogously, it is important that the WBG maintain its “honest broker” ability to help countries engage in systemwide energy planning. A perverse result would occur if disengagement from coal had a chilling effect on the WBG’s ability to engage in policy and planning dialogue that could promote low-carbon alternatives.

IEG recommends that:

- The WBG should help countries find alternatives to coal power while retaining a rarely used option to support it, strictly following existing guidelines (including optimal use of energy efficiency opportunities) and being restricted to cases where there is a compelling argument for poverty or emissions reductions impacts that would not be achieved without WBG support for coal power.

The WBG cannot tackle coal substitution alone. Complementary financing for renewable energy, and investments in technology research and development, are needed from the developed world to provide better options for WBG clients.

Protected areas deter tropical deforestation, providing local environmental benefits and conserving biodiversity as well as reducing carbon emissions. These impacts are greater when sustainable use of the forest is permitted, and greater

still for indigenous areas. This suggests compatibility of social and environmental goals. Environmental service payments can, in principle, achieve much the same results in forests where protected areas are not an option. However, payment for environmental services impacts have been diluted by limitations of finance and unfocused targeting of payments. Consequently, IEG recommends the following:

- The WBG should continue to explore, in the REDD context, ways to finance and promote forest conservation and sustainable use, including support for indigenous forest areas and maintenance of existing protected areas.

In terms of WBG instruments—

- MIGA’s upcoming FY 2012–15 Strategy should outline MIGA’s role and scope for MIGA to provide political risk insurance to catalyze long-term financing for renewable energy projects, building on its expertise and existing portfolio of climate-friendly guarantee projects.
- The World Bank should enhance the delivery of its guarantee products by taking actions to improve policies and procedures, eliminate disincentives, increase flexibility, and strengthen skills for the deployment of the products. It should assess the potential for greater use of partial risk guarantees to mobilize long-term financing for renewable energy projects, particularly in the context of feed-in tariffs or other premiums to support investment in renewable energy.
- The Carbon Partnership Facility and other post-Kyoto carbon finance efforts should focus on demonstrating truly catalytic ways to overcome barriers to low-carbon investments. They should also have clear exit strategies.

Reorient incentives toward learning and feedback

The WBG is valued by clients for its knowledge. It produces and publishes an impressive array of research, analyses, reviews, and toolkits, drawing in part on its experience. Yet by failing to gather feedback from operations, it squanders valuable sources of knowledge—knowledge that could improve its products and advice in economically measurable ways—by failing to learn from its project experience:

- Hundreds of millions of dollars are allocated in guarantees or loans for energy efficiency, without systematic feedback on how and where these interventions are inducing investments.
- CFL distribution projects are being scaled up to multi-million bulb efforts without systematic feedback from earlier projects on which interventions are most effective and sustainable.¹
- Protected area and community forest projects lack systematic monitoring of forest conditions (including carbon storage and biodiversity), of the welfare of forest

residents, and of the post-project financial sustainability of management. Failure to document impacts or to learn systematically from experience has kept the REDD initiative from having a 20-year “head start.”

Failure to monitor can also lead to skewed incentives. For lack of an alternative, the WBG (and to some extent this evaluation) uses dollar volume of commitments to measure the organization’s orientation toward climate issues. Using dollars as a scorecard was arguably important for the Bonn Commitment in directing attention and resources toward renewable energy and energy efficiency. But ultimately the use of an input rather than an outcome measure risks driving the organization toward inefficient or ineffective activities. For instance, efficient lighting programs offer much higher returns—in cost savings and GHG reduction—than investment in renewable energy. But a hydro plant offers a much higher ratio of loan amount to staff preparation cost and is therefore potentially more attractive in a budget-constrained organization that scores achievement by dollars loaned.

The CDM experience with monitoring points to a way forward. Unlike most other development projects, carbon projects are required to monitor their outputs. (Otherwise they do not get paid.) Calculating carbon offset production requires stipulating a “business as usual” emissions level. This is difficult and has often been contentious. But it also requires measuring the project’s actual performance—for instance, how many hours a wind turbine operates, or how many CFLs are distributed and installed. This generates timely, publically available, comparable information.

Just as private sector firms derive value from monitoring the performance of and customer satisfaction with their

products, the WBG has an interest in tracking the performance and sustainability of its projects. At the same time, it can work with public and private clients, when requested, to help them implement benchmarking and monitoring systems, so as to better define goals and track outcomes.

This becomes increasingly feasible as information costs plummet; remote sensing resources multiply in number, sensitivity, and accessibility; and cell phone access becomes nearly universal. By wiring projects and sectors to return current and reliable information on forest cover, T&D losses, household access to electricity, and so on, global innovation can be accelerated, and the returns to investment enhanced.

The WBG is a natural nexus and starting point for this global public good, which should eventually expand to a global network of information sharing. This is consistent with the strategic objectives for knowledge creation and capacity building.

Specific recommendations include the following:

- Measure projects’ economic and environmental impact during execution and after closure and aggregate this information for analysis. For instance, renewable energy projects should monitor capacity utilization, and energy efficiency projects should monitor energy savings. This may require the use of concessional funds to defray additional costs of monitoring by staff, clients, and project proponents.
- Link these measures to a results framework that shifts the SFDC toward a focus on outputs such as power produced, power access, forest cover, and transit share of urban trips, rather than money spent.

TABLE 6.1 Summary of Sectoral Findings

Sector	Intervention	Direct impacts	Leverage and diffusion impacts	Monitoring needs and issues
Renewable energy — on grid	Lending	Longer loan terms significantly improve bankability. Better upfront planning has been important to assure better outcomes in hydropower. Hydropower has generally higher returns than wind power.		What are the economic and carbon impacts? What are the reasons for over or underperformance in capacity utilization?
	Guarantees	Guarantees against breach of contract could significantly improve bankability.		

TABLE 6.1 Summary of Sectoral Findings (continued)

Sector	Intervention	Direct impacts	Leverage and diffusion impacts	Monitoring needs and issues
	Carbon finance	Carbon finance has little impact on bankability of wind and hydropower projects. Moreover, the stated rationales for the use of carbon funds often refer to barriers that are best addressed with greater leverage through policy reform (such as unreliable power purchase agreements) rather than at the project level. Carbon finance has significant impact on bankability of projects that reduce methane emissions. Performance of carbon projects has often been poor (lower production of permits than expected).	Thirty-five percent of WBG carbon finance projects claimed some degree of technology transfer.	Carbon project monitoring provides valuable feedback. For example, poor performance of landfill gas projects was detected and corrective actions taken. GEF or other funds could enhance this de facto monitoring system.
	Resource surveys	Siting makes a huge difference in economic returns because of spatial variation in wind, water, geothermal, and so forth. There have been modest investments by the Bank in resource surveys. Impact not evaluated.		How useful are surveys? Can remote sensing provide continually updated and improved information on wind and water resources?
	Policy reform		Standardized small power purchase agreements have reduced the costs of entry of small hydropower producers in Sri Lanka, with significant cumulative impact. Regulatory reforms in China, Mexico, and Turkey have catalyzed wind investments.	What is the fiscal impact and investment response of feed-in tariffs or renewable portfolio standards?
Solar home photovoltaics	Subsidies	Subsidies increase household demand; impact not well measured.	Quality-contingent subsidies for manufacturers boost competition and quality, and reduce price at the national level. No global impact on price; scale was too small.	Longevity and utilization of the solar home systems Manufacturing quality Market penetration Geographical extent of the electric grid and connection rate within the grid (to assess market size for photovoltaic); price elasticity of demand.
	Microfinance	Specialized microfinance institutions were able to support SHS buyers in Bangladesh and Sri Lanka.		

(Continued)

TABLE 6.1 Summary of Sectoral Findings (continued)

Sector	Intervention	Direct impacts	Leverage and diffusion impacts	Monitoring needs and issues
Energy efficiency	Subsidized guarantees for financial intermediaries' energy efficiency lending to industry, commercial, and residential sector	Guarantees facilitate energy efficiency investment by SMEs with poor credit, in poorly developed credit markets, or for housing coops in East Europe; but are superfluous for larger firms or for banks' trusted clients.	Guarantees were not, as assumed, catalytic in inducing diffusion of energy efficiency lending.	Pool information on subproject performance to identify promising market niches.
	Technical assistance for banks	In China, technical assistance helped Industrial Bank gain market share; in Russia, may have helped banks to convince customers to borrow for energy efficiency. Energy efficiency appraisal tool was useful to recipient banks.	Some diffusion of energy efficiency practice among Russian banks.	
	On-lending through financial intermediaries	Useful in countries with poorly developed credit markets.		
	ESCO demonstration		High leverage in China: demonstration was scaled up. But ESCOs are small and are themselves credit-constrained, limiting scalability.	
	Public sector reform to permit ESCO contracts		In Hungary, facilitated nationwide investments by municipalities in efficient heating and lighting.	
	Direct IFC investments in energy efficiency	Screening existing clients for energy efficiency opportunities has identified small loans with low absolute levels of CO ₂ reduction and is likely not cost-effective in staff time. Mainstream lending is usually too late in the project cycle to affect technology choice. However IFC may be able to finance some credit-constrained large firms with high absolute levels of energy and GHG savings.		

TABLE 6.1 Summary of Sectoral Findings (continued)

Sector	Intervention	Direct impacts	Leverage and diffusion impacts	Monitoring needs and issues
	Efficient lighting	Apparent very high returns to compact fluorescent light distribution	Potentially very high demonstration and diffusion effects; poorly documented.	Operations research on impact of alternative promotion strategies on adoption and diffusion of CFLs; surveys on CFL usage.
	Building and appliance efficiency and efficiency policies	Evaluated in IEG (2009)	With supportive enforcement and supply of efficient materials, equipment, and techniques, has had large catalytic impact in developed countries.	Survey info on building energy consumption, both existing stock and new construction.
	T&D loss reduction	High returns to engineering-based reductions in technical losses.	Institutional and legal reform can promote reduction of nontechnical losses.	Real time, spatially disaggregated information on technical and nontechnical losses; better understanding of who benefits from nontechnical losses.
	Energy pricing reform	Evaluated in IEG (2009). Some examples of progress, for example, Vietnam.	Very high leverage in promoting energy efficiency and making renewable energy more competitive.	Information on levels and trends in energy pricing; industry and household surveys on incidence of subsidies, burden of energy costs.
Urban transit	Bus Rapid Transit	Strong returns in health, congestion reduction, fuel savings; modest CO ₂ reductions.	Bogota and Mexico City projects have had demonstration impact.	Information on ridership, auto versus transport share, congestion, air pollution levels in transport corridors; evaluation of the effectiveness of vehicle scrappage programs.
Forests	Protected areas	Strict protected areas reduce deforestation on average; reductions are higher for protected areas that allow sustainable use, and higher still for indigenous areas.		Info is lacking on protected area impacts on biodiversity and local livelihoods and on protected area management practices.
	Afforestation/ Reforestation/ regeneration	There have been implementation problems in most afforestation/ reforestation BioCarbon Fund projects. Small project scale makes these uneconomic; low GHG impact; trade-offs.	Silvopastoral Project has demonstration effect, was scaled up.	Better documentation of the impacts of reforestation and afforestation on biomass, hydrology, biodiversity, and livelihoods.
	Payment for environmental services	Impact depends on the efficiency with which payments are sized and targeted at properties at risk for deforestation.		Better information on behavior of recipients versus nonrecipients.
	Support for use of sustainability certification by agribusinesses	Chain-of-custody tracing is expensive and has little impact in IFC-supported investments in Brazil.	Combination of NGO pressure on buyers, and government monitoring may have had significant impact on reducing Brazilian deforestation.	Impacts of certification schemes (timber, palm oil, etc) remain unknown. Better information required on relative prices of certified versus uncertified goods.

(Continued)

TABLE 6.1 Summary of Sectoral Findings (continued)

Sector	Intervention	Direct impacts	Leverage and diffusion impacts	Monitoring needs and issues
Technology transfer	Venture capital investments in early stage clean technology companies	Has failed when investments had multiple handicaps: noncommercial technologies, inexperienced entrepreneurs, uninterested markets.	A new IFC approach—invest in proven entrepreneurs and globally proven technologies—could be high leverage.	
	Direct IPR transfer	Had modest effects in efficient boilers project.	Private companies did not share transferred technologies.	
	Grants for R&D		Had encouraging results in REDP project. Industry-wide support led to competition, price reductions.	Monitor results of such projects.
	Demonstration of new technologies	Has been successful where there was a clear purpose for demonstration and target audience and where adoption was profitable: for example, introduction of ESCOs in China; Regional Silvopastoral program in Colombia. Has failed or bogged down where purpose was not clear, for example, 1990s era investments in concentrated solar power; or when there was an expectation that private companies would share proprietary technologies.		Incorporate good monitoring into projects with pilot/demonstration purposes; monitor diffusion if that is the goal.

Source: IEG.

Note: CFL = compact fluorescent light bulb; ESCO = energy service company; GEF = Global Environment Fund; GHG = greenhouse gas; IFC = International Finance Corporation; IPR = intellectual property rights; NGO = nongovernmental organization; R&D = research and development; REDP = China's Renewable Energy Development Project; SHS = solar home voltaic system; SME = small and medium enterprise; T&D = transmission and distribution; WBG = World Bank Group.

