Large-Scale Residential Energy Efficiency Programs Based on Compact Fluorescent Lamps (CFLs)

Approaches, Design Issues, and Lessons Learned

EXECUTIVE SUMMARY

Principal Authors

Dilip R. Limaye
Ashok Sarkar
Jas Singh

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Preface

For the past two decades, the World Bank Group (WBG) has been engaged in promoting energy efficiency. At the 2004 Bonn International Conference for Renewable Energies, the WBG committed itself to increasing financing for renewable energy and energy efficiency operations by 20 percent per year over the next five years. Since then, investment operations for energy efficiency have grown steadily, from US$177 million in fiscal 2003 to nearly US$1.7 billion in fiscal 2009. These projects have addressed the full range of end use and supply-side opportunities and have focused on removing institutional, regulatory, financial, and technical barriers. The WBG's commitment to energy efficiency is further reinforced through its key role in leading the global cooperative effort to reduce greenhouse gas (GHG) emissions through the Clean Energy Investment Framework and subsequent Strategic Framework on Climate Change and Development.

Energy efficiency remains as important as ever to the WBG and its client countries, in view of universal concerns over global energy security, competitiveness, and environmental protection. Although energy efficiency can alleviate pressures in all three areas, realizing large-scale energy savings is a significant challenge for the WBG's client countries. Questions persist on how best to identify, package, and finance many small, dispersed projects in a given market. Other informational, technical, financial, and behavioral barriers remain, thwarting efforts to convince end users to reduce their energy waste. Whereas some promising models from the developed world exist, difficulties lie in adapting them to fit the conditions and markets in the developing world.

In recent years, the WBG has been particularly active in responding to the growing demand for residential lighting programs as a means of reducing energy use, easing peak demands, mitigating environmental impacts, and easing the energy cost burdens to consumers. Since 1994, WBG-supported residential compact fluorescent lamp (CFL) programs have been completed or are ongoing in more than 20 countries, covering some 50 million CFLs globally, including in Argentina, Bangladesh, Burundi, Czech Republic, Ethiopia, Mali, Mexico, Pakistan, the Philippines, Poland, Rwanda, Senegal, Sri Lanka, Thailand, Uganda, and Vietnam.

With this experience, the WBG and its Energy Sector Management Assistance Program (ESMAP) concluded there was a critical mass of operational documents and experience that would aid the design of new CFL-based residential energy efficiency programs in additional WBG member countries. Thus, ESMAP developed this "CFL Toolkit" to compile and share important operational (design, financing and implementation) elements, documents, lessons learned, results, and other relevant data into a user-friendly format. The toolkit does not seek to prescribe certain models or methods, but rather to share operational documents from past projects to help inform new ones. As such, the toolkit includes key implementation/operational aspects, such as economic analysis and financial analysis (including carbon financing), elements of program design, methodologies and survey instruments for market assessment and potential, procurement guidelines, technical specifications, bidding documents, consumer surveys, awareness campaign information, environmental and safety issues related to CFLs, program evaluations, and associated Terms of Reference (TORs) for various project activities.

Acknowledgments

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The World Bank task team comprised of Bipulendu Narayan Singh, Samira Elkhamlichi, Abhishek Bhaskar, Xiaoyu Shi, and Isabel Lavadenz Paccieri. Major contributions to this report were made by Michael Philips, consultant (who drafted the CFL Program Matrix in the annex), Gerald Strickland, consultant (who drafted Chapter 5, Key Issues with CFLs), and Anne Arquit Niederberger, consultant (who prepared the initial drafts of the section on Carbon Finance Using CDM).

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Any errors and omissions are solely the responsibility of the authors. Please address questions or comments to Ashok Sarkar (asarkar@worldbank.org).

Acronyms and Abbreviations

AC	Alternating current
ADB	Asian Development Bank
BELP	Bangalore Efficient Lighting Program
BLS	Baseline Study
CBO	Community-based organization
CCT	Correlated color temperature
CDM	Clean Development Mechanism
CER	certified emission reduction (GHG reduction credit)
CFD	Carbon Finance Document
CFL	Compact fluorescent lamp
CFU	Carbon Finance Unit
CLASP	Collaborative Labeling and Appliance Standards Program
CPA	CDM program activity
CRI	Color rendering index
DSM	Demand-side management
CO_2e	Carbon dioxide equivalent
CO_2e/kWh	Carbon dioxide equivalent per kilowatt-hour
EA	Environmental Assessment
ECCP	European Climate Change Programme
EE	Energy-efficient or energy efficiency
ELI	Efficient Lighting Initiative
EMC	Electromagnetic Compatibility (equipment directive)
EnERLIn	Energy Efficient Residential Lighting Initiative
ERPA	Emissions Reduction Purchase Agreement
ESMAP	Energy Sector Management Assistance Program
EU	European Union
FTL	fluorescent tube light
g	Gram
GEF	Global Environment Facility
GHG	Greenhouse gas
GLS	General lighting service (lamps)
GPOBA	Global Partnership on Output-Based Aid
GWh	Gigawatt-hour
HCC	Host Country Committee
HCC MOU	Host Country Committee Memorandum of Understanding
HPF	High power factor
ICSMS	Internet-Based Information and Communication System for Cross-Border Market Surveillance
IEA	International Energy Agency
IL	Incandescent lamp
K	Kelvin
KfW	Kreditanstalt für Wiederaufbau
kW	Kilowatt
kWh	Kilowatt-hour
LoA	Letter of Approval
LoE	Letter of Endorsement

