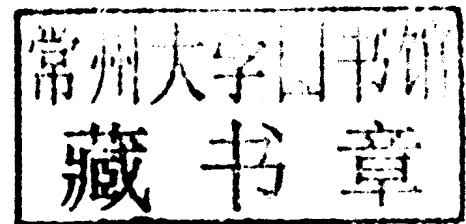


ASSESSING THE IMPACT OF IFC'S CHINA
UTILITY-BASED ENERGY EFFICIENCY FINANCE PROGRAM
Energy Efficiency Finance



Assessing the Impact of IFC's China Utility-Based
Energy Efficiency Finance Program

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Abbreviations

BOB	Bank of Beijing
CBRC	China Banking Regulatory Commission
CEEF	Commercializing Energy Efficiency Finance Program
CHUEE	China Utility-Based Energy Efficiency Program
CO ₂	Carbon dioxide
ECP	Energy Conservation Project
EMC	Energy management company
EMCA	Energy Management Company Association
EPC	Energy performance contract
ESCO	Energy service company
GEF	Global Environment Facility
GHG	Greenhouse gas
HEECP	Hungary Energy Efficiency Cofinancing Program
IB	Industrial Bank
IEG	Independent Evaluation Group
IFC	International Finance Corporation
kg	Kilogram
NSP	New suspension precalcinations
RSEF	Russia Sustainable Energy Finance Project
RSF	Risk-sharing facility
SME	Small- and medium-sized enterprise

All dollar amounts are U.S. dollars unless otherwise indicated.

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Energy efficiency finance is an integral part of the International Finance Corporation's (IFC) focus on environmental sustainability and climate change. As IFC is planning a significant scale-up in this line of business over the next two years, it is important to review and assess its experience from past operations.

This evaluation assesses the performance of IFC's energy efficiency finance program in China aimed at stimulating energy efficiency investments through bank guarantees and technical assistance. The program's significance is underpinned by the fact that China's size, rapid economic growth, and inefficiencies in energy use make it one of the world's largest emitters of carbon dioxide (CO₂). The utilization of IFC's program has been rapid compared with other similar programs. The program started in 2006. As of June 2009, the 98 energy efficiency investments supported by the program have reduced greenhouse gas emissions by 14 million CO₂ tons per year, slightly in excess of the target set at the beginning of the program. This amount equals the annual emissions of Bolivia, for instance, but it is small for China—less than 40 percent of the annual emissions of the largest emitter of CO₂ among China's power plants.

The difference made by the program is traced along the chain of interventions: (i) at the level of banks, the program is narrowly based on one of the two partner banks, which, with the help of the program, expanded its energy efficiency lending as a new business line; (ii) at the level of energy management companies, the program's technical assistance improved the program participants' access to finance; and (iii) at the end-user level, it promoted the use of energy efficiency investments that achieved reduction of greenhouse gas emissions.

However, there is only a weak differentiation in behavior surrounding energy efficiency investment between end

users supported by the program and other similar companies that were not. In China, as a result of government intervention, there are several other programs that support investments in energy savings. It appears likely that several end users supported by the IFC program would have implemented energy efficiency projects even in the absence of support from the program. The evaluation also estimates that less than 10 percent of bank clients would not have invested in energy efficiency without the loans guaranteed by the program. The relatively low additionality at the end-user level reflects the fact that most of the program's guaranteed loans were used by large companies that already had greater access to financial sources than smaller companies did; this was in contrast to the original plan of emphasizing small and medium companies.

Despite the modest additionality of the IFC program, the social benefits of the program significantly exceed its costs. This assessment is a partial and static recording of gains from efficiency improvements alone, setting aside any downside from increased use of coal that greater efficiency might lead to. A broader look is needed to also consider structural changes to measure the share of cleaner energy sources.

The evaluation recommends areas of improvement to realize greater impact. First, the program needs to emphasize areas where the potential additionality is high, such as small enterprises. Second, the program needs to concentrate more on activities that have the potential to reduce emissions significantly, such as energy efficiency for buildings. Third, the program's subsidy elements need to be reoriented to the areas of market failure, with IFC increasing its coverage of first loss from its own resources.