APPENDIX A

Renewable Energy Tables and Figures

TABLE A.1 World Bank Group Commitments to 2003–08 Low-Carbon Projects (by source)									
Project type	IBRD	IDA	IFC	MIGA	Guarantees	GEF-World Bank	IFC-GEF	Carbon finance	Total
Off-grid and mini-grid renewables									
Direct investments including cook-stoves and household biomass/biogas	86.2	141.5	165.4	1.8	0.0	273.1	0.0	380.1	515.0
Via funds that support subprojects	3.5	199.5	0.0	0.0	0.0	0.0	0.0	0.0	235.4
Grid renewable energy									
Direct investments in RE	801.1	634.7	513.9	313.8	227.5	59.2	0.0	34.7	3,054.8
Via financial intermediaries	202.0	0.0	0.0	0.0	0.0	0.0	0.0	65.7	212.6
Energy efficiency									
Transmission and distribution loss reduction	188.7	247.6	144.4	39.6	0.0	32.4	0.0	0.0	632.8
End user energy efficiency	119.7	21.4	199.7	0.0	0.0	10.5	0.0	0.0	422.1
Combined heat and power and/or district heating	340.7	51.0	29.5	0.0	0.0	72.9	0.0	42.0	477.4
Supply-side energy efficiency	336.0	8.3	117.6	0.0	0.0	22.9	0.0	3.3	527.7
Energy efficiency investments via financial intermediaries	314.0	3.8	214.1	0.0	0.0	10.3	165.1	20.6	811.8
Other									
DPL, other investment programs and technical assistance	192.4	74.7	389.3	0.0	0.0	3.9	0.0	93.0	753.3
Combinations of RE and energy efficiency, or unspecified, via financial intermediaries	0.0	5.0	227.1	0.0	0.0	18.0	77.0	38.2	335.3
Total	2,584.3	1,387.4	2,000.8	355.2	227.5	503.0	242.1	677.7	7,978.1
<p>Source: IEG.</p> <p>Note: Unit of analysis is the project component. Excludes freestanding WBG AAA and IFC advisory services, and “special financing.” DPL = Development Policy Lending/Loan; GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation; MIGA = Multilateral Investment Guarantee Agency; RE = renewable energy.</p>									

Secondary and tertiary sector	High risk				Medium risk				Low risk			
	No.	Max FRR %	Min FRR %	Avg FRR %	No.	Max FRR %	Min FRR %	Avg FRR %	No.	Max FRR %	Min FRR %	Avg FRR %
Large hydro	0				0				4	34.0	10.4	16.5
Small hydro (<10 MW)	0				0				2	13.1	12.6	12.9
Wind power	1				0				5	9.9	8.0	8.6
Thermal power generation									6	18.0	7.2	12.3
Coal	0				0				3	14.0	7.2	11.6
Gas	1				1				3	18.0	10.6	13.1
All infrastructure (including sectors not listed above)	27	35.0	14.0	20.6	32	33.7	10.0	18.4	51	36.0	7.2	15.7

Source: IEG.
Note: FRR = financial rate of return.

	Traditional financing				Total traditional financing	Blended activities		Total blended financing	New financing			Total new financing	Total
	Guarantees	IBRD standalone	IDA standalone	IFC		IBRD-GEF-carbon finance blend	IDA-GEF-carbon finance blend		GEF standalone, including med size	World Bank carbon finance	IFC-managed carbon finance		
All hydropower, grid connected	453.0	849.4	528.5	358.7	2,189.7		72.9	72.9	0.4	145.5	33.7	179.6	2,442.2
Large hydropower, with reservoir (including rehabilitation)	203.1	394.9	190.9		789.0					6.0		6.0	794.9
Large hydropower, run-of-river	249.9	540.4	213.6	351.6	1,355.5		72.9	72.9		129.5	28.7	158.2	1,586.6
Small hydropower		202.0	28.0	7.1	237.1				0.4	4.1	14.0	18.5	255.7
Mini/micro/pico hydropower									0.4	5.9		6.4	6.4

Source: IEG.
Note: Unit of analysis is the project component. Excludes freestanding WBG AAA and IFC advisory services, and “special financing.” GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation.

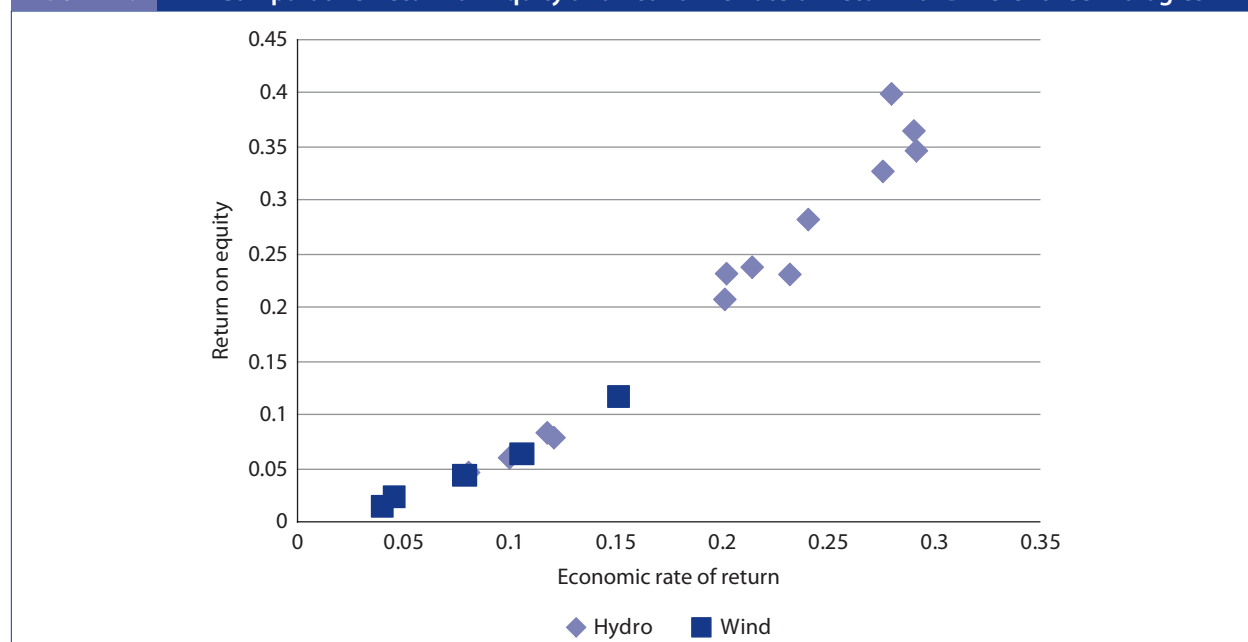
TABLE A.4 Grid-Based Biomass/Biogass/Landfill Gas/Methane Commitments 2003–08 by Technology and Product Line/Funding Source

	Traditional financing				Total traditional financing	Blended activities		Total blended financing	New financing			Total new financing	Total
	Guarantees	IBRD standalone	IDA standalone	IFC		IBRD-GEF-carbon finance blend	IDA-GEF-carbon finance blend		GEF standalone, including med size	World Bank carbon finance	IFC-managed carbon finance		
Biogas				2.8	2.8	40.2		40.2		5.8	4.2	10.0	53.0
Biomass				39.7	39.7	20.0		20.0		48.9	21.0	69.9	129.6
Municipal landfill										18.4		18.4	18.4
Biomass unknown			28.0		28.0					0.0			28.0

Source: IEG.

Note: Unit of analysis is the project component. Excludes freestanding WBG AAA and IFC advisory services, and “special financing.” GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; IFC = International Finance Corporation.

FIGURE A.1 Comparative Return on Equity and Economic Rate of Return for Different Technologies



Source: IEG, based on project documents.

Note: This comparative analysis does not represent actual or predicted performance of the projects, because of the following standardized assumptions: lifetime 30 years; tariff 6 cents/kWh; toll to grid 0.2 cent/kWh; no carbon finance or other incentives. Financing structure: interest rate 8 percent; grace period 2 years; maturity 10+ grace years; debt/equity 2.3; no local inflation; no hard currency inflation; stable exchange rate. Income tax rate 33 percent, capital gain tax rate 10 percent, VAT 18 percent; depreciation 10 years, 95 percent of total value at 10 percent rate.

FIGURE A.2 Capacity versus Planned Capacity Utilization, CDM Hydropower Plants

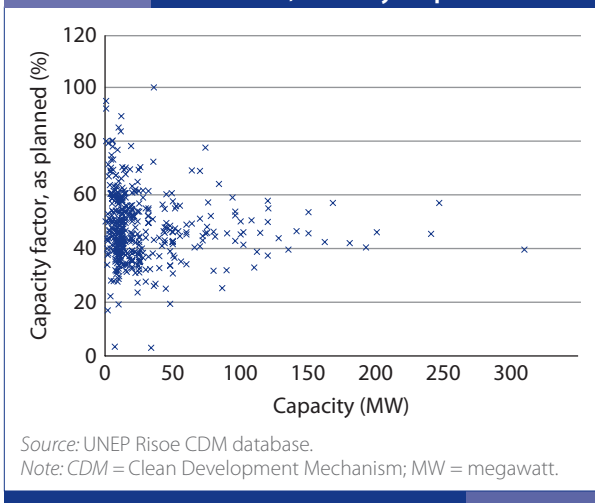


FIGURE A.3 Return on Equity as a Function of Electricity Tariff

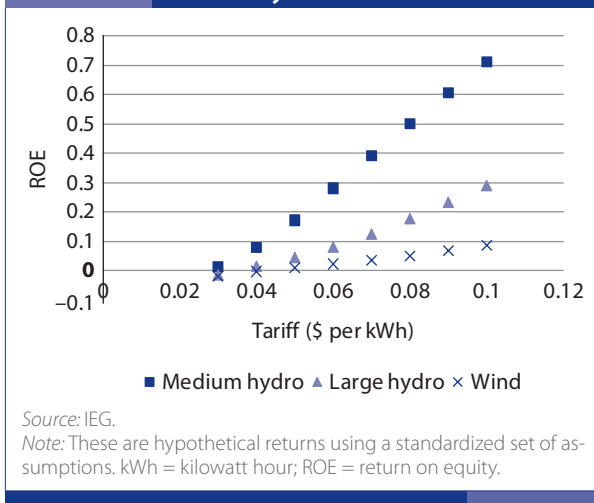


TABLE A.5 Key Factors in Hydropower Project Performance, with Outcomes and Lessons from Project Reviews

	Negative examples	Positive examples
Resettlement and environmental issues	<p>Latin America: One factor that led to unsatisfactory project ratings was that the resettlement and environmental management program were only partly implemented, with major issues remaining unaddressed. In addition, poor oversight of the areas to be flooded resulted in invasion of families seeking resettlement compensation.</p> <p>Government was slow in performing land acquisitions and housing construction, adding to pressures that slowed down project.</p> <p>Africa: Absence of information disclosure and communications developed in a sustainable manner.</p> <p>East Asia: Until 2003, resettlement was carried out inadequately because of lack of knowledge or understanding at the provincial level of the Resettlement Action Plan, some provincial offices' delayed approval of the compensation guidelines, and disparity between the compensation rates in the Resettlement Action Plan and that which the provinces approved. In 2003, the situation was resolved with Plan-based compensation agreements being signed with all the households.</p>	<p>East Asia: Ertan resettlement program appears to have been successful overall and has given satisfactory results in terms of restoration or improvement of living standards and better access to infrastructure and other services for the bulk of the affected population. A 10-year post-project rehabilitation levy on the project company's electricity sales provided funds for environmental protection around the reservoir, infrastructure maintenance, infrastructure improvements, and income-boosting activities for the resettlement villages. This is a useful instrument to help ensure project sustainability, because it eliminates uncertainty about funding from budgetary sources. The use of an international environmental and resettlement panel proved its worth.</p> <p>East Asia: High-quality up-front assessment ensured the project success—the highly satisfactory outcome of resettling more than 74,000 people.</p> <p>East Asia: An independent review rated resettlement performance highly —“the best resettlement option was deduced from the country's past resettlement experience. The women's role in resettlement is emphasized.” An international panel of experts on environment and resettlement has conducted 12 meetings and helped ensure effective management of adverse environmental impacts, by overseeing implementation of a systematic environmental management plan.</p>

(continued)

TABLE A.5 (continued)

	Negative examples	Positive examples
Project design issues: Policy context	<p>Low ratings in some unsatisfactory projects in Africa were caused by weakness or absence of up-front detailed assessment.</p> <p>East Asia: Lack of sufficient counterpart funding from the provincial government delayed the implementation of the irrigation works and the resettlement program. Resettlement problems were compounded by the absence of a provincial resettlement office (as has usually existed in other Chinese resettlement cases) and the Bank's initial overestimation of Hainan's institutional capacity. As a result, the borrower has not yet achieved the project's resettlement objectives.</p> <p>Africa: Failure to define water rights at an early stage of development of a hydroelectric project created water use, conservation, and environmental problems that were difficult to solve during project construction and introduced implementation delays.</p> <p>Africa: Lack of government ownership led to low performance. Weak government commitment to implement — (unbundling generation, transmission and distribution, transparent subsidies) and low capacity of utilities to lead sector reforms could be the main reason for failure.</p> <p>South Asia: At the time of project appraisal, neither the government nor the Bank had a clear vision of how power sector reform would be carried out during the life of the project. Hence, in the two years before the project closing, as reforms started to take off in some states, the project was buffeted by unanticipated and sometimes ad hoc state regulatory changes. With one exception, states did not address the renewable energy dimension of the sector.</p>	<p>East Asia: (a) The Bank assisted the utility in optimizing its investment program, particularly at the time when the country had been severely affected by economic and financial crises. The utility modified its power development plans, deferred many independent power producer projects, reduced operating costs, and scaled down its investment Program. (b) The utility adopted sound policies and strategies for environmental and social management and defined a framework and guidelines for environmental assessment of power development plans. (c) The utility implemented the recommendations of a study on economic regulation, tariffs, and development of bulk supply after the economic/ financial crises had faded out; these include efficiency considerations in determining revenue targets, transparent mechanisms for transfer of subsidies, and the restructuring of the consumer billing system to provide for accounting of transmission and distribution charges. (d) The Bank acted as a facilitator and played an informal role in advising the government on the reform of the power sector, especially while the country experienced the economic and financial crises. During this period the Bank, through Energy Sector Management Assistance Programme, had a more formal participation in an independent review of the Power Pool and Electricity Supply Industry Reform Study conducted by National Energy Policy Office</p> <p>A Southeast Asia project was built on the outcomes of the first renewable energy project; by then the general strategies for renewable energy had been coordinated to the project activities.</p>
Project design: Geological study	<p>East Asia: The bank instability in the lower reservoir and the excessive local ground settlement in the upper reservoir were all unforeseen and delayed work progress. Adequate risk coverage/insurance products could be built in the business model to mitigate such risks for both the developers and lenders.</p>	
Development of adequate power evacuation infrastructure	<p>Africa: Project delay was caused by the absence of coordination between the project implementation plans and counterparts on provision of the energy delivery from the plant to the consumers.</p>	<p>Renewable Energy Project: One of the most crucial issues and/or potential barriers in the scaling up development of large and small hydropower plants is the interconnection between the plant and the nearest grid point to maximize the power usage. Providing grid extension up to the plants based on an integrated basin development approach is one solution which should be considered when encouraging hydropower development.</p>

Source: IEG, based on ICR reviews and PPARs.