LoI	Letter of Intent
LVD	Low Voltage Directive
M&E	Monitoring and evaluation
MDB	Multilateral development bank
mg	Milligram
MOU	Memorandum of understanding
MP	Monitoring Plan
mtoe	Million tons of oil equivalent
MW	Megawatt
MWh	Megawatt-hour
NPV	Net present value
NGO	Nongovernmental organization
PCN	Project Concept Note
PDD	Project Design Document
PEN	Combined protective earthing and neutral conductor
PFC	Power factor compensation
PIN	Project Idea Note
PoA	Program of Activities
T&D	Transmission and distribution
TOR	Terms of Reference
TTL	Task team leader
TV	Television
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	U.N. Framework Convention for Climate Change
USAID	U.S. Agency for International Development
V	Volt
VAC	Volts alternating current
VAT	Value added tax
W	Watt
WBG	World Bank Group

Biographies of Principal Authors

Dilip R. Limaye is President and CEO of SRC Global Inc. and is internationally recognized as a pioneer and an entrepreneur with more than 40 years of experience in the alternative energy field. He has been a consultant to the World Bank on energy efficiency and sustainable development for the past 10 years. He was the principal consultant on the World Bank's energy-efficient lighting projects in Rwanda, Sri Lanka, Uganda, and Vietnam, and co-principal investigator of the World Bank's AMS-II.J methodology for CDM projects for CFLs. Mr. Limaye was also a senior advisor to USAID in the development and implementation of the Bangalore Efficient Lighting Program in India. He is on the board of several companies in the alternative energy field. He is the co-author or editor of seven books and has presented more than 40 technical papers at international conferences. Mr. Limaye received his bachelor's degree in Industrial Engineering from I.I.T. Bombay and his master's degree in Operations Research from Cornell University. He has conducted post-graduate studies in international business at the University of Pennsylvania and in Alternative Energy Systems at Drexel University. He has also completed the Executive Program on Global Climate Change and Economic Development at Harvard University.

Ashok Sarkar works as a Senior Energy Specialist in the World Bank's Energy Unit, where he coordinates the overall efforts and strategic initiatives in energy efficiency. He has more than 18 years of international energy sector development experience spanning more than 30 countries in Asia, Africa, Eastern Europe, and Latin America. Prior to joining the World Bank in 2005, he worked on sustainable energy operations at the Asian Development Bank in Manila, the Philippines; in the USAID's Office of Energy, Environment and Enterprise in New Delhi, India; at Resource Management Associates, Inc., an international energy consulting firm based in Madison, Wisconsin; and at Bharat Heavy Electricals Limited, a power engineering company based in India. Along with his undergraduate training in mechanical engineering from the University of Delhi, India, he holds a master's degree in Energy Planning and Policy from the Asian Institute of Technology in Thailand, and a Ph.D. from the Gaylord Nelson Institute of Environmental Studies at the University of Wisconsin-Madison. Between 2005 and 2007, he served as a member of the CDM Methodologies Panel to the UNFCCC in Bonn.

Jas Singh has worked on energy efficiency and sustainable energy issues for more than 15 years in more than 25 countries and currently serves as a Senior Energy Specialist within the World Bank's Energy Sector Management Assistance Program (ESMAP). Prior to 2008, he was a Senior Energy Advisor at USAID for four years. Before joining USAID, Mr. Singh worked in the World Bank's East Asia and Pacific Region for nine years on energy efficiency and other sustainable energy programs in China, the Philippines, Thailand, and Vietnam. Mr. Singh holds an M.Sc. in International Development from the University of Pennsylvania and a B.Sc. in Mechanical Engineering from UCLA.