Vinod Thomas
Director-General
Evaluation

The International Finance Corporation (IFC) and financing energy efficiency. IFC's support to energy efficiency finance started in 1997 with a program in Hungary. It has grown since then to include operations in Eastern Europe, the Russian Federation, and East Asia. Financing energy efficiency is now an integral part of IFC's strategic focus on sustainability and climate change. The Corporation's goal over the next two years is to achieve a threefold expansion of its energy efficiency investments. As IFC plans to scale up energy efficiency business, it is important to review and assess the experience accumulated through past operations.

IFC's energy efficiency finance program in China. This evaluation by the Independent Evaluation Group (IEG) looks at the experience of IFC's energy efficiency finance program in China—China Utility-Based Energy Efficiency Finance Program (CHUEE). China's soaring demand for coal to generate electricity and a surge in cement production made it one of the world's largest emitters of carbon dioxide (CO₂). Most Chinese industries are inefficient in their energy use. The Chinese government has recognized this to be a major risk to China's sustained growth and has made energy efficiency a top national priority.

The IFC program, which started in 2006, is aimed at stimulating energy efficiency investments in China through two main instruments: bank guarantees for energy efficiency loans and technical assistance to market players, including utilities, equipment vendors, and energy service companies, to help implement energy efficiency projects. Both types of interventions rely on subsidies funded by donors. An initial design aimed at promoting the switch from coal to gas and centered around a gas utility failed to materialize and was abandoned because of strategic mismatches between the gas utility and the financial intermediaries.

Implementation to date. Program utilization has been rapid, compared with objectives and the experience of other similar programs. As of June 2009, the program's participating banks provided loans totaling to 3.5 billion Chinese yuan (\$512 million). These loans financed 98 energy efficiency projects, such as heat and gas recovery power generation and the introduction of efficient production systems. The steel, chemical, and cement industries are the largest beneficiaries. Based on engineering calculations,

IEG estimates that these investments reduced greenhouse gas (GHG) emissions by 14 million CO₂ tons per year, slightly in excess of the target set at the beginning of the program. This reduction is roughly equivalent to the annual emissions of a country such as Bolivia (USEIA 2009)¹ and amounts to 40 percent of the annual emissions of the largest emitter of CO₂ among China's power plants. Compared with other energy efficiency programs in China and elsewhere, the program stands out for the quick utilization of its guarantee facility.

Focus on impact. This evaluation goes beyond objectives and benchmarks as standards for assessing performance to look at the impact that the program has made on energy efficiency in China. It asks, "Is the program making a difference in reducing GHG emissions by helping transform the market for sustainable energy efficiency finance in China?" It examines the difference the program has made, compared with a situation without IFC intervention, traced along the chain of interventions: the effects on banks' energy efficiency lending, the actual implementation of these projects by end users, and the GHG reductions the program caused.

Impacts at the bank level. The program has been working closely with two partner commercial banks: Industrial Bank (joined in 2006) and the Bank of Beijing (joined in 2007). Driven by strong government commitment, financing energy efficiency has been booming in China in recent years. Thus, it is very likely that without the program, the participant banks would have grown their energy efficiency business.

However, with the program, Industrial Bank has grown at twice the rate of comparator banks (controlling to the extent possible for initial conditions, such as level of commitment to energy efficiency and preprogram levels of energy efficiency finance), and the quality of its energy efficiency lending portfolio has been good. Its faster growth relative to comparator banks was underpinned by the program's support for establishing a dedicated department for energy efficiency lending—a unique feature among Chinese banks—the preparation of guidelines and procedures for energy efficiency loans, and building the capacity for applying project finance tools to energy efficiency finance.

Regarding the Bank of Beijing, the program has not yet left a clear mark of impact. The Bank of Beijing has been actively engaged in a World Bank program that started before

CHUEE and focused on financing energy service companies (ESCOs). CHUEE added a few energy efficiency loans that are a fraction (less than 10 percent, by number of loans) of the Bank of Beijing's overall energy efficiency lending and are of similar type as the loans supported by the World Bank program, although somewhat larger. Furthermore, the Bank of Beijing's overall growth in energy efficiency finance has been less than that of comparator banks. Thus, the program has provided relatively weak additionality and incremental impacts to the Bank of Beijing so far. The program is therefore narrowly based on one of the partner banks as the main conduit of the guaranteed loans. The introduction of other banks has been delayed because of regulatory hurdles.