TABLE A.6 CER Yield Rate, Non-Hydro CDM Projects					
Host party	WBG unit	Type of project	Supplemental information	Scale	CER issuance rate
Brazil	Bank	Methane recovery and utilization	Landfill gas flaring	Large	0.02866
Argentina	IFC	Methane recovery and utilization	Landfill gas recovery and utilization	Large	0.09123
Indonesia	PCF	Cement	Alternative fuels	Large	0.21724
Philippines	Bank	Wind power	1.65 MW x 20units	Large	0.48997
India	Bank	Energy efficiency	Factory	Small	0.6457
India	IFC	Wind power	58.2 MW	Large	0.82788
China	Bank	HFC reduction		Large	0.9857
China	Bank	HFC reduction		Large	1.03266
South Africa	IFC	N ₂ O decomposition		Large	1.05671
Columbia	PCF	Wind power	1.3 MW x 15units	Large	1.07518
India	IFC	Wind power	0.6 MW x 28units	Large	1.08339
Brazil	Bank	Biomass	Bagasse	Large	1.13683

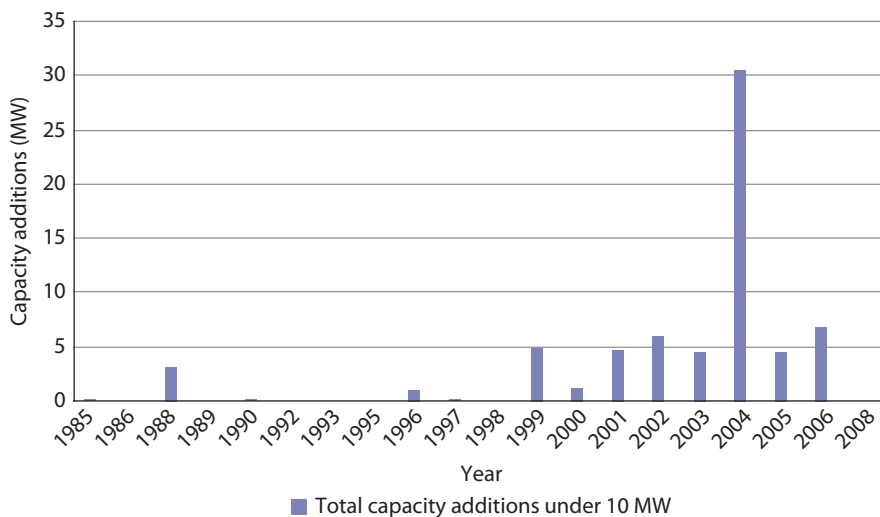
Source: IEG.
Note: CDM = Clean Development Mechanism; CER = certified emission reduction; HFC = Hydrofluorocarbon; IFC = International Finance Corporation; MW = megawatt; PCF = Prototype Carbon Fund; WBG = World Bank Group.

TABLE A.7 Solar Projects			
Project	Total project costs ^a (\$ million)	Project dates	
		Initiation	Completion
Argentina Renewable Energy in the Rural Market	79.10	12/09/1999	12/31/2011
Bangladesh Rural Electrification and Renewable Energy Development	25.34	12/31/2002	12/31/2012
Bolivia Decentralized Energy, ICT for Rural Transformation	13.93	12/18/2003	11/27/2009
China Renewable Energy Development	155.90	12/12/2001	06/30/2008
India Renewable Resources Development	23.80	04/06/1993	12/31/2001
Mongolia Renewable Energy and Rural Access	9.76	05/04/2007	12/31/2011
Pacific Islands Regional Sustainable Energy Finance	5.00	06/21/1007	12/31/2017
Philippines Rural Power	11.90	05/06/2004	12/31/2012
Senegal Electricity Services for Rural Areas ^a	18.00	06/30/2005	12/31/2012
Sri Lanka Energy Services Delivery	9.20	2/20/1997	12/31/2002
Sri Lanka Renewable Energy for Rural Economic Development	28.30	10/07/2002	06/30/2011
Uganda Energy for Rural Transformation	9.80	07/30/2002	02/28/2009

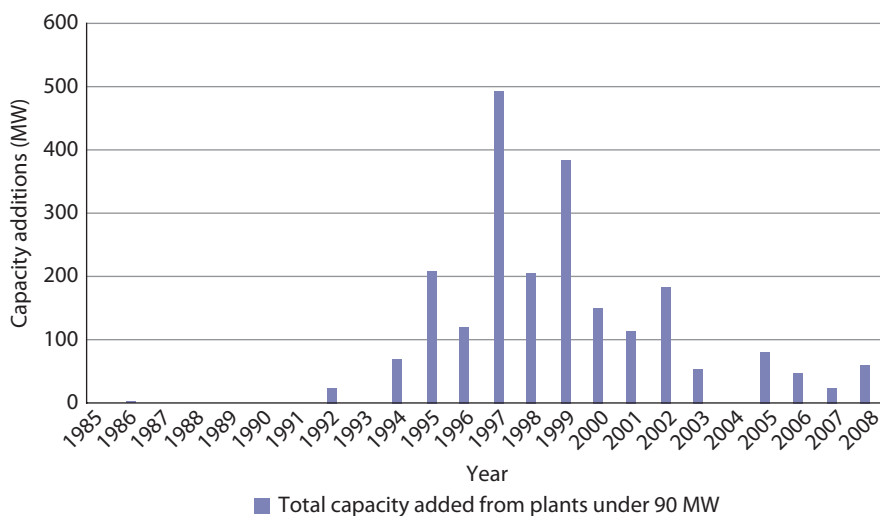
Source: World Bank.
a. Costs/financing are specific to solar component except Senegal Electricity Services of Rural Areas Project.

FIGURE A.4 Growth in Small Power Producers

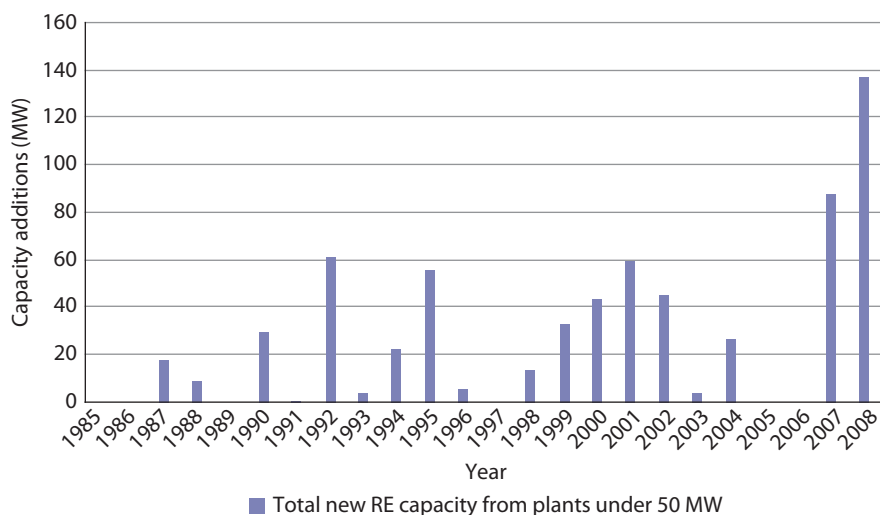
A. Hydro/biomass capacity expansion (< 10 MW), Sri Lanka



B. Gas capacity expansion (< 90 MW), Thailand



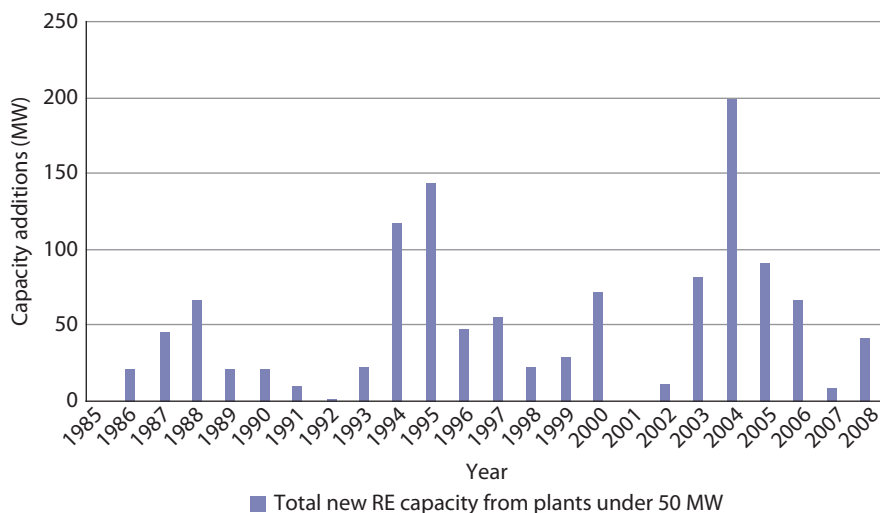
C. Renewable energy expansion (<50 MW) Andhra Pradesh



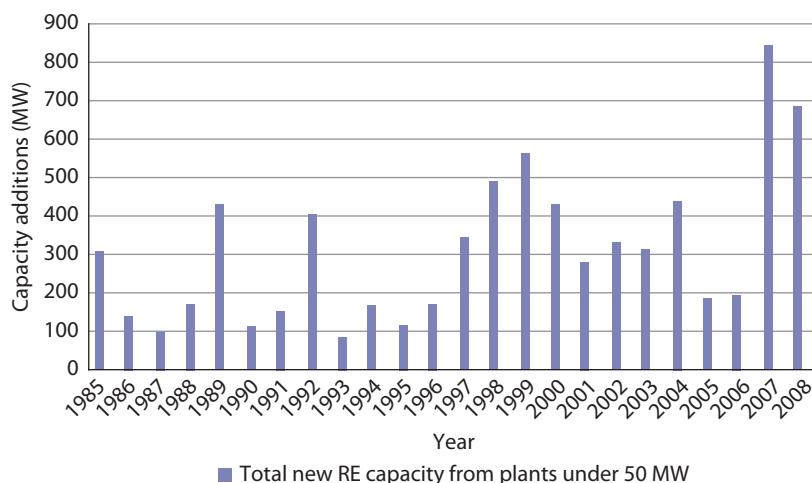
(continued)

FIGURE A.4 Growth in Small Power Producers (continued)

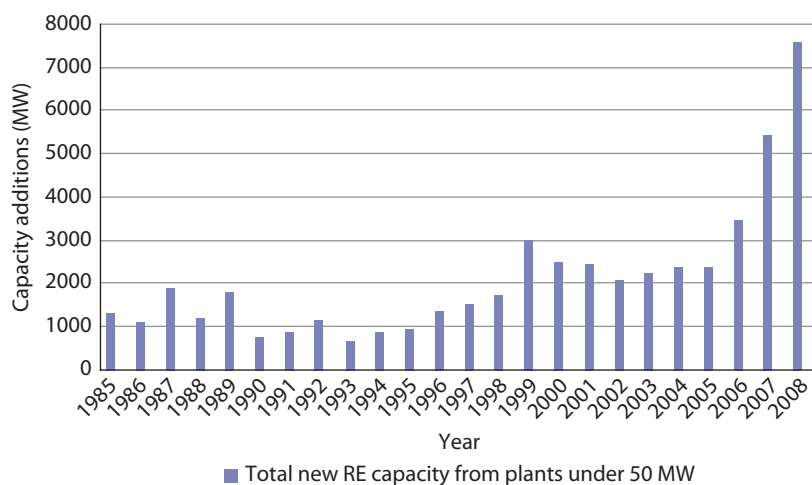
D. Renewable energy expansion (<50 MW), India: Tamil Nadu



E. Renewable energy expansion (< 50 MW), India excluding Tamil Nadu and Andhra Pradesh



F. Renewable energy expansion (< 50 MW), developing countries excluding India, Indonesia, Sri Lanka, and Thailand (excluding Andhra Pradesh and TN)



Source: Platts World Electric Power Plant database.

Note: Panel A—SPP initiation 1998; Panel B—SPP initiation 1992; Panel C—SPP initiation 1995; Panel D—SPP initiation 1995.

World Bank Experience with Renewable Energy Surveys

Survey projects aim to reduce barriers to renewable energy development by developing or collating spatial and temporal data on wind speeds, water flows, sunshine hours, geothermal potential, or biomass availability. These data, made freely available, enable investors to select specific sites for the more intensive local surveys needed to instigate specific projects. Resource-based site selection can make a huge difference to project viability. For instance, an International Finance Corporation-financed geothermal plant performed poorly because the steam resource was much weaker than expected. Exploration constitutes a large proportion of geothermal energy costs, so a tool that increases the yield rate of exploratory drilling could boost profitability.

The Bank has undertaken relatively few projects with significant renewable resource survey components. Survey

components typically constitute a minor part of a much larger energy sector project—the component containing the resource survey typically constitutes 1–5 percent of the total project spending, and this component often includes technical assistance or capacity building that is not related to the resource survey.

International Development Association/International Bank for Reconstruction and Development or Global Environment Facility (GEF) funding constitutes most or all of the resource survey financing. GEF financing has played a major role in all the surveys save Morocco. Of the surveys listed here, only the Republic of Yemen and Armenia are complete. Data on survey impacts are not available.

Year	Country	Resources	Scale	Component cost (\$ millions)	Bank component contribution (\$ millions)
2005	Yemen, Rep. of	Wind	National	1.00	1.00
2006	Mexico	Wind	National	4.27	3.90
2006	Lao PDR	Biomass, micro-hydro	National	1.70	1.70
2006	Armenia	Hydro, wind, solar, biomass, geothermal	National	3.65	3.00
2007	South Africa	Solar, biomass, hydro.	National	0.78	0.45
2008	Morocco	Wind	National	1.00	1.00
2008	Mexico	Wind, hydro	Unavailable	12.46	7.94
2008	Ghana	Wind, biomass, micro-hydro	National (biomass, hydro), 3 specific sites (wind)	1.96	1.74
Total				25.82	20.73

Source: IEG review of project documents.