Executive Summary

The power sector in many World Bank client countries is under severe stress as a result of generation supply deficits that are creating increasing electricity supply-demand gaps. At the same time, the electric power sector in many of these countries contributes substantially to both global-level and local emissions. In most developing countries, lighting is one of the most important uses of electricity in the residential sector. Evening lighting demand from households accounts for a major portion of the local electric utility's peak load. Among a menu of demand-side energy-efficiency measures, energy-efficient lighting technologies offer one of the most promising solutions to help bridge the supply-demand gap in many developing countries.

Most of the lighting in the domestic sector in developing countries is provided by inefficient incandescent lamps (ILs). Compact fluorescent lamps (CFLs) can provide the same amount and quality of light as ILs while using only one-fifth of the electricity that is consumed by ILs. CFLs can also last 5–10 times longer than ILs. During the last 15 years, an increasing number of countries have taken steps, including many with support from the World Bank, IFC, the Global Environment Facility (GEF), and other organizations, to implement programs to replace ILs with CFLs on a larger scale to achieve the multiple objectives of reducing peak loads, utility losses, and customer electricity bills, as well as to contribute toward mitigating the impacts of climate change by reducing GHG emissions.

These CFL programs have had their share of successes and difficulties that provide a substantial storehouse of implementation experience. These energy-efficient lighting initiatives, based on large-scale deployment of CFLs, have provided substantial operational experience, demonstrated peak load and energy reduction impacts on the grids, and have been able to showcase how demand-side energy-efficiency measures can be implemented at a much lower cost and in a shorter time frame compared to that required for adding new generation capacities. Developing countries can benefit from the lessons learned by improving how they plan for and structure their large-scale, energy-efficient lighting programs.

The Energy Sector Management Assistance Program (ESMAP) of the World Bank initiated an activity in 2008 to help practitioners benefit from these experiences. The objective is to develop good-practice operational models and templates or toolkits to help scale up the replication of large-scale, energy-efficient lighting programs. The overall goal of this report is to review and synthesize the important operational (design, financing, and implementation) elements, including those related to carbon finance and GEF synergies from the past experience of the Bank and other organizations, together in a user-friendly toolkit format. The report covers CFL-based programs primarily for the residential or small commercial markets.

This report, prepared as a part of the user-friendly, Web-based toolkit that will be available in 2010 through a Website, summarizes the important elements of developing and implementing large-scale CFL programs. It also provides information on typical program objectives and design options, including an overview of the various approaches and their relative strengths and weaknesses, institutional arrangements, procurement procedures, use of subsidies, marketing and communication efforts, program evaluations, and the use of carbon financing. Developing countries can benefit from the lessons learned from these programs to structure their energy-efficient lighting programs better.

The primary objective of this report is to provide policy makers, Bank staff, program implementers, and other practitioners with a better understanding of CFL program design and implementation. The report is intended not only to help promote the adoption of CFL programs, but also, by showcasing specific experiences from a series of case studies, to help project managers develop an understanding of implementation "good practices."

Why CFL Programs?

Lighting technology has come a long way since the invention of the IL more than 100 years ago. Of the many technologies invented in the last century, CFLs offer developing nations the best opportunity to reduce energy consumption in the residential sector, thereby providing a range of major benefits to consumers, utilities, governments, and the environment. The efficiency (efficacy in lumens per watt) of CFLs has also been increasing gradually since these lamps became commercially available around the early 1980s.

Table ES-1: Benefits of Energy-Efficient Lighting

Benefits of Energy Efficient Lighting	
Customer	Energy savings, reduced bills, mitigation of impacts of higher tariffs
Utility	Peak load reduction, reduced capital needs, reduced cost of supplying electricity
Government	Reduced fiscal deficits, reduced public expenditures, improved energy security
Environment	Reduction in local pollution and in Greenhouse Gas (GHG) emissions

Despite the fact that CFL programs present a "win-win" situation for all parties involved, the implementation of energy-efficient lighting initiatives in developing nations has been very slow. Some barriers hindering the path to successful project implementation include the poor quality of some of the CFLs on the market, the high price of high-quality CFLs, and the increase in CFL costs resulting from value added tax (VAT) and import or customs duties. CFL programs need to be designed to overcome these barriers and provide high-quality CFLs at a reasonable and affordable price to successfully initiate the market shift toward the adoption of this efficient and highly desirable technology.

CFL Program Design Approaches

Large-scale programmatic implementation of CFLs can be accomplished in many different ways. Some of the policy-based approaches used by different countries include regular energy efficiency standards and labeling systems to assure the quality of the CFLs in the market and programmatic phase-out policies that gradually ban ILs from being manufactured or imported and sold in the domestic markets. Also popular are bulk procurement and distribution approaches mostly carried out by electric utilities that reduce the cost of the CFLs and assure product quality through rigorous technical specifications, and market channel-based approaches that utilize the existing retail distribution channels (including coupon or voucher programs, branding and promotion, and rebates). A comparison of these approaches is provided in Table ES-2.