Impact at the energy management companies level. The program facilitated access to financing for the key market players—energy service companies—through technical assistance for capacity building and by brokering new relationships with banks. The CHUEE-supported energy management company (EMC) network has 135 members. Given the nature of the program, not surprisingly, the companies that participated in the program had a better chance of securing bank loans than those that did not participate. We estimate that controlling for other relevant factors, membership in the network enhanced EMCs' chances of obtaining bank financing by 31 percent. Independently of membership in the network, technical assistance (from any source) increased the probability of projects obtaining financing by 27 percent. Network participants also had a higher growth than the nonparticipants.

Impacts at the end-user level. A survey of cement companies (the third largest group of beneficiaries) that were not supported by the program but that shared the same characteristics as CHUEE's end users reveals widespread awareness of and interest in implementing energy efficiency projects. However, smaller companies are about half as likely as large companies to implement such projects. They also have significantly lower rates of using bank loans to finance energy efficiency projects than the larger companies. It is among such smaller companies that the program's impacts are found. Based on program data, interviews, and surveys among users and nonusers, an estimated 9 percent of banks' clients who benefitted from the program would not have implemented their energy efficiency investments without the loans that CHUEE guaranteed. These are relatively small companies facing constraints in their access to finance largely because of their inability to meet collateral requirements. The additionality of these loans can be linked directly to the program's guarantee, which lowered the banks' collateral requirements and facilitated access to credit for these borrowers.

In estimating the overall impact, the evaluation therefore does not discount the additionality at the borrower level given by the program's additionality at the bank level, as-

suming in effect that even though participating banks would have grown their energy efficiency finance business without the program, they would not have reached the type of small and medium enterprises that were facing collateral constraints in the absence of the program's guarantee. The relatively low additionality at the end-user level reflects the fact that most of the program's beneficiaries have been large companies, in contrast to the original plan to emphasize small and medium companies. The original expectation was that 60 percent of the guaranteed loans would be small (about \$0.2 million). In reality, the average loan size was \$5.7 million, and loans of \$0.2 million or less constituted less than 10 percent of the actual portfolio.

Moving down market to smaller companies remains a key challenge, as these companies are the ones with limited access to finance for energy efficiency projects. Although the program's additionality is strong with these borrowers, the size of their projects tends to be smaller than average for the program as a whole, and their impact on GHG reduction is correspondingly more modest. Moving down market therefore needs to be accompanied by scaling up for maximum impact on CO₂ reduction.

In addition to the public benefits related to GHG reduction, the projects that were facilitated by CHUEE have also generated private benefits in the form of energy savings that are captured by the implementing enterprises, the financiers, and other involved parties.

Overall impact. The overall impact of the program consists of the GHG reduction and the private benefits generated by projects that would not have happened without the program, plus nonquantifiable benefits related to demonstration and spillover effects. The latter appear to be emerging—according to results of an IEG survey on the impact of CHUEE, the program is well known in China, and there is interest among banks to learn from its approaches to the end users—but are hard to estimate. The real quantifiable impacts from the guaranteed loans are estimated at \$384 million over a 10-year period since inception of the program. It is possible that the impact is underestimated—more than 68 percent of borrowers indicated in the IEG survey that without the program they would still have implemented their energy efficiency projects but on a smaller scale or over a longer time frame. The critical factors that affect the magnitude of the benefits are the program's additionality at the bank level, banks' additionality with end users, the size of average CO₂ emission reduction per project, and the prices of CO₂ and coal (for the energy-saving calculations).

Costs. The social costs expended to derive the benefits consist of (i) project investments costs; (ii) the costs of running the program, including the costs of the technical assistance provided; and (iii) the subsidy embedded in the partial loss cover by the Global Environment Facility (GEF), which underpinned the guarantee facility.

Of these costs, the valuation of the first loss cover presents methodological difficulties. Given the lack of actuarial data, and in the absence of a market in similar guarantee or insurance products, the estimates are based on the expected default rate at the inception of the program. This represents an estimate of the willingness to pay for the protection given by GEF. The base case default rate was expected to be 4 percent, and the GEF subsidy was used to cover these potential losses. This GEF first loss cover catalyzed the IFC guarantees and supported the energy efficiency lending by Industrial Bank. The program collected \$1 million in guarantee and other fees. The cost of running the program so far is \$4.8 million, including \$3 million in technical assistance provided, without explicit fees levied to beneficiaries.