Energy Efficiency: Supplementary Information

Country/Region	Year	Design features			Expected outcomes		
		Primary goal	WBG commitment (\$ millions) (T&D components)	Commercial loss reduction?	Technical loss reduction (percent of generation)	NPV (\$ millions)	ERR (%)
Tajikistan	2003		26.4		20 (reduced from 30 to 10)	—	—
Philippines	2004	Loss reduction	5	Yes		—	—
Moldova	2004	Loss reduction	22	Yes	5	69.2	39.3
Sub-Saharan Africa	2005	Interconnection/trading	75	No	2	—	48
Benin	2005	Access expansion	52.2	No	—	65	35
Tajikistan	2005	Commercial loss reduction	8.5	Yes	—	—	—
Albania	2005	Loss reduction	41	No	—	—	46
Senegal	2005	Access expansion	15.7	Yes	2 (reduced from 17.5 to 15.5)	—	—
Vietnam	2005	Access expansion	225	Yes	—	68.5	16.5
Sierra Leone	2005	Loss reduction	22	Yes	—	—	21
Turkey	2006	Capacity increase	150	No	—	—	15
Montenegro	2006	Capacity, outage reduction	2.1	No	—	—	13
Guinea	2006	Loss reduction	5.9	Yes	—	—	—
Bosnia and Herzegovina	2006	Loss reduction	43	No	—	—	19
Sub-Saharan Africa	2006	Interconnection/trading	55	No	3 (reduced from 5 to 2)	—	—
Lao PDR	2006	Access expansion	6	Yes	5 (reduced from 22 to 17)	281	687
Yemen, Rep.	2006	Loss reduction	48	Yes	5.5 (reduced from 25 to 19.5)	33	—
Tajikistan	2007	Loss reduction	1	Yes	5 (reduced from 18.7 to 13.7) (ex post)	—	—
Madagascar	2007	Loss reduction	2.9	Yes	—	—	—
Timor-Leste	2007	Loss reduction	1.6	Yes	—	—	—
Nigeria	2008	Loss reduction	15	Yes	10	—	—
Guinea	2008	Loss reduction	7.4	yes	—	2.29	25
Dominican Republic	2008	Loss reduction	42	Yes	8 (reduced from 15 to 7)	428	73
Ghana	2008	Loss reduction	77.4	Yes	—	—	—
Burundi	2008	Loss reduction	22	Yes	5.4 (reduced from 24.4 to 19)	—	—
Zambia	2008	Access expansion	21	No	9 (reduced from 23 to 14)	69	45
Tajikistan	2008	Loss reduction	2.3	No	—	—	—
Brazil	2008		25		—	—	—

Source: IEG component database. IEG has included some components not labeled as 'low carbon' in CEIF database.
Note: ERR = economic rate of return; NPV = net present value; T&D = transmission and distribution; WBG = World Bank Group. — = information not available.

TABLE C.2 Completed Low-Carbon Energy Efficiency Projects with Transmission and Distribution Main Focus, 1999–2009

Year	Country	T&D project cost (\$million)	Loss reduction targets	Loss reduction impacts	Expected economic effects	Ex post economic effects
1999	India (Andhra Pradesh)	260	Total losses 33%→26.4%	Total losses 38%→26.5%	ERR 37.6%	ERR 41.8%
1999	Armenia	90	Total losses 33%→18%	Total losses 33%→16.5%	ERR 24%, NPV \$106m	NPV \$1,547m
1999	Azerbaijan	9.4				
1999	Thailand	943				ERR 13% (includes generation component)
1999	Yemen, Rep. of	19.4	Total losses 39.5%→31%	Total losses 39.5%→33%		EIRR 10.5% (includes generation)
2000	Kazakhstan	367	Transmission losses 6%→5%	Transmission losses 6%→6.2%	EIRR 24.5%, NPV \$146m	EIRR 24.1%, NPV \$142m
2000	Uttar Pradesh, India	201	Technical losses 41%→30.4%	Technical losses 41%→32.8%	29% ERR	18% ERR (changed WTP assumption)
2001	Bosnia and Herzegovina	36			Improve revenue collection, 97/89/87 to 99/100/96 (%)	Improve revenue collection to 99/99/99 (%)
2001	India	1,465			17.2% ERR (sector)	15.9% (sector, using comparable assumptions)
2001	Rajasthan, India	221	Distribution losses 38%→12%	Rural feeders losses reduced 62.2%→21.1%	35% ERR (sector)	ERR 22.39% (sector), ERR 18.1% (transmission), 38.6% (distribution)
2002	Albania	40		Losses 41.8% to 41%		
2002	Nigeria	122	Technical losses 11%→8%	Technical losses 11%→9.5%	29.2%, \$76.9m	
2007	Tajikistan		Losses kept below 19%	Losses reduced 18.7→13.7%	Customer payment increased to 54%	Customer payment increased to 718%

Source: World Bank.

Note: Technical losses 33% → 26.4% means that losses were reduced from 33% to 26.4%. This is not an exhaustive list of all completed projects since 1999 that had transmission and distribution focus. ERR = economic rate of return; NPV = net present value.

FIGURE C.1 Natural Gas Prices for Industrial Users (Euros/GJ), 1998–2009

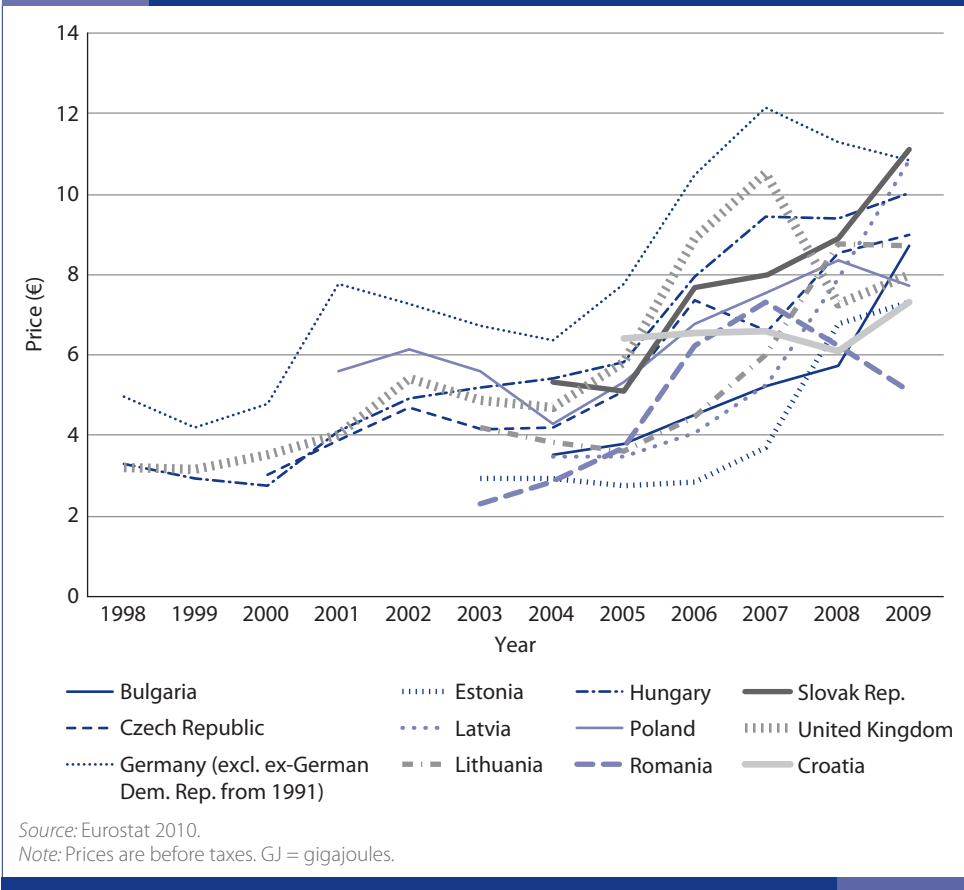


TABLE C.3 Completed CFL Project Impacts

Country, approval year	Number of CFL bulbs	Ex ante expectations	Ex post direct impact
Thailand, 1993	900,000	238-MW peak reduction, 1,427 GWh per year ^a	566-MW peak reduction, 3,140 GWh per year ^a
Jamaica, 1994	100,000	1-MW reduction, 4.4 GWh per year, 5,200 tons CO ₂	1.7-MW reduction, 5.5-GWh savings, 6,500 tons CO ₂
Mexico, 1994	1,700,000	Peak demand reduction 100 MW, Energy savings 100 MW, 1,014 GWh	Peak demand reduction 34 MW, energy savings 978 GWh
Poland, 1994	1,218,000	519-GWh overall savings, 198,000 tons CO ₂	725 GWh overall savings, 206,000 tons CO ₂ (short term)
Various (ELI), 2000		3,364-GWh energy savings, 1.8 million tons CO ₂	2,590 GWh energy savings, 1.9 million tons CO ₂
Uganda, 2001	800,000	20-MW peak demand reduction, 53,000 tons of carbon per year	20-MW reduction
Vietnam, 2003	1,000,000	33.4-MW demand saving, energy savings 40 GWh per year, 48,000 tons of carbon per year	30.1-MW peak load reduction, 45.9 GWh per year energy savings
Ethiopia, 2006	5,800,000	131-MW demand reduction, 560 GWh per year (includes street lighting as well as CFLs)	5-MW demand reduction (first 350,000 bulbs only)

Source: World Bank data.

Note: CFL = compact fluorescent light; DSM = Demand side management; ELI = efficient lighting initiative; GWh = gigawatt hour; MW = megawatt. a. Entire DSM project, not just CFLs.

TABLE C.4 Reviewed Energy Efficiency Financial Intermediation Projects

Project name	Country	WBG approval year	Approach	Closing Year
IBRD				
Bulgaria Energy Efficiency Fund (BEEF)	Bulgaria	2005	Specialized fund	2010
Croatia Energy Efficiency Project	Croatia	2003	Loan to ESCO+PCG (2) to local banks	2010
Poland GEF Energy Efficiency project	Poland	2004	Grant to ESCO+PCG to local banks	2011
Romania Energy Efficiency Fund (FREE)	Romania	2002	Specialized fund	2007
Energy Conservation Project I	China		ESCO	
IFC				
Hungary Energy Efficiency Co-financing Program (HEECP)	Hungary	1997	PCG to local banks	2001
HEECP 2	Hungary	2001	PCG to local banks	2005
Commercializing Energy Efficiency Finance (CEEF) (1)	Czech Republic, Estonia, Hungary, Latvia, Lithuania, Slovak Republic	2002	PCG to local banks	2008
OTP ESCO	Hungary	2006	PCG to local banks	2011
Russian Sustainable Energy Finance Program (RSEFP)	Russian Federation	2005	Credit lines and PCG to local banks	2010
CHUEE I	China		PCG to local banks	

Source: IEG.

Note: ESCO = energy service company; GEF = Global Environment Facility; OTP = Hungarian bank; PCG = Partial Credit Guarantee.

Lessons from Completed Transmission and Distribution Projects

Although little evidence is currently available from transmission and distribution projects approved by the World Bank over 2003–08, evaluation lessons can be drawn from previous Bank projects and reform efforts outside the Bank.

Review of these projects provides some lessons:

Large reductions in technical and nontechnical losses are feasible but are not always achieved.

A \$201 million 2000–04 Bank project in Uttar Pradesh, India, was successful in its technical component (increasing capacity and reducing losses) but unsuccessful in overall power sector reforms because of a change of government. The project was successful in reducing technical losses, from 41 percent in 2002 to 32.8 percent in 2004 (though still behind a target of 30.4 percent) but unsuccessful at reducing nontechnical losses, which remained at roughly 11 percent. The ex ante project rate of return was appraised at 29 percent, and the ex post rate of return was estimated at 18 percent (rising to 25 percent when gains to nonbilled consumers are included); the shortfall was due to a more conservative valuation of power.

Success depends crucially on local utility implementation, particularly for nontechnical loss reductions. It is difficult to reduce nontechnical losses without a local reform “champion.”

A \$40 million Bank power sector rehabilitation project in Albania carried out over 2005–06 demonstrated weak results because of poor management by local utilities. The project was designed to increase use of on-grid power and to reduce transmission and distribution losses and outages. The project failed to achieve sustained target improvements in loss reductions or bill collection. Total losses fell from 44.8 percent in 2001 to 39.7 in 2004, but they increased to 41 percent by 2006. Technical gains were difficult to estimate and were offset by increases in nontechnical losses. The economic impact of the project was poor, as expected increases in electricity sales did not eventuate.

Power sector restructuring alone has not been sufficient to improve transmission and distribution performance in countries with high losses.

A reform project in Andhra Pradesh, India, carried out by the state government (without Bank support) over 2000–03 had major success in reducing nontechnical losses (Bhatia and Gulati 2004). The state utility was in poor financial condition, with losses of \$0.9 billion in 1997. Despite power sector restructuring, new distribution utilities remained weak, billing only 42 percent of the power entering their system because of losses and nonmetered agricultural users. The utility companies undertook major institutional change, replacing meters and introducing remote-metering technology. Irregularities in billing and metering were found for 15 percent of the 23,000 industrial connections inspected in 2000–01. Total transmission and distribution losses were reduced from 38 percent in 2000 to 26 percent in 2003 through reductions in nontechnical losses caused by regularization of 2.25 million unauthorized connections.

Impacts of transmission projects are tied to activity in the generation sector. Power planning requires a systems approach. Separating transmission from generation is difficult because of their complementarity.

A Bank-supported transmission development project in Nigeria (carried out over 2004–08) highlights the impact of the generation sector on transmission investment economic returns, as well as the potential vulnerability of loss reduction gains. The project was designed to respond to critical power needs in Nigeria and an urgent request for assistance from the newly elected democratic government. It aimed to implement a major transmission system investment while supporting power sector reforms, including commercialization of the power sector. The project was also motivated by the Bank's desire for involvement in the power sector reform process. Total project cost was \$122 million (\$103 million from the International Development Association).

Transmission infrastructure investments reduced technical losses from 11 percent to 8 percent in 2007, but losses rebounded to nearly 9.5 percent by 2008 because of a combination of poor maintenance and increased power transmitted through the system transmission. Although significant gains were made in system reliability, the projected economic benefits were not realized because power generation did not increase by enough to take advantage of

the new capacity. Transmission system collapses were reduced from 15 in 2000 to 5 in 2008. The project claimed an economic rate of return of 29.2 percent and a net present value of \$76.9 million. However, these calculations assumed that grid users would switch from expensive off-grid power to cheaper on-grid power, which has not yet happened.

A Bank project in Kazakhstan further demonstrates the interplay between generation and transmission and a potential problem with using “percentage loss” project targets as a measure of project performance. The project was

implemented over 2000–05 and added significant transmission capacity to the system. The goal was for transmission losses to drop from 5.8 percent in 1998 to 5.0 percent by 2005, but losses actually increased to 6.9 percent in 2005 and 6.2 percent in 2006. However, this increase in losses was due to a 40 percent increase in generation over the period, which was the result of a booming economy. Higher power generation causes higher transmission losses, as lines become congested. Without the transmission investments from the project, losses would have been even higher.

