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PROMOTING ENERGY EFFICIENCY AND RENEWABLE ENERGY

GEF Climate Change Projects and Impacts

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Executive Summary

This paper provides the first systematic review of GEF climate change projects, offering a catalogue of project types and design approaches. The 84 projects reviewed represent an extensive knowledge base and range of innovative approaches to promoting energy efficiency and renewable energy. The paper also provides an initial review of emerging project impacts across the entire portfolio and suggests future evaluation methods. The paper will interest those seeking to understand the GEF's approach to climate change mitigation, those designing GEF climate change projects or any other project to build sustainable markets for climate-friendly technologies, and those undertaking project impact evaluations. The paper does not evaluate project implementation performance nor does it address the huge implementation challenges faced by project managers.

Climate Change Mitigation Strategies

Energy-efficiency and renewable energy technologies are prominent in most sustainable development programs, for example Agenda 21, and in scientific assessments like those of the Intergovernmental Panel on Climate Change (IPCC). Global climate change mitigation particularly depends on widespread use of these technologies in all countries. These technologies can also advance important national development goals, such as cleaner air, energy services for rural populations, and energy-efficient domestic industries. Many opportunities exist to utilize these technologies although realization of these opportunities is often constrained by many types of barriers.

Since 1991, the GEF has assisted developing countries and countries in transition in meeting both national-development and global-climate-change objectives by means of energy efficiency and renewable energy technologies. The GEF and its three implementing agencies, the UN Development Program, the UN Environment Program, and the World Bank Group (including the Group's private-sector affiliate, the International Finance Corporation) have developed, financed, and implemented a series of projects that reflect the GEF's climate change mitigation strategies. Many types of agencies are executing the projects, including national and local governments, private-sector entities, and non-governmental and community organizations. The range of project beneficiaries, cofinancing sources, and other stakeholders is equally diverse.

GEF climate change mitigation strategies have evolved as the GEF continues to experiment, learn from experience, and leverage resources that are tiny relative to the enormous challenges posed by climate change. An initial three-year pilot phase was followed by the adoption of an operational strategy and three long-term operational programs. These long-term programs are designed to promote energy efficiency and renewable energy by removing barriers, reducing implementation costs, and reducing long-term technology costs. Programs are designed to build sustainable commercial markets, leverage financing from public and private sources, and facilitate technology diffusion. With its limited resources, the GEF cannot significantly affect greenhouse gas emissions in the short term; rather, the GEF promotes the development and use of technologies that are critical for addressing the climate change problem in the long term.

The GEF continues to explore and adopt new strategies and policies. For example, the GEF is considering how to further engage the private sector in projects and strategic planning; contingent financing is being piloted as a way to reduce technology financing risks without the need for direct grants; new strategic partnerships with other agencies are being formulated; and new ways for non-governmental organizations and other stakeholders to participate in projects are being considered.

GEF Climate Change Projects

From 1991 to mid-1999 the GEF approved grants totaling $706 million for 72 energy efficiency and renewable energy projects in 45 countries. The total cost of these projects exceeds $5 billion because the GEF grants have leveraged financing and other resources from governments, other donor agencies, regional development banks, the private sector, and the three GEF project implementing agencies. An additional $121 million has been approved in grants for 20 climate change "short-term response measures." Direct project beneficiaries include government agencies, private-sector firms, community organizations, households, and providers of public services. The climate change project portfolio continues to grow as new projects are approved by the GEF Council on a regular basis.

Existing project designs from the past eight years represent an extensive knowledge base and range of approaches to promoting energy efficiency and renewable energy. Experience and knowledge of experts in each country are incorporated into project designs, along with substantial technical reviews. Approved projects reflect innovative, experimental attempts to promote technologies through new approaches and best practices. Experimentation is needed because GEF projects take place in diverse national contexts and because accumulated international historical experience is still far from providing definitive answers about how to accomplish GEF objectives in developing countries and countries in transition. Projects are often the first of their kind in the countries concerned. Project designs continue to evolve based on information from earlier projects, international best practices, and increasing understanding of how to accomplish the strategic goals of the GEF.