Much information is available on standards and labeling (from sources such as CLASP, the Collaborative Labeling and Appliance Standards Program), so these approaches are not discussed in this report. The report summarizes the recent initiatives in many countries to phase out ILs. Much of the material in this report focuses on bulk procurement and distribution and market channel–based approaches, describing the key steps in program design and implementation, illustrative economics of CFL programs, financing options, the potential role of the Clean Development Mechanism (CDM) and carbon finance, key issues related to CFL programs and lessons learned.

Table ES-2: Comparison of Program Design Approaches

Design Approach	Advantages	Limitations
1. Bulk purchase and distribution	Bulk procurement lowers upfront CFL cost without subsidy. Distribution can achieve high penetration. Technical quality assured through tender specs. Relatively quick to implement.	Interferes with existing market channels. Raises concerns about market sustainability. Requires strong institutional and management systems.
2. Market-based approaches	Enhances existing market channels. Provides more options to customers. Lower implementation costs.	May not substantially reduce upfront CFL costs. Requires effective monitoring of market. Requires mature market with existing high quality CFL suppliers and retailers. Slower implementation rate.
2a. Coupons	More market-based approach with use of existing distribution channels to help ensure sustainability. Allows customers to choose products.	Need measures to protect against low quality products and fake coupons. Harder to ensure lower retail prices. Customers need good access to information to make informed choices.
2b. Branding	Allows customers to select outlets and products with simple branding. Some manufacturer negotiation can bring down upfront cost barrier. Allows manufacturers to target marketing efforts.	Branding alone may not be enough to overcome upfront cost barrier. Need for credible branding agency with strong informational component.
2c. Rebates and subsidies	Helps address higher incremental costs, participation can require trade-in of older models to ensure disposal. May fit well with carbon financing.	May not be sustainable. Allocation of subsidies must be equitable. High potential for free riders.
2d. Agents	Can create market for proactive selling. Allows agents to determine best marketing approaches. Combines marketing with selling. Fits well with carbon financing.	Need to protect against possible collusion between agent and customer. Agents may 'oversell' products. Does not address higher upfront costs for customers.
3. Standards and labeling	Provide clear and credible information to customers. Low implement cost. Labeling creates platform for standards to eliminate low quality products and helps phase-out.	Does not address the higher upfront cost to consumers. When labeling is voluntary, participation may be low. Standards require considerable effort for proper testing and enforcement.
3(a). Phase-out policies	Effective mechanism for replacing inefficient ILs. Clear signal to suppliers and customers regarding CFL efficiency. Maintains and enhances existing CFL retail channels.	Requires national legislation or regulation. Affects existing market channels and local suppliers. Requires considerable time for implementation. Has led to some hoarding in Europe.

Phase-Out Policies

As more and more nations recognize the savings potential that can be realized by replacing incandescent bulbs with CFLs, policy makers have begin to enact legislation or regulations that mandate the phase-out of incandescent bulbs. A number of countries, including Australia, Canada, United Kingdom, the United States, and those in the European Union have already passed legislation that mandates the phase-out of ILs by a set date, and a number of other nations are in the process of passing similar regulations.

Cuba was the first country to successfully complete the phase-out of ILs. Cuba banned the sale of incandescent lamps and implemented a program of direct substitution of ILs with CFLs in households. It is understood that this was completed sometime in 2007 making Cuba the first country in the world to have phased-out incandescent lighting. Another 10 Caribbean countries and Venezuela are reported to be implementing similar measures. The GEF has recently launched a project to speed up the transformation of the market for environmentally sustainable, efficient lighting technologies in the emerging markets of developing countries by phasing out ILs.

World Bank and Partner Organization Programs

During the past few years, the World Bank has stepped up its efforts to provide support to developing countries attempting to design financial incentive-based programmatic approaches and to implement large-scale, energy-efficient lighting programs. The World Bank Group's involvement in promoting efficient lighting began in the late 1990s when the International Finance Corporation (IFC) and the GEF partnered to implement large-scale CFL programs in a number of countries, including Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines, and South Africa, under the Efficient Lighting Initiative (ELI). ELI developed technical specifications for CFL quality and established the ELI Quality Certification Institute.