APPENDIX E

Coal

	Afsin-Elbistan A Thermal Power Plant	Lignite Power Technical Assistance Project	Maritza East 1	Tata Mundra Ultra Mega Power Plant	Lanco Amarkantak Power Plant
WBG unit	World Bank (IBRD)	World Bank (IDA)	MIGA	IFC	IFC
Country	Turkey	Kosovo	Bulgaria	India	India
Project type	Rehabilitation	Rehabilitation and new power plant	New Plant (replacing older unit)	New Plant	New Plant
Safeguards category classification	A	B	A	A	A
Power plant size	1,355 MW	600 MW (rehab of Kosovo A) and 600 MW (new Kosovo C)	660 MW	4000 MW	600 MW
Unit sizes	3x340 MW + 1 x 335 MW	3 x 200 MW (rehab); 1 x 600 MW (new)	2 x 330 MW	5 x 800 MW	2 x 300 MW
Coal	Domestic lignite	Domestic lignite	Domestic lignite	Imported Indonesian coal	Domestic coal
Sulfur control	FGD to be installed by 2010	FGD is planned for Kosovo C, but not for Kosovo A.	FGD is part of the design	Use of low sulfur coal (0.6% S content)	Use of low sulfur coal (0.5% S content)
Type of support	Debt (Specific Investment Loan)	Technical Assistance (IDA Grant)	Political risk insurance	Senior debt	Equity
Approval date	June 6, 2006	October 12, 2006	2006	April 8, 2008	June 1, 2007
WBG support	\$336 million	\$10.5 million	Up to €99 million	\$450 million	\$8 million
Total project cost	\$481 million	Not yet defined	€1.15 billion	\$3.2 billion	\$578 million
Other components	Support for financial and generational restructuring (€3 million)	Sector policy, legal, regulatory, transactions and safeguards advice			

Source: IEG (Chikkatur background paper, drawing on public documents including World Bank Project Appraisal Documents, IFC Summary of Proposed Investment and Environmental and Social Review).
Note: MW = megawatt; WBG = World Bank Group.

TABLE E.2 Coal Plant Case Studies Emissions

	Afsin-Elbistan A Thermal Power Plant (Turkey)	Lignite Power Technical Assistance Project (Kosovo)	Maritza East 1 (Bulgaria)	Tata Mundra Ultra Mega Power Plant (India)	Lanco Amarkantak (India)
Climate obligations	Ratified Kyoto—no obligation; potential EU ETS	Not ratified UNFCCC; potential EU ETS	Ratified Kyoto. Need to reduce by 8% below 1990 emissions	Ratified Kyoto. no obligations; potential CDM credits	
Case study facility	Subcritical rehab	Kosovo C supercritical	Subcritical w/ FGD	Supercritical no FGD	Subcritical no FGD
Prior facility	Pre-rehab plant	Kosovo A	Old plants	None	None
Comparator (counterfactual) plant	Pre-rehab plant	Subcritical similar to Kosovo B	Old plants	8 units of 500 MW each, subcritical	Same plant
Lower carbon alternative	Gas	Gas	Nuclear	Gas w/LNG investment ^b	Gas w/pipeline investment ^b
Size (case study) MW	1,355	600	660	4,000	660
Size (Prior facility) MW	1,000	275	500		
Size (comparator) MW	1,000	600	500	4,000	660
CO ₂ intensity kgco ₂ /kWh (case study)	1.43	0.85	1.37	0.85 ^c	0.91
CO ₂ intensity kgco ₂ /kWh (prior facility)	1.64	1.85	2.00		
CO ₂ intensity kgco ₂ /kWh (comparator)	1.64	1.47	2.00	0.95^d	0.91
Reduction (case study/prior facility)	12.8%	<54.1%	31.5%		
Reduction (case study/comparator)	12.8%	<42.2%	31.5%	<10.5%	0.0%
CO ₂ emissions in Mt /year (case study) ^a	13.58	3.57	6.34	23.83	4.21
CO ₂ emissions in Mt /year (prior facility) ^a	11.49	3.57	7.01		
CO ₂ emissions in Mt /year (comparator) ^a	11.49	6.18	7.01	26.63	4.21
Difference in annual emission mt/year (case study-prior facility)	2.09	0.01	-0.67		
Difference in annual emission mt/year (case study-comparator)	2.09	-2.61	-0.67	-2.80	0.00
CO ₂ switching cost to lower carbon alternative (\$/tCO ₂)	\$5	\$37	Not determined	\$135/\$70 For gas at \$11/\$7 per mm BTU	\$115/\$60 For gas at \$11/\$7 per mm BTU
WBG additionality in catalyzing the investment	Not determined	Yes	Not determined	Yes	No
WBG impact on technology choice	No	Yes	No	No	No
WBG impact on reducing social and local environmental impacts	Yes	Yes	Yes (attribution to EBRD)	Yes	Yes

Source: IEG (Based on public documents and imputations).

Note: The italicized numbers reflect design parameters, bold numbers reflect intensities from operational data. In general, intensity based on actual operation would be higher than the design values. BTU = British thermal unit; CDM = Clean Development Mechanism; EBRD = European Bank for Reconstruction and Development; EU = European Union; ETS = Emissions trading scheme; FGD = Flue-gas desulfurization; LNG = liquefied natural gas; UNFCCC = United Nations Framework Convention on Climate Change; WBG = World Bank Group.

a. The annual emissions are calculated with a capacity factor of 80% in all cases.

b. LNG investment for the Tata case and the pipeline investment for the Lanco case is assumed to be \$1,000/kW.

c. The CO₂ intensity for Tata is assumed to be 0.85 kgCO₂/kWh, as per Tata's own calculation, as given in the supplemental EIA. IFC gives a rate of 0.75 kgCO₂/kWh.

d. Based on average emissions intensity of 500 MW units in India. Data based on version 5 of CEA's Baseline Carbon Dioxide Emissions from Power Sector.

APPENDIX F

Transport Tables and Figures

Region	Prereview period 1998–2002				Review period 2003–08				Postreview period 2009–present					Total 1998–present				
	GHG goal	GHG goal low	No GHG goal	Subtotal	GHG goal	GHG goal low	No GHG goal	Subtotal	GHG goal	GHG goal low	No GHG goal	N/A	Subtotal	GHG goal	GHG goal low	No GHG goal	N/A	Total
LAC	1	2	5	8	5	5	7	17	3	2	1	1	7	9	9	13	1	32
EAP		6	1	7	3	2	2	7		1		3	4	3	9	3	3	18
AFR			7	7	2	2	3	7				2	2	2	2	10	2	16
SA		2	3	5			2	2	2	2			4	2	4	5		11
ECA			6	6			1	1								7		7
MNA			4	4			2	2			1		1			7		7
Total	1	10	26	37	10	9	17	36	5	5	2	6	18	16	24	45	6	91

Source: World Bank project documents.
Note: **GHG goal** includes operations with explicitly designed components to address carbon reduction with corresponding performance indicators and systems to track and monitor progress. **GHG goal low** includes other operations that explicitly mention carbon benefits (avoiding global warming) and assume fuel savings or mode shifting that could have carbon reduction potential, but that do not monitor or track carbon reductions. **No GHG goal** includes all other operations that do not mention GHG reduction explicitly. GHG = greenhouse gas.
Regions: LAC = Latin America and the Caribbean; EAP = East Asia and Pacific; AFR = Sub-Saharan Africa; SA = South Asia; ECA = Europe and Central Asia; MNA = Middle East and North Africa. N/A Project document not available.

TABLE F.2 Number of Operations with GHG-Reduction Objectives, by Mode and Subperiod

GHG objective	Prereview period 1998–2002			Review period 2003–08			Postreview period, after 2008				Total				
	GHG goal	GHG goal low	No GHG goal	GHG goal	GHG goal low	No GHG goal	GHG goal	GHG goal low	No GHG goal	N/A	GHG goal	GHG goal low	No GHG goal	N/A	Total
Totals	1	10	26	10	9	17	5	5	2	6	16	24	45	6	91
A) No PT investments ^a			8			6			1				15		15
B) Traditional PT investments			11			2							13		13
<i>a) Traditional bus improvements</i>			2										2		2
<i>b) No dominant PT mode^b</i>			9			2							11		11
C) Urban rail investments		3	6		2	2		3				8	8		16
<i>a) commuter rail</i>		3	5		2	1		3				8	6		14
<i>b) Metrolight rail</i>			1			1							2		2
D) Newer PT investments	1	5		8	6	5	4	1	1	6	13	12	6	6	37
<i>a) Dedicated bus lanes</i>		5			3	1						8	1		9
<i>b) Proto-BRTS</i>				2	2			1		3	2	3		3	8
<i>c) BRTS</i>	1			6	1	4	4		1	3	11	1	5	3	20
E) Other interventions ^c		2	1	2	1	2	1	1			3	4	3		10
<i>a) NMT</i>		1										1			1
<i>b) Local air quality</i>		1		2	1		1	1			3	3			6
<i>c) Technical assistance</i>			1			2							3		3

Source: World Bank project documents.

Note: BRTS = bus rapid transit system; GHG = greenhouse gas; N/A = project document not available; NMT nonmotorized travel; PT = public transport.

a. Includes operations with explicitly designed components to address carbon reduction with corresponding performance indicators and systems to track and monitor progress.

b. Includes other operations that explicitly mention carbon benefits (avoiding global warming) and assume fuel savings or mode shifting that could have carbon reduction potential, but that do not monitor or track carbon reductions.

c. Includes all other operations that do not mention GHG reduction explicitly.

Energy Project Portfolio Databases

CEIF Database (Master Energy Database)

Scope 2003–08

This database, compiled by the World Bank Energy Anchor, was the starting point for IEG's analysis. Although the Clean Energy Investment Framework (CEIF) was formulated in 2005, the database was backfilled to include projects approved in 2003. It covers all World Bank Group energy projects across the International Bank for Reconstruction and Development/International Development Association, the Global Environment Fund, Carbon Finance, International Finance Corporation, and the Multilateral Investment Guarantee Agency.

The unit of observation is the project component.

Component type categories include—

- Oil (extractive industries and downstream, excluding generation)
- Gas (extractive industries and downstream, excluding generation)
- Coal (extractive industries and downstream, excluding generation)
- Energy efficiency
- New renewable energy, broken down by technology, for example, wind, small hydro, solar photovoltaic, solar thermal, geothermal, and bioenergy. If there is more than one technology supported by the component, the general category “New Renewable Energy” is assigned. New Renewable Energy excludes hydropower > 10 MW.
- Large hydro
- Thermal generation (oil, gas or coal, specified)
- Transmission and distribution
- Other (including policy operations, environmental assessment).

Components were also mapped to the following groups:

- *Low carbon*: Renewable energy projects (including all hydropower), energy efficiency, rehabilitation of power plants, district heating, biomass waste-fueled energy; reduction of gas flaring, transmission and distribution components that target low carbon and/or energy efficiency, and other—investments with lower carbon goals.
- *Access*: Those that increase access to electricity services. In IDA countries, all investments in generation

and transmission and distribution are assigned to the category of Access (as they all aimed to increase electrification); in IBRD countries only electricity access projects and rural electrification projects are considered as “Access.”

- *Blended low carbon and access*: Those access projects that use low carbon energy options to increase access to electricity.
- *Transmission and distribution, oil and gas; other thermal generation*: projects that do not specifically target lower carbon or energy efficiency (some transmission and distribution is classified under low carbon, however).
- *Other energy*: Projects with energy policy support (Development Policy Loans) or projects for which energy form cannot be defined clearly or that have multiple energy subsector support—that do not target lower carbon and/or energy efficiency.

IEG review of the database

For this evaluation, IEG reviewed and modified the 2003–08 CEIF database as follows.

Some components were further disaggregated, based on descriptions in appraisal documents. For instance, an \$87 million component labeled “New Renewable Energy” was disaggregated into subcomponents: a \$20 million biomass facility and a \$67 million wind project.

IEG used budget allocations reported in the appraisal document rather than the sectoral percentage assignments used for project classification. For instance, the Turkey Renewable Energy project is a \$202 million operation designed to support development of the renewable energy, providing financing via Turkish banks to private developers. CEIF recorded this project as \$101 million operation, because the project was officially allocated among the following sectors: central government administration (10 percent), micro- and small and medium enterprise finance (40 percent), and renewable energy (50 percent). IEG classified the entire expenditure as financing for renewable energy development (\$202 million), including large hydropower, geothermal energy, and wind (as in the Project Assessment Document). For this reason, IEG's reckoning of commitment amounts sometimes exceeded the CEIF's.

IEG eliminated a few cases of double counting, usually involving GEF-funded components.

IEG identified some components that did not have clear low-carbon content, based on review of project documents. These projects were excluded from the scope of the Climate II database.

CEIF designates some transmission and distribution projects as “low carbon,” but not others. In principle, improvement of existing systems is considered as energy efficiency, as opposed to construction of new systems. In practice, some of the transmission and distribution projects discussed in chapter 3 appear to result in loss reductions but are not included in either the CEIF or IEG tally of low-carbon projects.

IEG added information and codes describing component or project objectives, technologies, instruments, and capacity (if applicable).

Bonn Commitment Database and Renewable Energy and Energy Efficiency WBG Progress Reports

Scope 1990–2008

At the Bonn International Conference on Renewable Energies in 2004, the WBG made a commitment to accelerate its support for new renewable energy and energy efficiency and committed to increase its financing for new renewable

energy and energy efficiency at a growth rate of 20 percent per annum between fiscal years 2005 and 2009, compared to a baseline commitment of \$209 million (equal to the average of the previous three years).

The World Bank reported on this commitment annually. For Bonn Commitment purposes, relevant project types were solar, wind, geothermal, biomass energy, hydropower of 10 MW or less, waste to energy, and energy efficiency (demand-side management and end-use energy efficiency, supply side energy efficiency—including mass transit system). Large hydropower (>10 MW) was tallied but not counted toward the Bonn Commitment. A comparable database, but with different criteria for energy efficiency, was backfilled to 1990.

The following project types are classified by CEIF as low-carbon but are not counted toward the Bonn Commitment:

- Policy reform loans (except where directly concerned with renewable energy and energy efficiency)
- Reduction of gas flaring
- High-efficiency thermal plants are classified in CEIF as a low carbon, but not included in Progress Report/Bonn Commitment data
- Industrial low carbon investments
- Landfill gas capture without utilization.