Efficiency. The real rate of return of the program is conservatively estimated at 38 percent per annum—a high rate given the seemingly modest rate of additionality at the level of end users. The estimate assumes that 9 percent of projects are additional and reflects their net benefits, but it includes the entire costs of CHUEE and technical assistance so far, as well as the costs of the first loss cover. The private return in the form of energy savings from this program is 20 percent, based on total project costs and energy savings measured using international energy prices. Social benefits in the form of carbon emission reductions are about one-third of total quantifiable benefits. The relatively high rate of return reflects the win-win nature of energy efficiency investments, which can generate both significant social and private benefits, and indicates a functioning model focused on leveraging and mobilizing commercial-based lending for financing energy efficiency projects. Although the sizeable public benefits suggest that even a modest additionality can be sufficient to justify the subsidies involved, high private returns argue for a more discriminate use of subsidies for energy efficiency projects.

The broader setting. It is important to note that the performance of the program was heavily influenced by the government's policies and the earlier efforts of other players. The Chinese government has demonstrated a strong commitment to moderating the country's expanding energy consumption. It is putting substantial pressure on large industries to improve energy efficiency. Noteworthy is the World Bank assistance to local EMCs, which helped establish the whole energy industry. The program, relying mainly on commercial funding through IFC's guarantees, builds on these efforts.

The analysis presented here is partial and static. Given the small size of the program in the overall market for energy efficiency projects, the analysis does not attempt to capture the indirect impacts of improved energy efficiency on the final demand for energy and, ultimately, coal in China. Some energy analysts have argued that energy efficiency improvements on a large scale can lead to broader macro-

economic impacts that in turn can result in an increase in energy consumption (see Geller and Attali 2005).

Such perverse macroeconomic impacts can be achieved by two means: making energy appear effectively cheaper than other inputs and increasing economic growth, which pulls up energy use. Empirical research has found that there is validity to the claim that widespread energy efficiency improvements can lead to macroeconomic impacts that erode some of the direct energy savings from energy efficiency improvements, but these impacts tend generally to be small (Geller and Attali 2005). Nonetheless, these macroeconomic impacts need to be taken into account by policy makers and development institutions in the design of national or regional programs and interventions in energy efficiency. These macroeconomic impacts also highlight the importance of pursuing, in addition to energy efficiency, structural changes aimed at increasing the share of cleaner sources of energy, such as renewable energies and natural gas in the overall energy balance. China places strong emphasis on increasing the proportion of energy that comes from renewable sources and natural gas. IFC is supporting China's goals in this regard, and in its original design, CHUEE was intended to be part of these efforts. However, because of difficulties in matching partners' interests, CHUEE failed to implement the original plan to support the switch from coal to gas.

Summary of Lessons from the Program's Experience So Far

Careful selection of private sector partners is needed to meet strategic program objectives. The program experienced different outcomes between the two banks—Industrial Bank and the Bank of Beijing—in terms of portfolio growth and the ability to use the guarantee. Earlier IFC energy efficiency programs in other countries also experienced varied usage of financial facilities. Obviously, a guarantee by itself is not an adequate incentive to increase energy efficiency lending, and the program needs to find the right balance between the banks' strategic objectives and the program's objectives. Industrial Bank, for example, combined the marketing of energy efficiency loans with a strategy of retaining customers. Thus, it made energy efficiency loans largely to existing clients, whereas the Bank of Beijing targeted new clients and faced difficulty in growing its energy efficiency loan portfolio.

Flexibility is needed in program design to respond to unexpected challenges and opportunities. The program experienced complete modification of its business model and responded with additional resources when confronted with larger-than-expected market demand for investment. This situation indicates that programs require some flexibility to respond to new developments in the market or to changes in regulations.

Government policies and market readiness are important factors in determining program design and success. In China, the timing for the program was right, as the government was putting significant emphasis on promoting energy efficiency activities. It had already put various policy measures in place for energy efficiency. Also, the World Bank initiatives for the EMCs paved the way for further assistance by IFC and other development organizations. The program built on these market conditions.

The combination of private and public benefits in energy efficiency projects suggests the need for a more discriminate and dynamic approach to subsidies in the energy efficiency business. As the sector matures and certain types of energy efficiency projects become well established, subsidies need to shift to less mature areas with high growth potential and significant social benefits. Indiscriminate use of subsidies impedes the commercialization of energy efficiency finance.

Caution is needed in applying a utility-based energy efficiency finance model in emerging markets. Utilities may not have incentives to curtail energy consumption or expand their market through energy switching when there are enough potential customers. It is important to assess incentives, policy environments, and the degree of match between a utility's clients and partner banks' market strategies.