ELI has also become a cornerstone of the World Bank Group's own procurement guidelines. ELI criteria and certified products have been used to inform procurement in a number of large-scale CFL projects, totaling some 50 million CFLs distributed in countries ranging from Argentina to Bangladesh, Mali to Mexico, and Rwanda to Vietnam. Following the success of the ELI, the World Bank successfully implemented a 1 million CFL deployment program in Vietnam (in 2004–05) as a part of the Demand-Side Management and Energy Efficiency Project. Subsequent large-scale CFL deployment programs have been successfully implemented in several countries, such as Ethiopia, Rwanda, and Uganda, and new programs are being launched in many other countries, including Argentina, Bangladesh, Mexico, and Pakistan,. The Asian Development Bank (ADB) is sponsoring a large CFL program as a part of the Philippines Energy Efficiency Project, and the United Nations Development Program (UNDP) has initiated large CFL programs in Russia and China.

Bulk Procurement Programs

Many of the World Bank and partner organization programs have used the bulk procurement approach. Bulk procurement involves the purchase, en masse, of a large quantity of lamps by either the utility or a government agency. The process is generally conducted via a competitive bidding process using technical specifications that assure high quality of the CFLs procured. Some of the advantages of bulk procurement include

- Significantly reduced CFL cost.
- Substantial reductions in peak load.
- Rapid achievement of load reduction.
- Quality assurance via technical specifications.
- Immediate benefits to utilities, customers, and society.
- Simplifying the process of applying for carbon credits.

While bulk procurement provides significant benefits to all parties involved, it does have some limitations. The competitive bidding process and strict technical specifications may limit the number of competing manufacturers or suppliers, and the result of the competitive process may limit the number of CFL suppliers selected, and the CFL types (for example, size and color rendering), thereby limiting customer choice. The process also requires a substantial effort on the part of the utility for distributing the CFLs, and comprehensive consumer awareness measures. The distribution approach used in bulk procurement programs will generally not use existing market channels and may be detrimental to existing CFL suppliers and retailers. This kind of distribution also entails additional costs for program implementation. These programs therefore raise some issues of long-term sustainability.

Market Channel-Based Programs

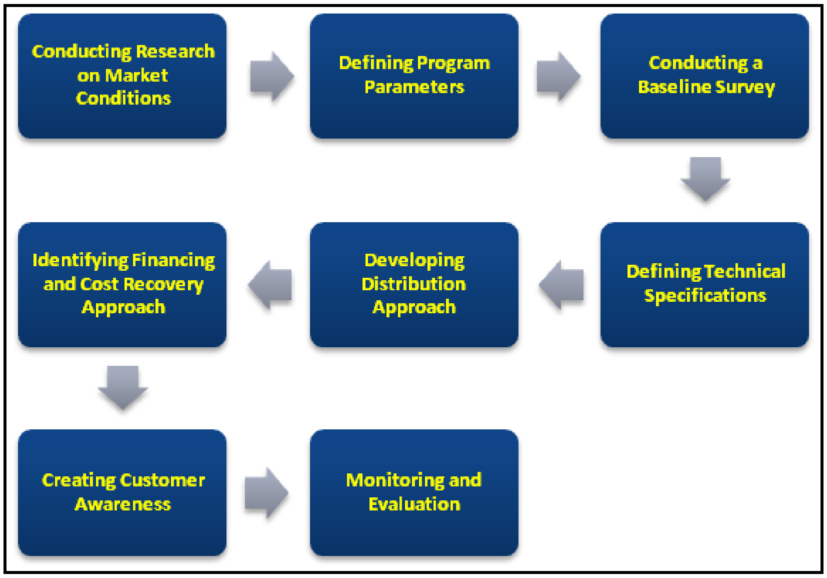
Market channel-based programs utilize the existing supply and distribution channels to promote and facilitate increased utilization of CFLs. Instead of one or two CFL types under the bulk procurement approach, the market channel–based approach promotes the use of many CFL types and wattages provided that they meet some predetermined technical quality specifications. By using existing distribution channels, these programs impose a low burden on the utility (or government) with respect to CFL procurement and distribution. The mechanisms used in these programs may include a combination of rebates, coupons, branding, cooperative advertising and promotion, and financing through the utility bills.

Limitations of market channel–based approaches is that they do not achieve the level of cost reduction possible through bulk procurement, and that they require the existence of multiple suppliers and retail channels of high-quality CFLs. Therefore, such approaches are more likely to be applicable in “mature” CFL markets where there are a number of existing suppliers and retailers or after there has already been a bulk procurement program. Another limitation is that consumer participation in the program may be lower compared to programs that directly distribute the CFLs to the customers.

Key Elements of Program Design and Implementation

The key elements of program design and implementation are shown in Figure ES-1.