APPENDIX H

Pilot and Demonstration Projects

TABLE H.1 Assessment of Monitoring and Implementation Plans from Low-Carbon Energy Projects with Pilot or Demonstration Objectives, 2007–09

Project and location	Year	Bank commitment to project (millions)	Product line	What is being demonstrated?	To whom?	Assessment of monitoring and evaluation (0 = no details, 1 = moderate, 2 = strong)		
						Internal project outcome	Logical framework for demonstration	Demonstration impact
Small Scale Livestock Waste Management Program, Thailand	2009	\$6.39	Carbon offset	Effectiveness of techniques for reducing methane emissions through improved livestock waste management; economic viability of adopting these techniques when supported by carbon financing	Livestock producers in Thailand	2	0	0
Rural Energy Access Project, Republic of Yemen	2009	\$26.4	IDA	Feasibility of increasing energy access to rural households using SHS	Donor agencies that might fund scale-up projects	1	1	0
Renewable Energy Development Project, Vietnam	2009	\$200	IDA	Financial viability of small-scale grid-connected renewable energy projects	Commercial banking sector	1	1	1
Coal-Fired Generation Rehabilitation Project, India	2009	\$180 (IBRD) \$25.4 (GEF)	IBRD GEF	Effectiveness and financial viability of energy-efficient rehabilitation of coal plants (versus replacement); effectiveness of framework for implementation, risk mitigation and post-rehabilitation O&M of energy efficiency renovation and modernization	Government of India, electricity utilities in India	2	2	1
Emergency Power Project, Central African Republic	2009	\$8	IDA	Effectiveness of prepaid meters in reducing nontechnical losses from power distribution (pilot)	Enerca (power utility)	Unknown	2	Unknown
Regional Sustainable Transport and Air Quality Project, LAC Region	2009	\$40	GEF	Effectiveness of transport investments in improving air quality	Other cities in Latin America and Caribbean Region	2	2	1

TABLE H.1 Assessment of Monitoring and Implementation Plans from Low-Carbon Energy Projects with Pilot or Demonstration Objectives, 2007–09 (continued)

						Assessment of monitoring and evaluation (0 = no details, 1 = moderate, 2 = strong)		
Project and location	Year	Bank commitment to project (millions)	Product line	What is being demonstrated?	To whom?	Internal project outcome	Logical framework for demonstration	Demonstration impact
Bioenergy Sugar Ethanol Wastewater Management Process, Thailand	2009	€4.5	Carbon offset	Technology for methane capture from wastewater treatment		2	0	0
Energy Efficiency Project, Montenegro	2009	\$9.4	IBRD	Feasibility of energy efficiency program in public sector	Public agencies in Montenegro	1	0	0
Thermal Power Efficiency Project, China	2009	\$19.7	GEF	Viability of efficiency improvements in thermal power plants	Power utilities in China.	2	2	1
Ecofarming Project, China	2009	\$120	IBRD	Technology best practice for integrating biogas into production systems	Local governments in China.	2	1	0
GEF-World Bank Urban Transport Partnership, China	2008	\$21.0	GEF	Series of high-profile demonstration projects that will create models of sustainable transport solutions	Local governments, municipalities, transport authorities	2	2	1
GEF Increased Access to Electricity Project, Zambia	2008	\$4.5	GEF	Pilot “Sustainable Solar Market Packages (SSMP)” —preparation of nine sustainable solar market packages	Rural Energy Agency—to provide solar photovoltaic energy to public institutions, households, commercial consumers	2	1	0
Energy Access Project, Burkina Faso	2008	\$38.8 (pilot \$1 million)	IDA	Inerfuel substitutions: Pilot activities leading potentially to the production of biofuels from Jatropha, cotton, and other agricultural residues	Private sector, households	1	0	0
Energy Development & Access Expansion Project, Tanzania	2008	\$111.5	GEF/IDA	Loss reduction in distribution systems. Rural energy agency is piloting schemes for off-grid and energy expansion. Scale up of pilot activities: solar photovoltaic, small PPA	Consumers in energy efficiency component. Private sector, cooperatives, NGO—renewable energy component	2	1	0
Electricity Distribution and Transmission Project, Pakistan	2008	\$256.7	IDA	Pilot energy efficiency program, involving installation of energy saving equipment at the customer level	Utilities	2	0	0

(continued)

TABLE H.1 Assessment of Monitoring and Implementation Plans from Low-Carbon Energy Projects with Pilot or Demonstration Objectives, 2007–09 (continued)

						Assessment of monitoring and evaluation (0 = no details, 1 = moderate, 2 = strong)		
Project and location	Year	Bank commitment to project (millions)	Product line	What is being demonstrated?	To whom?	Internal project outcome	Logical framework for demonstration	Demonstration impact
Electricity Sector Efficiency Improvement Project, Guinea	2008	\$11.7	GEF	Pilot operation focusing on improvement of commercial and technical efficiencies	Government, utilities	2	1	1
Liaoning Medium Cities Infrastructure Project III, China	2008	\$191.0	IBRD	Contribute to implementation of heating reform by implementing in new heat-only boiler and CHP supplied systems: piloting technical approaches in network design through use of about 150 building-level substations and in metering through use of building-level meters	Provincial government, heating companies/utilities	2	2	1
Integrated Solar Combined Cycle Power Project, Morocco	2007	\$43.2	GEF	Demonstration of operational viability of hybrid solar thermal power generation (dissemination of information)	ONE (utility), government, private sector	2	2	1
Renewable Energy for Rural Access, Mongolia	2007	\$7.0	GEF/IDA	Demonstration of technical models for small hybrid systems in the extreme climate conditions of Mongolia (dissemination of information, public awareness)	Herders, private sector	2	2	1
Hybrid Solar Thermal Integrated Cycle, Mexico	2007	\$49.4	GEF	Demonstrate the operational viability and value added of integrating a solar field with a large conventional thermal facility	Utility, private sector	2	1	0
Furatena Energy Efficiency Project, Colombia	2007	\$1.1	Carbon finance	Demonstration pilot to exemplify a new approach to panela (sugar cane) production and commercialization	Hillside sugar cane producers	2	0	0
Urban Transport Project, Ghana	2007	\$8.0	GEF	BRT Infrastructure design and implementation	Local governments, transportation authorities	2	0	0

Source: World Bank data.

Note: CHP = combined heat and power; GEF = Global Environment Facility; IBRD = International Bank for Reconstruction and Development; IDA = International Development Association; LAC = Latin America and the Caribbean Region; NGO = nongovernmental organization; O&M = operations and maintenance; PPA = Power purchase agreement; SHS = solar home system.

APPENDIX I

Carbon and Economic Returns of Projects

TABLE I.1 Carbon and Economic Returns on Projects			
Type	ERR (%)	Lifetime CO ₂ reductions (kg per \$ investment)	Data source (appraisal, evaluation)
CFL	714	80	Appraisal
CFL	122	26.7	Evaluation
CFL	178	134	Appraisal
T&D	43.2	6.8	Appraisal
T&D	16.5	10.6	Appraisal
T&D	22.4	14.9	Evaluation
Off-grid solar	93.4	3.1	Evaluation
Off-grid solar	31.0	11.8	Evaluation
energy efficiency finance	20.0	23.4	Evaluation
Financial intermediary energy efficiency	22.0	61.4	Evaluation
Financial intermediary energy efficiency	20	117.2	Evaluation
Direct energy efficiency	143	160.3	Appraisal
Large hydro	18.1	57.2	Appraisal
Large hydro	7.0	15.4	Appraisal
Large hydro	17.1	21.8	Appraisal
Medium hydro run-of-river	18.0	42.8	Appraisal
Hydro	6.7	42.4	Appraisal
Hydro run-of-river	2.9	32.9	Appraisal
Medium hydro run-of-river	11.9	37.3	Appraisal
Medium hydro run-of-river	14.3	77.9	Appraisal
Medium hydro run-of-river	14.7	75.4	Appraisal
Medium hydro reservoir	16.5	82.8	Appraisal
Medium hydro	13.3	76.0	Appraisal
Medium hydro	9.5	25.4	Appraisal
Hydro run-of-river	12.7	49.5	Appraisal

TABLE I.1 Carbon and Economic Returns on Projects (continued)

Hydro run-of-river	8.7	76.9	Appraisal
Hydro run-of river	4.7	71.1	Appraisal
Mini-hydro	24	61.2	Evaluation
Wind	11.9	15.0	Appraisal
Wind	11.3	13.2	Appraisal
Wind	5.5	14.1	Appraisal
Wind	7.1	10.0	Appraisal
Wind	12.5	34.7	Appraisal
Wind	7.0	16.8	Appraisal
Wind	14.7	41.0	Appraisal
Wind	3.9	14.9	Evaluation
BRT	81	9.6	Appraisal

Source: World Bank data.

Note: BRT = bus rapid transit; CFL = compact fluorescent light; T&D = transmission and distribution.

Caveats:

- These estimates have many limitations and are presented to indicate rough orders of magnitude and to illustrate the need for more thorough and rigorous analysis.
- Estimates—all adapted from WBG project documents—are mostly based on ex ante appraisals and could be overly optimistic. They are not produced with consistent methodologies or rigor.
- Carbon reductions per dollar consider only investment costs; operations and maintenance are excluded.
- Economic rates of return (ERRs) typically do not include nonmonetized benefits such as reduction in local air pollution or the value of increased energy security.
- ERRs take the electricity tariff (and any associated capacity payments) to represent the economic value of electricity (except in the case of solar home photovoltaics). In many cases tariffs are artificially low, so this will be an underestimate.
- In this sample, wind projects receive tariffs that are 2.2 times higher, on average, than the tariffs received by hydropower plants. Hence these estimates should not be used for a head-to-head comparison of wind and hydro.
- Lifetime emission reductions are based on approximations of project lifetime. Grid power plants are assumed to provide emission reductions for 20 years; solar home photovoltaic systems 15 years; bus rapid transit 14 years; energy efficiency projects, transmission and distribution projects and off-grid power have an assumed lifetime of 10 years; compact fluorescent light bulb life is 6 years. To the extent that projects provide emission reductions beyond this, emission reductions are understated.
- ERR values for compact fluorescent light bulb projects generally include only fuel savings; they do not also include the value of deferring the need for construction of peak load plants, or reductions in load shedding.
- Much of the variation in emission reductions (particularly for hydro) comes from variation in the carbon intensity of the baseline power generation being displaced by the project.
- Energy efficiency financial intermediary project ERR counts all benefits from subproject investments, regardless of whether they were triggered by WBG involvement.
- For direct investments in energy efficiency, the (relatively small) costs of energy audits are excluded.
- Most of the economic benefits from offgrid solar come from studies that find high household willingness to pay for electrical power.

Recent WBG Developments in Emission Mitigation Activities

The main body of this paper and portfolio analysis has focused on the 2003–08 period. As noted, there has been an increase in climate-related activity since the 2008 adoption of the Strategic Framework on Development and Climate Change. This appendix provides a descriptive review of key developments since 2008, including the 2009 energy portfolio, the Climate Investment Funds, the Carbon Partnership Facility, the Forest Carbon Partnership Facility, and the Low Carbon Growth Studies program of the Energy Sector Management Assistance Program. These areas have not been evaluated in detail or fully validated by IEG analysis.

2008–09 Energy Portfolio Developments

The growth in support for low carbon energy activities continued in fiscal 2009, reaching annual commitments of more than \$3.3 billion. Low carbon financing constitutes roughly 40 percent of the energy portfolio. Although IEG has not formally validated the CEIF 2009 low carbon portfolio classification, the CEIF definitions have been very similar to IEG's reckoning of low carbon support in the past (see figure J.1).

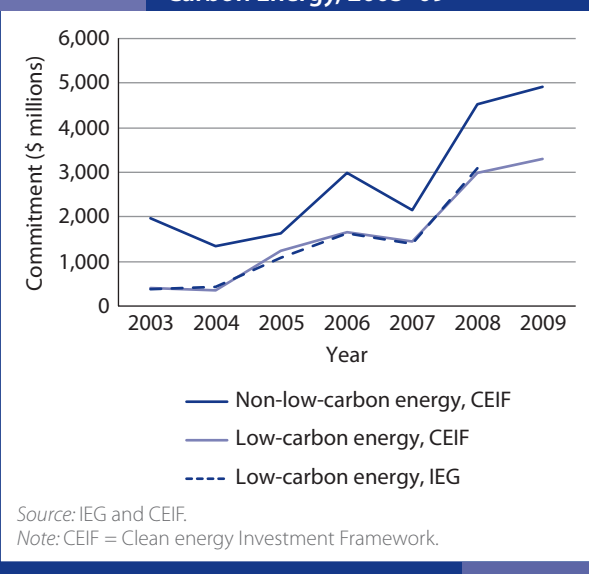
Most financing continues to come from traditional (IDA, IBRD, and International Finance Corporation) funding sources, with the proportion coming from traditional financing increasing in 2009.

For the first time, more than half of the low carbon portfolio is for energy efficiency, though support for new renewables has also increased markedly.

The increase in financing for low carbon projects in fiscal 2008 and 2009 comes primarily from a few large investments. In fiscal 2008, most financing for energy efficiency and large hydropower was provided by stand-alone projects; 26 percent came from just three IBRD projects: India Rampur Hydropower Project (\$395 million), China Energy Efficiency Financing (\$200 million), and China Liaoning Med. Cities III (an energy efficiency project, \$185 million).

The following year, the portfolio was dominated by large energy efficiency investments; 40 percent of financing came from 5 World Bank projects: Turkey Private Sector Renewable Energy and Energy Efficiency Project (\$500 million

FIGURE J.1 Financing for Low and Non-Low Carbon Energy, 2003–09



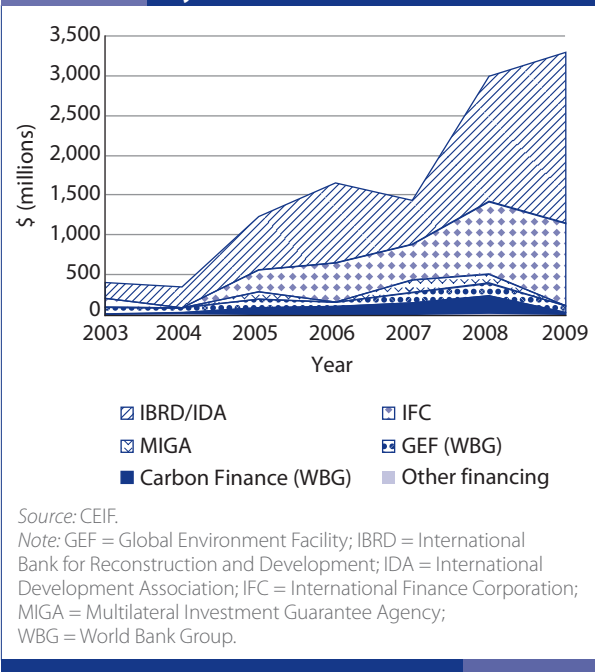
IBRD), India Coal-Fired Generation Rehabilitation (\$225 million), Turkey Programmatic Electricity Sector Development Policy Loan (\$200 million), Vietnam Renewable Energy Development Project (\$199 million), and Nigeria Electricity and Gas Improvement (\$182 million).