An exit plan is critical. Many of the efforts to promote financing of energy efficiency focus on generating investments rather than on the sustainability of maintaining energy efficiency investments after a program has completed. Moreover, there is little practical information on how to terminate a program or how to shift its focus when commercial energy efficiency operations are emerging and starting to compete with the program. One of the factors behind the quick build-up of Industrial Bank's energy efficiency loan portfolio was the technical reviews of external consultants funded by CHUEE. However, the overreliance on external consultants has undermined the program's sustainability by reducing incentives to build internal capacity for such reviews.

Areas for Improvement and Recommendations

Although the social benefits exceed costs by a significant margin, the relatively modest additionality indicates room for improvement. The analysis of the factors affecting return suggests several ways to enhance impact and efficiency:

1. Increase additionality at the level of banks and end users.

The program has supported substantial emission reductions mainly through projects by larger

companies, but not all reductions can be counted as impact. The program needs to orient activity to the areas where additionality is potentially most significant. The program activity should be more strategically focused on areas where IFC could have a unique role, such as working with small and medium enterprises, residential housing, and commercial buildings. This requires that IFC consider and design new approaches and work with different types of partners, not just extend already existing types of program activities.

2. Enhance the CO₂ emission reduction impact of projects financed through the program by moving into areas identified as having high potential, but not addressed currently by market participants.

Despite the explosive growth of energy efficiency finance in China, the most important areas for emission reductions are currently not adequately addressed by market participants. The China National Development Reform Commission showed that the most significant emission reduction should come from industrial boiler retrofitting, followed by energy savings in building (for example, using less energy because of better insulation). Banks so far have not provided financing in those areas identified as having high potential. Moreover, in these areas there are many small and dispersed users, and access to finance and technical services is more challenging than for the large enterprise energy users. Thus, additionality is also high in these areas of high energy saving potential.

3. Reorient subsidies to areas with a market failure and increase IFC's involvement in first loss guarantee.

The program has reduced the first loss cover under the GEF grants, but IFC continues to rely on GEF to provide first loss guarantees. Furthermore, there is no assurance that the banks will continue to lend without substantial collateral in the absence of the program's guarantees.

Efforts are also being made to charge for technical assistance. These measures need to be pursued with existing and new partners, as they can both provide a market test of additionality and enhance sustainability. The program should prepare a plan to ensure the sustainability of energy efficiency lending activities. It should design a workable plan to hand off technical appraisal functions to client banks and encourage risk taking. These efforts need to be supplemented by policy work of the World Bank Group to promote market-based practices in financing energy efficiency and more discriminate use of subsidies at the sectoral level.

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

On March 31, 2010, the Informal Subcommittee of the Committee on Development Effectiveness (CODE) considered an Independent Evaluation Group (IEG) report entitled *Energy Efficiency Finance: Assessing the Impact of IFC's China Utility-Based Energy Efficiency Finance Program*.

Summary

The Committee welcomed the IEG impact evaluation report, which provided useful insights and is relevant to the growing energy efficiency initiatives that are part of the overall effort to address climate change. In considering the International Finance Corporation's (IFC) involvement in the China Utility-Based Energy Efficiency (CHUEE) program, the critical need to keep in mind its additionality—particularly in terms of knowledge, capacity building support, and financial leverage—was highlighted. While acknowledging the importance of addressing energy efficiency of small and medium-sized enterprises (SMEs) and the building sector, some members wondered whether IFC should shift its focus to them as recommended by IEG. They saw the benefit of working with a limited number of larger, higher emitters of CO₂, where results achieved may provide a positive demonstration effect for both end users and participating banks. Moreover, concerns were raised about the relative complexity of reaching large numbers of SMEs and residential housing and commercial buildings. Other comments and questions raised included, among others, IFC's role in addressing market failures, the need to adjust the program during implementation, assumptions used to assess impact and IFC contribution, and replicability of the CHUEE program. More generally, members emphasized the importance of tailoring support to the country environment and ensuring government ownership of and commitment to achieve positive results.

Recommendations and Next Steps

The Subcommittee recommended that management keep in mind IFC's additionality in its future support for energy efficiency initiatives.