Figure ES-1: Key Elements of Program Design and Implementation



- **Conducting research on market conditions:** The project's initial research defines pre-implementation market conditions, such as the current supply of CFLs in the market, local market prices for both CFLs and ILs, lamp quality, customer perceptions of CFLs, timing of peak loads, and electricity tariffs.
- **Defining program parameters:** This step includes definition of the procurement and distributions approach, customer awareness and promotional strategies, cost recovery (if any), and rebates or subsidies.
- **Conducting a baseline survey:** The baseline survey determines levels of pre-implementation IL and CFL use and the appropriate number of CFLs to be procured. The baseline survey is also helpful in developing promotional and educational campaigns, since it provides insights into local perceptions of CFL technology. Such a survey is a mandatory required for CDM.
- **Defining technical specifications:** To assure CFL quality, it is important to define the technical specifications used in the competitive bidding process. Such specifications generally include lamp type, wattage, lumen output, rated lifetime, voltage tolerance, color temperature, color rendering, lumen maintenance, power factor, safety, harmonics, mercury content, test specifications, warranty, packaging, and other requirements.
- **Developing distribution approach:** Distribution may be done door-to-door (using utility employees or agents, nongonvernmental organizations (NGOs), or courier services) or by asking the customers to pick up the CFLs at a utility office pr payment center.
- **Defining financing and cost recovery approach:** Some programs provide the CFLs at no cost to the customer. While free distribution maximizes customer participation and can achieve results quickly, it has been argued that free distribution of CFLs may create market distortions and create problems with customer repurchase when the CFLs need to be replaced. Other programs have

included provisions to recover some or all of the program costs from the customers (either thorough the utility bills or direct customer payments to a retailer). Potential disadvantages of cost recovery include lower penetration rates, slower market response, and greater administrative burden or cost.

- **Creating customer awareness:** Marketing and promotion campaigns can substantially bolster the success of a CFL program. Marketing channels employed in CFL campaigns have included television, radio, billboards, slogans, logos, newspapers, and displays.
- **Monitoring and evaluation:** An important element of program design is the monitoring and evaluation (M&E) plan. Programs sponsored by the World Bank, GEF, or other donor agencies require a formal evaluation, and an M&E plan needs to be included in program design.

Illustrative CFL Program Economics

Table ES-3 illustrates the economics of an illustrative CFL program to replace 1 million 60 watt ILs with 15 watt CFLs. The table shows the key program design parameters and the program benefits and costs to the customer, utility, and the nation. The results are striking in terms of the beneficial impacts of the program, for example:

- The total program cost is US$2.0 million, assuming the CFL costs of US$1 million, program administration, CFL distribution, and communication and awareness costs of US$500,000, and CDM costs of US$500,000.
- The total customer bill savings are more than 20 times the total cost of the program.
- The utility peak demand savings are 38.9 MW (assuming transmission and distribution losses of 15 percent, coincidence factor of 85 percent, net-to-gross ratio of 90 percent, and power factor of 50 percent).
- The total utility capacity cost savings are US$37.9 million, and total energy cost savings are US$31.6 million for total utility savings of US$69.5 million (net present value of US$48 million).
- The customer bill savings are US$44.8 million.
- In addition, assuming an emissions factor of 0.8 kg CO_2e/kWh, the CFL program produces GHG reductions amounting to about 317,000 tons CO_2e that would provide CDM revenues of about US$3.2 million, assuming a price of US$10.00 per ton.
- The net present value (NPV) of national benefits (using a discount rate of 10 percent) is equivalent to more than US$50 million compared to the total program cost of US$2.0 million.

Table ES-3: Illustrative Economics of a CFL Program

Program Information		
Number of CFLs installed	Number	1,000,000
Capacity of CFLs	Watts	15
Rated Lifetime of CFLs	Hours	8,000
Capacity of ILs replaced	Watts	60
Cost of CFLs	$/CFL	1.00
Cost charged to customer	$/CFL	0.00
Distribution cost	$/CFL	0.20
Program management cost	$	100,000
Marketing & promotion cost	$	200,000
CDM costs	$	100,000
Daily usage	Hours/day	3.5
Power factor	%	50%
Coincidence factor	%	85%
Net-to-Gross ratio	%	90%
Customer Benefits and Costs		
Annual energy savings	GWH/Year	57.5
Total energy cost savings	Million $	44.8
Avoided costs of ILs	Million $	2.1
Total benefits	Million $	46.8
NPV of benefits (economic analysis)	Million $	32.6
Customer costs	Million $	0.0
NPV of net benefits	Million $	32.6
Net benefits minus costs	**Million $**	**32.6**
Benefit to cost ratio	**Ratio**	**N/A**
Utility Benefits and Costs		
Capacity savings - generation Level	MW	38.9
Annual energy savings - utility	GWH/year	60.5
Avoided capacity costs	Million $	37.9
Avoided energy costs	Million $	31.6
Total utility benefits	Million $	69.5
NPV of benefits (economic analysis)	Million $	48.4
Program costs	Million $	2.0
Revenue loss	Million $	44.8
Total costs	Million $	46.8
NPV of total costs	Million $	32.9
Net benefits minus costs	**Million $**	**15.5**
Benefit to cost ratio	**Ratio**	**1.5**
National Benefits and Costs		
Avoided capacity costs	Million $	37.9
Avoided energy costs	Million $	31.6
CDM revenues	Million $	3.2
Total national benefits	Million $	72.7
NPV of benefits (economic analysis)	Million $	50.6
Total national costs	Million $	2.0
NPV of total costs	Million $	1.7
Net benefits minus costs	**Million $**	**48.8**
Benefit to cost ratio	**Ratio**	**29.5**
GHG Impacts		
Total GHG reductions	Thousand tons	316.9
Total CDM revenues	Million $	3.2