In order to make the project portfolio easily accessible, we organize it into clusters and synthesize project approaches within clusters. Projects within a cluster share common approaches that can be highlighted despite their diversity. Examples of project approaches include: installing demonstration equipment; catalyzing sustainable markets by increasing market volume, reducing technology costs, and raising consumer awareness; building capacities of public agencies, private-sector firms, and non-governmental organizations; creating or strengthening technology intermediation centers; disseminating information; conducting studies or targeted research; developing national strategies or policy frameworks; providing new financing services; and creating new institutions.

We define nine project clusters: solar home systems and rural energy services, grid-connected renewable energy, solar hot-water supply, precommercial renewable energy technologies, energy-efficient product manufacturing and markets, energy efficiency investments in industry, energy-efficient building codes and construction, district-heating energy efficiency and biomass/geothermal heat production, and fuel switching and production/recovery.

Key aspects of GEF projects include:

Equipment installations and demonstration. Many GEF projects install and demonstrate equipment, such as solar home systems, compact fluorescent lamps, and energy-efficient motors. The directly installed capacity and energy savings from these projects can be significant, but these installations are fundamentally intended as demonstrations and must be replicated in order to achieve large-scale, indirect impacts.

Capacity building. Capacity building, a central feature of most GEF projects, assists beneficiaries in understanding, absorbing, and diffusing technologies. Projects develop the skilled personnel and institutional capacities that are widely recognized as important for technology diffusion. Projects strengthen the capacities of public agencies, private-sector firms, financiers, consumers, community organizations, and non-governmental organizations. For example, many projects assist public agencies to regulate, promote, finance, and sustain technologies. Projects may also provide technical and commercial information and training/advisory services to private-sector firms.

New institutions and financing services. Projects are demonstrating a variety of new institutions and financing services for promoting technology diffusion. For example, financing is provided to local community organizations, private-sector financiers and financial intermediaries, local entrepreneurs, public or private revolving funds, private debt/equity funds, and private-sector renewable energy project developers. Projects pilot industrial-sector energy service companies (ESCOs), rural energy-service concessions, and utility-based demand-side management programs. Projects also provide combinations of different types of financing for private-sector activities, such as grants, concessional (no- or low-interest) loans, and contingent loans (forgivable under specified conditions).

Market transformation. Projects assist manufacturing firms to develop and market energy-efficient products as part of so-called "market transformation" approaches in which supply and demand sides are stimulated simultaneously. These approaches can include technical and financial assistance to producers, new equipment standards and certification, consumer information and education, regulatory changes, and other incentives.

Engaging the private sector in projects. The private sector participates directly in GEF projects as manufacturers and dealers, local project developers, financial intermediaries, recipients of technical assistance, technology suppliers and contractors, and project executors. In addition, several GEF projects are designed to directly mobilize private-sector financing. The International Finance Corporation is executing five projects in which managed investment funds are designed to leverage $375 million in financing from the private sector with $95 million in GEF grants. Other projects competitively solicit financial contributions from manufacturers to reduce retail equipment prices.

Roles of non-governmental organizations (NGOs). GEF projects involve international and national NGOs, community-based organizations, industry associations, consumer groups, and educational institutions. These organizations may help design and prepare projects, execute projects, advise implementation committees, train project beneficiaries, supply services and equipment, conduct social research, or provide technical or policy support.

Project Impacts and Replication

Although most approved projects are still being implemented, project experiences, impacts, and lessons are emerging. Out of 72 energy efficiency and renewable energy projects approved since 1991, eight were fully completed by mid-1999. We summarize the available information on GEF project impacts from a variety of sources but find the volume of current information small relative to the potential for future project impact assessments as the portfolio matures. Very little post-project evaluation has been possible, to judge indirect impacts on markets and stakeholders through replication because insufficient time has elapsed since completion of these projects. In some cases several years may be required to fairly judge indirect impacts. Evaluation activities by the GEF and its implementing agencies have been escalating as more results are becoming available.