Main issues discussed

Findings from the IEG impact evaluation report

Many members noted the role of country ownership and commitment in achieving the overall results of the CHUEE program. A few members observed that the report could have elaborated on the lessons learned regarding the role of the state in the context of market failures and regulatory frameworks to promote energy efficiency. Some members sought clarification regarding overall methodology to analyze the impact of the program, the basis of determining the reduction in CO₂ emissions, and the rates of return. A member suggested the need for modesty and caution regarding project impact, given the challenges of determining the counterfactuals. On the question of whether the original project design could have anticipated the mismatch between the utility and financial intermediary partners of the initial utility-based model, management stressed the importance of flexibility in project design to adjust to the changing market context, which allowed the initiative to ultimately achieve the positive results. Regarding the delay in effectiveness of the second guarantee facility approved by the Board in December 2007, this was attributed to the time needed to register the guarantees with the State Agency for Foreign Exchange.

IFC's additionality

Many members emphasized the importance of ensuring IFC's additionality through its interventions, based on its comparative advantage. Interest was expressed in learning about IFC's approach toward achieving the highest level of additionality, taking into consideration the operational challenges and risks. With regard to future IFC interventions, some members suggested that IFC should focus on a limited number of large producers of CO₂, especially where energy efficiency initiatives are at a nascent stage; IEG recommended that IFC's follow-up support focus on SMEs, residential housing, and commercial building to increase additionality. It noted the high potential development impact in terms of reducing CO₂ emissions and the positive demonstration effect through such successes.

Future support

Many members remarked on the increased complexities and higher costs of working at the level of SMEs and with the housing/building sector and expressed interest in the direction of future IFC engagement. They commented on the possibility of lower total CO₂ reductions achievable per intervention, longer time needed to achieve results, and higher transaction costs. Management acknowledged the challenges of working with SMEs and the housing/building sector and the possible lower outcomes. At the same time, they noted the growing interest of smaller banks in working with SMEs and changes in the regulatory framework that allow for short-term assets to be taken as collateral. In this context, management commented on the opportunity to help the government broaden the acceptance of financing greater energy efficiency among SMEs and to address policies to incentivize energy efficient buildings, which are expected to have an overall long-term impact in reducing

CO₂ emission. IFC was encouraged to compare different models of engagement in other countries and to draw lessons from them for consideration in other countries.

Replicability

Responding to some members' interest regarding the replicability of the CHUEE program, management commented on its ongoing work in Indonesia, the Philippines, and Vietnam. In addition, management is reviewing the possibility of applying the CHUEE finance and risk-sharing method to support financing of water saving investments in enterprises to address water scarcity issues in China. The potential use of funds other than the Global Environment Facility (for example, from the Clean Development Fund or the Climate Investment Fund) to support similar initiatives was encouraged.