Financing of CFL Programs

The financing mechanisms utilized in residential CFL programs in developing countries include the following:

- Grants from the GEF or other donors.
- Loans from The World Bank or other multilateral development banks (MDBs).
- Grants from the World Bank's Global Partnership on Output-Based Aid (GPOBA).
- Self-financing by local utility or government.
- Private sector financing.
- Carbon finance using the CDM.

Carbon Finance and CDM

The Kyoto Protocol of the U.N. Framework Convention on Climate Change includes provisions for a Clean Development Mechanism (CDM), which gives monetary value to GHG reduction credits (known as certified emission reductions or CERs) achieved through projects implemented in developing countries. The economic benefits of carbon finance under CDM can be quite substantial, as shown in Table ES-3. However, CDM projects impose substantial survey, analysis, and verification requirements.

To apply for carbon credits under CDM, a CFL project must apply a "baseline and monitoring methodology" that has been preapproved by the CDM Executive Board at the UNFCCC. At present, three approved methodologies applicable to CFL programs are available, one large-scale (AM0046) and two small-scale (AMS-II.C and AMS-II.J). Of these, AMS-II.J and AM0046 were designed specifically for residential CFL programs, whereas AMS-II.C is widely applicable to end-use electrical efficiency activities. Each of these methodologies faces limitations that have prevented its widespread application.

However, with the emergence of the concept of programmatic CDM, also known as Program of Activities (PoA), which can combine several small projects (also called CPA) in a spatial and temporal (up to 28 years) scale without defining more than one CPA in the beginning, has made the large-scale CFL programs (which are usually spread over several cities or municipalities or regions, each of which can be considered an individual CPA) easier to implement. As of November 1, 2009, five CFL projects and one PoA had been registered for CDM, although many others are in the registration process.

Key Issues with CFLs

Some of the important issues with CFL programs include the following:

CFL quality: The quality of CFLs has been a source of great concern for manufacturers, consumers, and market surveillance authorities alike. Poor quality of CFLs has in the past tainted their image and created negative perceptions. The newer generations of CFLs are much better-performing products. They last longer and continue to get smaller, better, more efficient, safer, and less expensive, and they also render a light quality that approaches closely that of ILs. However, low-cost and low-quality CFLs continue to be offered in the marketplace. CFL programs have therefore used tight quality specifications to assure product quality. A number of regional charters or specifications have been developed for technical requirements for CFLs. The most commonly available are ELI, the U.K. Energy Saving Trust, EU CFL Quality Charter, U.S. Energy Star standard, and the Asia CFL Quality Charter.

Health issues: Efforts around the globe to replace ILs with CFLs have provoked discussions fueled mainly by the press on possible health-related issues concerning CFLs. While data on CFL related health issues is limited, a number of evidence-based scientific studies and various position statements put forward by industry and regulators in various parts of the world have systematically provided answers that shed light on the alleged health impacts of CFLs. The conclusions are that CFLs are safe to use for consumers and workers alike.

Voltage fluctuation: Voltage fluctuation refers to the presence of any distortion on the network, including electronic disturbance to other appliances. Wide voltage fluctuation causes higher temperatures, which can cause circuits to burn out, leading to significant damage to the circuit, as well as the equipment. Such disturbances have led CFLs in some cases to have a shorter life. In some developing countries' power grids, low voltages can be detrimental to CFL survival. The newer, high-quality CFLs are better able to adapt to voltage fluctuations. Program designs need to consider the voltage fluctuation in the local areas where the CFLs are being distributed and assure that the technical specifications address the proper functioning of the selected CFLs.