Recent Activities: Climate Investment Funds

In 2008 the WBG and other multilateral development banks jointly established the \$6.2 billion Climate Investment Funds. The core of the Climate Investment Fund is the \$5.1 billion Clean Technology Fund (CTF), aimed at financing demonstration, large-scale deployment and transfer of low-carbon technologies in large or middle-income countries.

CTF financing eligibility requires the creation of country or sector investment plans, and then selects projects for financing on the basis of potential for greenhouse gas savings, cost-effectiveness, demonstration potential at scale, development impact, implementation potential, and additional costs and risk premium. Eligible technologies include the power sector, transportation, and energy efficiency in buildings, industry, or agriculture.

FIGURE J.2 Low-Carbon Energy, 2003–09, by Product Lines



To date, the CTF has supported creation of investment plans for 12 countries, and for Concentrated Solar Power in the Middle East and North Africa Region. Together these represent planned investments of \$40 billion, of which \$4.4 billion would be from CTF funds. Since May 2009, seven projects have been approved, five of which will be administered by the WBG and the rest by other multilateral development banks. The WBG projects support wind power in Egypt and Mexico, urban transport in Mexico, renewable energy in Thailand, and a mix of renewable energy and energy efficiency in Turkey.

The second part of the Climate Investment Fund is the Strategic Climate Funds. With an initial capitalization of \$250 million, the Funds aim to provide financing to pilot projects that target specific climate change challenges or sector responses in five to ten low-income countries. The Strategic Climate Fund is currently supporting three programs. The Pilot Program for Climate Resilience funds resilience projects and integration of resilience considerations into national development plans; the Forest Investment Program supports capacity building for forest governance and investments to reduce pressure on forests; and the Scaling up Renewable Energy Program supports actions to remove barriers that inhibit private sector investment in renewable energy in low-income countries. Whereas the CTF supports both renewable energy and energy efficiency, the much smaller, low-income-oriented Scaling up Renewable Energy Program supports only renewable energy.

Carbon Partnership Facility

The Carbon Partnership Facility (CPF) was established in 2007 as a response to uncertainty about the post-2012 international climate regime and the associated limited demand for post-2012 carbon assets. It is designed to develop and market emission reductions on a larger scale by providing carbon finance to investments that will deliver post-2012 emission reduction assets.

The CPF intends to scale up carbon finance by supporting programmatic and sector-based approaches to reduce greenhouse gas emissions and by collaborating with government and market participants. It will operate in traditional sectors (power, gas flaring, transport, waste management systems, and urban development), in sectors that have not been reached by the Clean Development Mechanism (urban transport and energy efficiency), and will pilot city-wide carbon finance programs.

CPF will draw on the World Bank's financial and knowledge resources to strategically integrate carbon finance with sustainable development plans. The emphasis on creating long-term credit streams will be attractive to both buyers and sellers, who prefer certainty in their offset requirements and revenue streams.

The CPF framework creates two funds. The Carbon Asset Development Fund supports the preparation of emission reduction programs, including grants. It provides funding for methodology development, emission reduction program identification and development, and asset feasibility, Project Design Document development and monitoring plan. In addition, the Fund covers all facility costs for emission reduction program preparation. The main sources of funding for CADF are buyers' payments and donors' contribution (about €2 million from each donor).

The Carbon Fund will purchase the emission reductions generated by the CPF programs. This fund became operational in May 2010 with €100 million in assets.

As of July 2010 the emission reduction program has signed agreements with a Moroccan solid waste management program (related to recent World Bank Development Policy Loans in Morocco on waste management), a Vietnam renewable energy program (corresponding to a World Bank loan in 2009), a Brazil solid waste management program, and an Amman city-wide program. In addition, there are 13 different programs under development in East and South Asia, Europe and Central Asia, the Middle East and North Africa, and the Africa Regions.

Forest Carbon Partnership Facility

The Forest Carbon Partnership Facility is designed to reduce emissions from deforestation and forest degradation

by providing value to standing forests. It also seeks to provide incentives and financing for the sustainable use of forest resources and biodiversity conservation. The Facility became operational in 2008.

The facility has two parts: a readiness mechanism, supported by the Readiness Fund, and a carbon finance mechanism, supported by the Carbon Fund. Under REDD Readiness, the Forest Carbon Partnership Facility will help developing countries prepare national reference scenarios for emissions from deforestation and forest degradation, develop country-owned strategies for reducing deforestation and forest degradation, and establish national measurement, reporting and verification systems for REDD. The Carbon Fund will pilot and test REDD carbon transactions in the countries that have established a sound national framework through the readiness mechanism.

Thirty-seven REDD countries had been selected for the readiness mechanism by the end of fiscal 2009 (compared with the original design target of 20). Thirty of these had signed participation agreements, and 18 had submitted detailed grant proposals (with three of the grant agreements fully signed). In this first year, the Facility has increased the target volume for the Readiness Fund from \$100 million to about \$185 million; as of March 2010 the Readiness Fund has \$115 million.

By the end of fiscal 2009 each country's Readiness Preparation Idea Note was submitted to the Facility and received one to three Technical Advisory Panel reviews/discussions, Facility Management Team reviews, and informal reviews by World Bank country teams.

REDD methodology support claims progress in the following areas: establishing the first Team Advisory Panel; developing instruments to support the process of the Readiness Mechanism; advancing thinking on reference scenarios, REDD modeling efforts, reporting and verification systems, and economic analysis of the costs of REDD; and creation of a capacity-building program for forest-dependent indigenous peoples and other forest dwellers.

Recent Activities: Low-Carbon Growth Studies

Starting in 2006, ESMAP's Low-Carbon Growth Country Studies Program began helping Brazil, China, India, Indonesia, Mexico, and South Africa assess their development goals and greenhouse gas mitigation strategies. The centerpiece of the program is a series of country studies designed to identify low carbon opportunities across a range of sectors, including energy, transport, waste, and land use/land use change. The studies or summary case studies have been publically released for Mexico, Brazil, and India. Most studies generate a baseline scenario and a low carbon alternative and describe the technical solutions by which the alternative could be achieved. Energy

access objectives are not highlighted in the studies published so far.

The studies recognize that climate change harms development and that mitigation actions form part of a development strategy. In each case, the studies recognize the vulnerabilities of the particular country to climate change, and thus the need for both mitigation and adaptation. However, they generally support the need for mitigation through an international climate agreement, and emphasize that any mitigation obligations must not harm the development rights of the poor. Low carbon development is also emphasized as a means of supporting negative cost no-regrets options, energy security, nonclimate pollution reduction, and ability to access carbon market opportunities.

Though the studies consider mitigation options in each sector sequentially, they attempt to take a systemic approach by making cost comparisons across sectors. Most studies develop a unified marginal abatement cost curve, where options are ranked by cost and scope. These lead to different strategies across countries, depending on the specific details of each case. In each case, there are many negative or zero cost changes, particularly in energy efficiency or land use change.

For example, for Brazil, the emphasis is on agriculture and deforestation, with emission reduction goals of 11.7 GtCO₂e per year. There are few low-cost mitigation options in the energy and transport sectors, because emission intensity is already low by international standards because of the reliance on hydropower and ethanol fuel. The Brazil study identifies negative cost options for roughly 1.1 GtCO₂e per year (mostly energy efficiency) and a further 7.1 GtCO₂e per year of roughly zero cost changes for avoided deforestation, livestock and zero-tillage cropping options.

For Mexico, the emphasis is still on agriculture and forestry, but energy and transport are also important in achieving emission reductions of 5.3 GtCO₂e per year. Under the low carbon scenario, the share of power from coal would drop from 31 to 6 percent, of which roughly 23.5 percentage points would come from increases in geothermal, biomass, wind, and small hydropower sources. Negative cost interventions would save 3.4GtCO₂e per year, including bus system optimization, cogeneration, charcoal production improvements, fuel economy standards, biomass power and improved cookstoves.

The strategies recognize that energy efficiency (including transport efficiency) and demand-side management will play a major role in any cost-effective mitigation strategy. In nearly every case, the scope for efficiency improvements is large and can be achieved at lower cost than increases in increasing generation through renewable energy.

Energy access issues were considered in the India study, though not in Brazil, China, or Mexico.

Evaluation Summary from Climate Change and the World Bank Group—Phase I

Climate change threatens to derail development, even as development pumps ever-greater quantities of carbon dioxide into an atmosphere already polluted with two centuries of Western emissions. The World Bank, with a newly articulated Strategic Framework on Development and Climate Change, must confront these entangled threats in helping its clients to carve out a sustainable growth path.

But this is known territory—many of the climate change policies under discussion have close analogues in the past. This phase of the evaluation, focused on the World Bank (and not the International Finance Corporation or the Multilateral Investment Guarantee Agency), assesses the World Bank's experience with key win-win *policies* in the energy sector—policies that combine gains at the country level with globally beneficial greenhouse gas (GHG) reductions. The next phase will look across the entire World Bank Group at *project-level* experience in promoting technologies for renewable energy and energy efficiency and at some issues related to climate change in the Bank's transport and forestry portfolios.

Within the range of win-win policies, this report examines two that have long been discussed but are more relevant than ever in light of record energy prices: removal of energy subsidies and promotion of end-user energy efficiency. Energy subsidies are expensive, damage the climate, and disproportionately benefit the well off. Their reduction can encourage energy efficiency, increase the attractiveness of renewable energy, and allow more resources to flow to poor people and to investments in cleaner power. Though subsidy reduction is never easy, the Bank has a record of accomplishment in this area, especially in the transition countries. About a quarter of Bank energy projects included attention to price reform. Improvements in the design and implementation of social safety nets can help to rationalize energy prices while protecting the poor.

End-user energy efficiency has long been viewed as a win-win approach with great potential for reducing emissions. It becomes increasingly attractive as the costs of constructing and fueling power plants rise. About 5 percent of the Bank's energy commitments *by value* (about 10 percent *by number*)

have gone to specific efficiency efforts, including end-user efficiency and district heating. Including a broader range of projects identified by management as supporting supply-side energy efficiency would boost the proportion above 20 percent by number. Few projects tackled regulatory issues related to end-user efficiency, though the Bank has invested in some technical assistance and analytical work. This historical lack of emphasis on energy efficiency is not unique to the Bank and reflects the complexity of pursuing end-user efficiency, a pervasive set of biases that favor electricity supply over efficiency, inadequate investments in learning, and inattention to energy systems in the wake of power sector reform.

The record levels of energy prices in 2008, although they have been relaxed, provide an impetus for the Bank and its clients to choose more sustainable long-term trajectories of growth. The mid-2008 oil price was equivalent to the 2006 price, plus a \$135 per ton tax on carbon dioxide—the kind of level that energy modelers say is necessary for long-term climate stabilization. To help clients cope with the burden of these prices, and take advantage of the signals they send for sustainability, the Bank can do four things:

1. It can make promotion of energy efficiency a priority, using efficiency investments and policies to adjust to higher prices and constructing economies that are more resilient.
2. It can assist countries in removing subsidies by helping to design and finance programs that protect the poor and help others adjust to higher prices.
3. It can promote a systems approach to energy.
4. And it can motivate and inform these actions, internally and externally, by supporting better measurement of energy use, expenditures, and impacts.

Goals and Scope

This evaluation is the first of a series that seeks lessons from the World Bank Group's experience on how to carve out a sustainable growth path. The World Bank Group has

never had an explicit corporate strategy on climate change against which evaluative assessments could be made. However, a premise of this evaluation series is that many of the climate-oriented policies and investments under discussion have close analogues in the past, and thus can be assessed, whether or not they were explicitly oriented to climate change mitigation.

This report, which introduces the series, focuses on the World Bank (International Bank for Reconstruction and Development and International Development Association), and not on the International Finance Corporation (IFC) or the Multilateral Investment Guarantee Agency (MIGA). It assesses its experience with key win-win *policies* in the energy sector: removal of energy subsidies and promotion of end-user energy efficiency. The next phase looks at the expanding project-level experience of the Bank and the IFC in promoting technologies for renewable energy and energy efficiency; it also addresses the role of carbon finance. A parallel study examines the role of forests in climate mitigation. The climate evaluation's final phase will look at adaptation to climate change.

Motivation

Operationally, the World Bank has pursued three broad lines of action in promoting the mitigation of GHG emissions, the main contributor to climate change. First, it has mobilized concessional finance from the Global Environment Facility (GEF) and carbon finance from the Clean Development Mechanism to promote renewable energy and other GHG-reducing activities. Second, and to a much more limited extent, it has used GEF funds to stimulate the development of noncommercial technologies. Third, and the subject of this evaluation, it has supported win-win policies and projects—sometimes with an explicit climate motivation, often without.

These actions not only provide global benefits in reducing GHGs, but also pay for themselves in purely domestic side benefits such as reduced fuel expenditure or improved air quality. The win-win designation obscures the costs that these policies may impose on particular groups, even while benefiting a nation as a whole. This presents challenges for design and implementation.

Two sets of win-win policies are perennial topics of discussion in the energy sector: reduction in subsidies and energy-efficiency policies, particularly those relating to end-user efficiency. This report looks at these, and at another apparently win-win topic: gas flaring. Flaring is interesting because of its magnitude, the links to pricing policy and to carbon finance, and the existence of a World Bank-led initiative to reduce flaring.

Findings

Development spurs emissions.

A 1 percent increase in per capita income induces—on average and with exceptions—a 1 percent increase in GHG emissions. Hence, to the extent that the World Bank is successful in supporting broad-based growth, it will aggravate climate change.

But there is no significant trade-off between climate change mitigation and energy access for the poorest.

Basic electricity services for the world's unconnected households, under the most unfavorable assumptions, would add only a third of a percent to global GHG emissions, and much less if renewable energy and efficient light bulbs could be deployed. The welfare benefits of electricity access are on the order of \$0.50 to \$1 per kilowatt-hour, while a stringent valuation of the corresponding carbon damages, in a worst-case scenario, is a few cents per kilowatt-hour.

Country policies can shape a low-carbon growth path.