Giovanni Majnoni, Chairperson

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Chapter 1

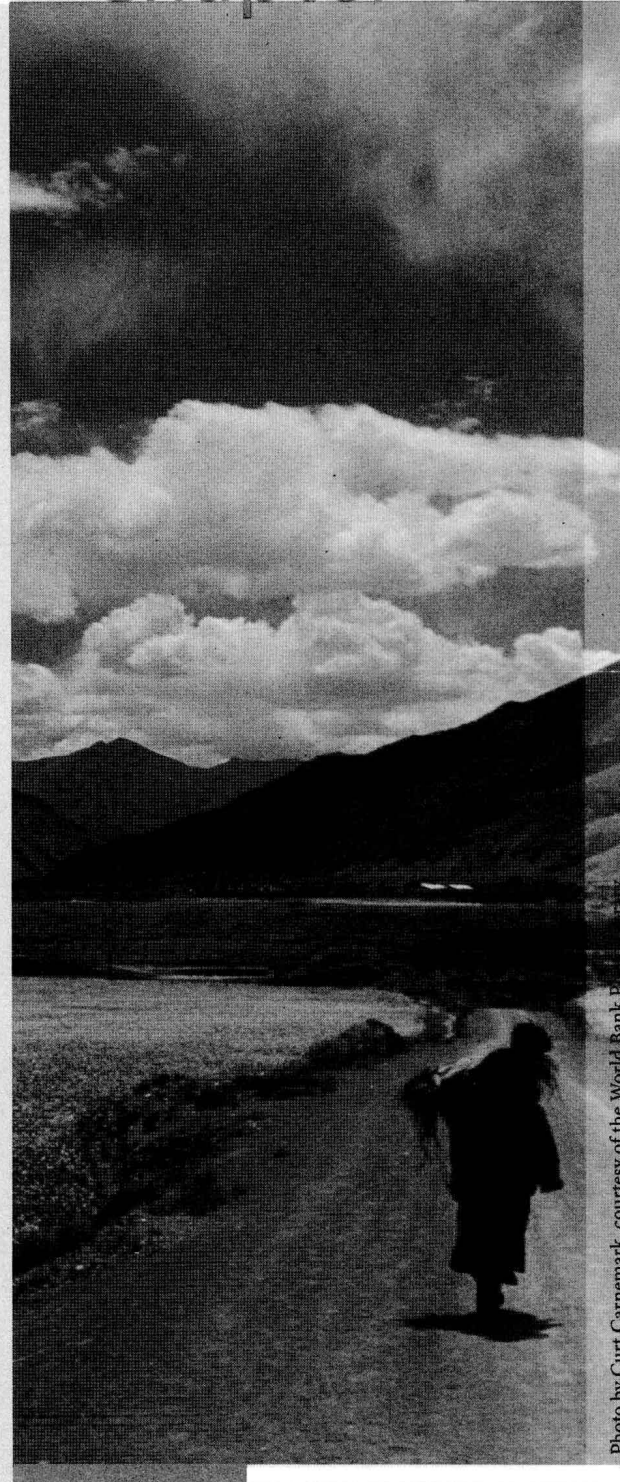


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Climate Change and Financing Energy Efficiency

Improving energy efficiency in developing countries can increase energy availability while reducing greenhouse gas (GHG) emissions. However, it faces many obstacles, including financing constraints. Consequently, many energy efficiency projects with prospects of good financial return remain unimplemented.

There is a need for market development assistance in designing, packaging, and financing projects that would help realize such investment. The International Finance Corporation (IFC) has been developing and implementing programs aimed at promoting commercial financing of energy efficiency projects through local financial institutions since 1997. Financing energy efficiency is now an integral part of IFC's strategic focus on sustainability and climate change. IFC's goal over the next two years is to achieve a threefold expansion of its energy efficiency investments. As IFC is planning to scale up energy efficiency business, it is important to review and assess the experience accumulated through past operations.

Climate Change and Energy Efficiency

Access to energy is critical to economic development and poverty reduction. However, continued economic growth results in rising energy demand. Use of fossil fuels for energy generation is highly correlated with human-induced climate change, which is having broad-reaching effects on the planet. A 2007 assessment report compiled by the United Nations Intergovernmental Panel on Climate Change confirms that global warming is a reality, which is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC 2007). The report concludes that increases in anthropogenic GHGs such as carbon dioxide (CO₂), methane, and nitrous oxide, which absorb and emit infrared radiation and trap heat within the Earth's surface-troposphere system, have caused most of the increases in average global temperatures since the mid-20th century. In 2004, the global annual emissions of anthropogenic GHGs increased by 70 percent from the 1970 level. CO₂ accounts for about 70 percent of GHGs, and CO₂ from fossil fuel use

for energy is the single largest source of GHG (57 percent of total greenhouse gas in 2004) (IPCC 2007, p. 5).

Energy efficiency improvements have the potential to reduce GHG emissions. Improvements are possible in the whole energy chain, from generation (supply-side energy efficiency), to transmission, to distribution to energy consumers (demand-side energy efficiency). Examples of demand-side energy efficiency measures include fuel-efficient transportation, building more energy-efficient buildings (that use better lighting, electric appliances, heating/cooling, and insulation), and more efficient use of heat and power in industrial plants. Efficiency gains that generate more economic outputs with less energy input are beneficial not just for cost savings and climate change mitigation, but also for reducing emissions that are harmful to human health (such as particulate matter and sulfur and nitrogen oxide). Also, lowering the cost contributes to improving energy supply security and economic competitiveness.

Such benefits have the potential for win-win solutions in terms of economic and environmental impacts. There is a wealth of straightforward energy saving investment opportunities that many energy users can afford to adopt. Most of these demand-side opportunities are in industrial (40 percent), residential (26 percent), and commercial (13 percent) sectors (Farrell and Remes 2009). Developing countries can benefit from such investment in particular, as 65 percent of available positive-return opportunities to boost energy productivity are located in developing regions (Farrell and Remes 2009).

However, many energy efficiency projects with prospects of good financial return remain unimplemented. In many rapidly industrializing countries, such as Brazil, China, and India, the key impediments to energy efficiency investments are the intertwined market failures: problems of high transaction costs, perceived high risks that may