Power factor: The power factor of an alternating current (AC) electric power system is defined as the ratio of the real power to the apparent power. Low-power-factor loads can increase losses in a power distribution system and result in increased energy costs. Many CFLs used in the early programs had power factors of about 0.50, and concerns were expressed regarding the effects of such low power factors on the grid. There is a general misconception that the low power factor of CFLs actually increases their energy consumption, and associated emissions, because of system losses. This is not true. Although low power factors do have an impact on the actual utility load reduction, the impact is not very large.

Harmonic distortion: While the replacement of ILs with CFLs will result in a reduction of the load on the electrical network, CFLs represent a "nonlinear" load that will inject harmonics into the mains that may distort the waveform of the mains voltage and lead to an increase in network losses. However, other home appliances, such as televisions and personal computers, also create harmonics, and a comprehensive field test study recently carried out by the Community of the Austrian Electricity Suppliers that included laboratory measurements and field measurements proved that the extensive use of CFLs did not lead to negative effects on the voltage quality.

Environmental issues: It takes approximately five times more energy to produce one CFL compared to one IL. However, because CFL lamps last on average between 6 and 15 times longer than ILs, the amount of energy needed for the production of one CFL is comparable to the production of between 6 and 15 ILs. Therefore the impacts of energy savings from the CFL clearly outweigh the environmental impact of its production and its end of life.

Mercury is an important component of CFLs and has been mentioned as an environmental issue. CFL programs therefore may need to address collection of the CFLs and recycling of the mercury. It should be noted, however, that mercury is present in CFLs in a very small amount. Studies conducted by the European Commission have pointed out that, even in the worst possible case that a CFL goes to a landfill, it will have saved during its lifetime more mercury emissions from electricity production in coal power plants than is contained in the CFL itself, so the overall mercury pollution balance is positive. CFL manufacturers have developed innovative ways to increase lamp performance while minimizing the use of mercury and the mercury content of lamps has been reduced by more than 90 percent. Low-mercury CFLs (containing less than 1 mg) are now becoming available in the market.

Lessons Learned

The experience from prior CFL programs provides valuable information for the design and implementation of new programs. It should be noted, however, that the experience clearly points out that there are significant differences across various countries among the customer characteristics, market characteristics, utility supply-demand situations, customer awareness, and interest in CFLs, and it is strongly recommended that, while the experience from prior programs provides useful guidance, the program design needs to be customized for local conditions. The important lessons learned are as follows:

- **Large economic and environmental benefits:** As shown above, a typical 1 million CFL program costing US$2 million can provide load reductions of 38.9 MW, representing utility cost savings of over US$69 million over the life of the CFL. The program also provides reductions in GHG emissions of more than 300,000 tons of CO_2 equivalent.
- **Quick results from bulk procurement and giveaway programs:** Bulk procurement of CFLs, combined with free distribution of the CFLs to the customers can generate quick results in peak load reductions, as well as in reductions in energy use and GHG emissions.
- **Necessity of long-term planning:** While the bulk procurement and distribution approach can provide quick results, it is important to recognize that such a strategy is not sustainable and a transition needs to be made to traditional retail channels for distribution and sale of CFLs.
- **Use of market channel–based approaches in advanced markets beneficial:** Market channel–based programs involving coupons or rebates are likely to be more appropriate in mature markets where there are many suppliers of high-quality CFLs.
- **Beneficial effects on market transformation:** Properly designed CFL programs can have substantial beneficial effects on market transformation resulting from the increased customer awareness and interest and the documentation of the benefits of the high-quality CFLs.

- **Importance of marketing and promotion:** Marketing and promotion campaigns are very important in influencing the customers' decisions regarding purchase and installation of CFLs.
- **Benefits of assuring product quality:** In most developing countries, there is a wide range of quality in the CFLs available in the market. Bulk purchase programs ensure high quality in the short term through technical specifications. In the longer term, standards and labeling can be effective.
- **Substantial savings in GHG from carbon credits:** CFL programs provide substantial savings in GHG and can therefore benefit from carbon finance through CDM. The value of carbon credits can be more than the entire program costs. However, the process for achieving CDM eligibility is laborious and will influence the design of the CDM program.

The World Bank/ESMAP CFL Toolkit

The World Bank/ESMAP has completed the development of a Web-based CFL Toolkit, (see http://www.esmap.org) which comprehensively covers a range of topics related to the design and implementation of CFL programs for the residential market. The overall objective of the toolkit is to present detailed information on CFL programs based on a review and synthesize the past projects implemented by the World Bank and other organizations.

The toolkit is structured in a user-friendly, Web-based format that is targeted at a broad, global audience and that can be used by World Bank staff and other practitioners in developing countries for more efficiently and effectively designing and implementing CFL programs.