Although there is a strong link between per capita income and energy-related GHG emissions, there is a sevenfold variation between the most and least emissions-intensive countries at a given income level. Reliance on hydropower is part of the story behind these differences, but fuel pricing is another. High subsidizers—those whose diesel prices are less than half the world market rate—emit about twice as much per capita as other countries with similar income levels. And countries with longstanding fuel taxes, such as the United Kingdom, have evolved more energy-efficient transport and land use.

Energy subsidies are large, burdensome, regressive, and damage the climate.

The International Energy Agency's 2005 estimate of a quarter-trillion dollars in subsidies each year outside the Organisation for Economic Cooperation and Development may understate the current situation. While poor people receive some of these benefits, overall the benefits are skewed to wealthier groups and often dwarf more progressive public expenditure. Fuel subsidies alone are 2 to 7.5 times as large as public spending on health in Bangladesh, Ecuador, the Arab Republic of Egypt, India, Indonesia, Morocco, Pakistan, Turkmenistan, República Bolivariana de Venezuela, and the Republic of Yemen. At the same time, subsidies encourage inefficient, carbon-intensive use of energy and build constituencies for this inefficiency.

The Bank has supported more than 250 operations for energy pricing reform.

Success has been achieved in the transition countries—in Romania and Ukraine, for example, where energy prices

were adjusted toward market levels, and the intensity of carbon dioxide emissions dropped substantially. Subsidy removal can threaten the poor, however. Recent efforts to assess poverty and welfare impacts systematically appear to have informed the design and implementation of price reform efforts, though not necessarily with direct Bank involvement. Examples include Ghana and Indonesia, where compensatory measures were deployed in connection with fuel price rises.

The Bank has rarely coordinated efficiency improvements with subsidy reductions to lighten the immediate adjustment burden on energy users.

An exception is the China Heat Reform and Building Efficiency Project, which links improved insulation with heat pricing. A growing number of projects sponsor nationwide distribution of compact fluorescent light bulbs, but this has been done in response to power shortages (Rwanda, Uganda) or to stanch utility losses (Argentina, Vietnam), rather than to facilitate subsidy reduction.

Despite emphasis on energy efficiency in Bank statements and in Country Assistance Strategies, the volume and policy orientation of IBRD/IDA efficiency lending has been modest.

Although the IFC has recently increased its investments in energy-efficiency projects, World Bank commitments for efficiency were about 5 percent by value of energy finance over 1991–2007. This includes investments in demand-side efficiency and district heating, and may also include some supply-side efficiency investments. By this definition, about 1 in 10 projects by number involve energy efficiency.

Including a broader range of projects identified by management as supporting supply-side energy efficiency would boost the proportion above 20 percent by number over the period 1998–2007. Globally only about 34 projects undertaken over the 1996–2007 period had components oriented to demand-side energy-efficiency policy. Among these, many attempts to promote efficiency have had limited success because the Bank has engaged with utilities, which have limited incentives to restrict electricity sales.

There are several reasons why end-user energy efficiency projects, and especially policy-oriented projects, appear to be under-emphasized in the Bank's portfolio.

The Bank has carried out some successful and innovative efficiency projects. But internal Bank incentives work against these projects because they are often small in scale, demanding of staff time and preparation funds, and may require persistent client engagement over a period of years. There is a general tendency to prefer investments in power generation, which are visible and easily understood, over investments in efficiency, which are less visible, involve

human behavior rather than electrical engineering, and whose efficacy is harder to measure. A general neglect of rigorous monitoring and evaluation reinforces the negative view of efficiency.

The Bank-hosted Global Gas Flaring Reduction Partnership (GGFR) has fostered dialogue on gas flaring, but it is difficult to assess its impact on flaring activity to date.

Associated gas (a by-product of oil production) is often wastefully vented or flared, adding more than 400 million tons of carbon dioxide equivalent to the atmosphere annually, or about 1 percent of global emissions. A modestly funded public-private partnership, the GGFR has succeeded in highlighting the issue, promoting dialogue, securing agreement on a voluntary standard for flaring reduction, and sponsoring useful diagnostic studies. But only four member countries have adopted the standard. The GGFR has emphasized carbon finance as a remedy for flaring, but the use of project-level carbon finance is a mere bandage for policy ailments that require a more fundamental cure.

Recommendations

In mid-2008, real energy prices were at a record high. While this is burdensome for energy users, it opens an opportunity for the Bank to support clients in making a transition to a long-term sustainable growth path that is resilient to energy price volatility, entails less local environmental damage, and is a nationally appropriate contribution to global mitigation efforts.

Clearly the World Bank needs to focus its efforts strategically on areas of its comparative advantage. This would include supporting the provision of public goods and promoting policy and institutional reform at the country level. Furthermore, the Bank can achieve the greatest leverage by promoting policies that catalyze private sector investments in renewable energy and energy efficiency, including those supported by IFC and MIGA. The analysis in this report supports the following recommendations:

Systematically promote the removal of energy subsidies, easing social and political economy concerns by providing technical assistance and policy advice to help reforming client countries find effective solutions, and analytical work demonstrating the cost and distributional impact of removal of such subsidies and of building effective, broad-based safety nets.

Energy price reform can endanger poor people and arouse the opposition of groups used to low prices, thereby posing political risks. But failure to reform can be worse, diverting public funds from investments that fight poverty and fostering an inefficient economy increasingly exposed to energy shocks. And reform need not be undertaken

overnight. The Bank can provide assistance in charting and financing adjustment paths that are politically, socially, and environmentally sustainable. Factoring political economy into the design of reforms and supporting better-targeted, more effective social protection systems will be elements of this approach.

Emphasize policies that induce improvement in energy efficiency as a way of reducing the burden of the transition to market-based energy prices.

Historically, energy efficiency has received rhetorical support but garnered only a small share of financial support or policy attention. This is beginning to change with such moves as China's commitment to drastically reduce its energy intensity and India's Energy Conservation Act. But the Bank can do much more to help clients pursue this agenda. If a real reorientation to energy efficiency and renewable energy is to occur, the Bank's internal incentive system needs to be reshaped. Instead of targeting dollar growth in lending for energy efficiency (which may skew effort away from the high-leverage, low-cost interventions), it needs to find indicators that more directly reflect energy savings and harness them to country strategies and project decisions. It needs also to patiently support longer, more staff-intensive analysis and technical assistance activities.

Increased funding for preparation, policy dialogue, analysis, and technical assistance is required.

Promote a systems approach by providing incentives to address climate change issues through cross-sectoral approaches and teams at the country level, and structured interaction between the Energy and Environment Sector Boards.

To tackle problems of climate change mitigation and adaptation, the Bank and its clients need to think, organize, and act beyond the facility level, and outside subsectoral and sectoral confines. One avenue for this is through greater attention to systemwide energy planning. Integrated resource planning, once in vogue, has been largely abandoned in the wake of power sector privatization and unbundling. Yet

current planning methods are inadequate in integrating considerations of end-use efficiency and in balancing the risks of volatile fuel prices and weather-sensitive electricity output from wind and hydropower plants. Water management, urban management, and social safety nets are other areas where cross sectoral collaboration is essential to promoting win-win policies and programs.

Invest more in improving metrics and monitoring for motivation and learning—at the global, country, and project levels.

Good information can motivate and guide action.

First, building on the Bank's current collaboration with the International Energy Agency on energy efficiency indicators, the Bank could set up an Energy Scoreboard that will regularly compile up-to-date standardized information on energy prices, collection rates, subsidies, policies, and performance data at the national, subnational, and project levels. Borrowers could use indicators for benchmarking; in the design and implementation of country strategies, including sectoral and cross-sectoral policies; and in assessing Bank performance.

Second, more rigorous economic and environmental assessment is needed for energy investments and those that release or prevent carbon emissions. These assessments should draw on energy prices collected for the Scoreboard; account for externalities, including the net impact on GHG emissions; and account for price volatility. Investment projects should also be assessed, qualitatively, on a diffusion index, which would indicate the expected catalytic effect of the investment in subsequent similar projects. It is desirable to complement project-based analysis with assessment of indirect and policy-related impacts, which could be much larger.

Third, monitoring and evaluation of energy interventions continue to need more attention. Large-scale distribution of compact fluorescent light bulbs is one example of an intervention that is well suited to impact analysis and where a timely analysis could be important in informing massive scale-up activities.

Chapter 1

1. MIT Joint Program on the Science and Policy of Global Change (<http://globalchange.mit.edu/resources/gamble/no-policy.html>) based on the research described in Sokolov and others (2009).
2. Carbon dioxide (CO₂) is the most important anthropogenic greenhouse gas, but there are others, such as methane. All are weighted according to their relative impact on climate change (for instance, methane is 25 times as potent as CO₂). The weighted sum is expressed as CO₂-equivalent, ppm.

Chapter 2

1. World Bank projects are evaluated after closure, and many investment projects last six to eight years or more. IFC projects are usually evaluated five years after the initial investment.
2. This set of projects follows the official classification of projects in an internal World Bank database. That classification may exclude some supply-side energy efficiency projects, including those that reduce T&D losses.
3. Classification based on 2009 status.
4. Data are from the Development Outcome Tracking System.
5. IEG's calculation of Bonn Commitment volume exceed management's report for 2005–08; no verification was attempted for the 2009 report.
6. But see Deichmann and others (2010), whose spatial analysis of Ethiopia suggests surprisingly broad competitiveness for grid-based electricity.
7. To impute the capacity factor, nominal capacity was multiplied by the ratio of actual certified emission reductions/design certified emission reductions.
8. For comparison, the average price of World Bank-purchased carbon credit is \$8.07, according to the Carbon Finance Unit's 2009 annual report. Average primary CER price in 2009 was \$12.69 according to World Bank (2010).
9. Data from January 2009.
10. The World Bank has recently supported an Indonesia Infrastructure Guarantee Fund, though it is not specifically targeted on renewable energy.
11. Two supported both on- and off-grid.
12. Global average, excluding high-income countries, from World Development Indicators 2007 (World Bank 2007).
13. The Sri Lanka Renewable Energy for Rural Economic Development Project has an exemplary monitoring system

and undertook a consumer satisfaction survey in 2006, but subsequent monitoring reports complained of an inadequate response rate.

Chapter 3

1. Tunisia (2005, \$8.5 million) and Uruguay (2004, \$6.9 million) were excluded for geographic coherence.
2. Many efficiency projects involve replacement of old equipment with new machinery that is both more efficient but also has higher production capacity—for instance, replacing a bakery oven with a new one that produces twice as much bread per day. Energy savings are calculated by assuming that, absent the project, the production would have been expanded using the old technology. This seems unlikely.
3. Environment Canada: <http://www.ec.gc.ca>.
4. An intermediate category of scrutiny for environmental impacts.

Chapter 4

1. Source is CAIT 7.0. Tabulation includes all GHGs and land use change.
2. If a project had performance indicators linked to GHG reductions, it was classed as having a formal goal. Otherwise, if the project mentioned GHG reductions as a project benefit, it was classed as having an informal goal.
3. Coincident with the financial crisis, which saw a Bank-wide increase in Development Policy Loans, about \$600 million in forest-related loans were committed during fiscal 2009–10.
4. The payments in question were for avoided deforestation, not for reforestation or natural regeneration. Thus, this observation of increased forest growth could either indicate a real but indirect impact (for instance, the abandonment of marginal grazing land due to the PES payment) or a spurious correlation (the recipients' land may, in fact, be of poorer quality than the control group's, for reasons that are not observable, with the result that they are more likely to give up grazing).
5. The Regional Silvopastoral Project is the reportedly the first World Bank-executed conservation project framed as an experiment. A review of the Nicaragua component of the project (GEFEO 2009) found that its control group was poorly constituted and unsuitable for control/treatment comparisons. The Colombia component appears to have a better constructed control group.

Chapter 5

1. From the chief economist's blog: <http://blogs.worldbank.org/climatechange/why-coal>.
2. Excluded was a small (60 MW) Indonesian facility. The investment in Medupi (South Africa) is out of the time frame for analysis.
3. The figures are not directly comparable because of the lag between approval and installation, but they convey the relative scale of WBG involvement. Private sector companies entered contracts to build and operate 87.0 GW of new capacity in Bank-borrower countries over 2003–08. Of these, projects totaling 10.9 GW had some WBG involvement. The WBG's share of investment (loans plus equity) in the private projects was 1.6 percent, plus guarantees covering 0.3 percent.
4. The demand for carbon offsets is driven partly by the need for some developed countries (appendix I) to meet their obligations under the Kyoto Protocol. At this writing, those obligations are not defined past 2012. However, CERs recognized under the CDM will in some cases be acceptable

in the European Union Emissions Trading System carbon market after 2012.

5. CF Assist helped with the design of the Fund to which this tax contributes.
6. The Montreal Protocol Fund's phase-out of ozone-destroying substances, many of which are also GHGs. It helps transfer technology and pays for the marginal cost of abatement of the substances.
7. However, new firms have entered the industry. They are ineligible for CDM payments for HFC-23 emissions, and are emitting growing amounts of the gas (Montzka and others 2010). Thus, low-cost GHG abatement opportunities are not being utilized.

Chapter 6

1. As this report was being finalized, a WBG-supported mass distribution of CFLs in Bangladesh took place and included a rigorous engineering assessment of impact on overall power consumption.

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Photo Descriptions

- x Women working in a compact fluorescent light bulb assembly plant.
- xiii Efficient steel press financed through an energy management company; Jinan, China.
- xix Lignite mining in Kosovo.
- xxi Cleaning solar panels.
- 1 Wind turbine in China.
- 7 People and livestock walking in a dust storm during a drought in Madagascar, circa 2007.
- 11 Boy stands in front of solar module at Caoduo School, Rongbo, Yu Shu—part of the 2008 Renewable Energy Development Project Ashden Award winner in China.
- 27 Ain Beni Mathar Integrated Combined Cycle Thermo-Solar Power Plant in Morocco.
- 33 Beneficiary of program that won Ashden Award for Sustainable Energy in Southeast Asia.
- 39 Energy transmission lines in Tajikistan.
- 40 Tangle of electric wires, Ho Chi Minh City, Vietnam.
- 42 Solar energy is used to light a village shop in Sri Lanka.
- 47 Deforestation in Brazil.
- 49 Traffic congestion in Mexico.
- 58 Deforestation in the Brazilian Amazon.
- 61 Ain Beni Mathar Integrated Combined Cycle Thermo-Solar Power Plant in Morocco.
- 69 Solar panels and telephones in Qunu in the Eastern Cape, South Africa.
- 79 Child standing on digester, which provides biogas from waste in a 2010 Ashden Award-winning project in Ngecha village, Kiambu West, Kenya.

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