Impacts are particularly visible from projects involving solar home systems, grid-connected wind and biomass power, energy-efficient lighting, and fuel switching and production/recovery. Completed or continuing projects have fostered new national policy and regulatory frameworks, international technology transfer through the private sector, growth of domestic industries for energy efficiency and renewable energy technologies and services, increased sales and investments, and provision of environmentally sound energy services to end-users. In addition to these development benefits, projects have directly and indirectly reduced greenhouse gas emissions (quantified greenhouse gas emissions reductions from individual projects are not addressed in this paper).

Replication of direct impacts to produce indirect impacts is integral to GEF climate change strategies. Replication may occur, for example, from local to national markets, from one private-sector firm to others, from one local government to another, and from one country to another. Although there are a variety of mechanisms to promote replication that can be incorporated into projects, replication ultimately depends on actions of governments, consumers, NGOs, and/or the private sector after a project is completed.

The problem of measuring direct and indirect impacts is fundamentally one of measuring changes in markets. There is scant published literature on this subject and thus GEF project evaluators tread in a relatively immature field. We propose a framework for measuring changes in markets that distinguishes between "physical changes," such as changes in investments and sales, and "market structure/function changes," such as changes in costs, transaction rules, availability of services, and human resource skills. In this framework, three different types of indicators measure *market interventions* (direct project outputs), *market development* (indirect changes catalyzed by projects), and *market sustainability* (long-term impacts). The framework has not yet been applied to completed GEF projects but suggests a direction for future evaluations.

As the number of projects in the GEF portfolio grows, there is potential synergy if projects in different countries or sectors reinforce each other and if project beneficiaries share their experiences and catalyze changes elsewhere. That is, a "critical mass" may be reached in some technology applications, project approaches, or countries, which will provide a "programmatic benefit" from the portfolio—that is, a benefit greater than the sum of the individual project benefits.

Overall, prospects for sustainability and replication of GEF climate change projects are still mixed and uncertain. GEF projects have attracted considerable attention from policy makers, the private sector, and NGOs. GEF strategies continue to evolve in dialogue with these and other stakeholders. Achieving and demonstrating programmatic benefits from the GEF project portfolio will depend on continued dialogue and understanding of project designs and impacts by all stakeholders.

Acronyms and Units

BIG/GT	Biomass Integrated Gasification/Gas Turbine
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
DSM	Demand-Side Management
ESCO	Energy-Service Company
GEF	Global Environment Facility
GHG	Greenhouse Gas
GWh	Gigawatt-hour
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
kW	Kilowatt
kWh	Kilowatt-hour
LPG	Liquid Propane Gas
MSW	Municipal Solid Waste
MW	Megawatt
MWe	Megawatt-electric
MWh	Megawatt-hour
MWp	Megawatt-peak
NFFO	Non-Fossil-Fuel Obligation
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
OP	Operational Program
PIR	Project Implementation Review
PMU	Project Management Unit
PURPA	Public Utilities Regulatory Policy Act
PV	Photovoltaic
PVMTI	Photovoltaic Market Transformation Initiative
R&D	Research and Development
REEF	Renewable Energy and Energy Efficiency Fund
SHS	Solar Home System
SHW	Solar Hot Water
SME	Small- and Medium-Size Enterprise
STAP	Scientific and Technical Advisory Panel
STRM	Short-Term Response Measure
T&D	Transmission and Distribution
TVE	Town and Village Enterprise
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change

Introduction

Since 1991, the Global Environment Facility (GEF) and its three implementing agencies (UN Development Program, UN Environment Program, and World Bank) have assisted developing countries and countries in transition in promoting energy efficiency and renewable energy technologies. GEF strategies for such assistance have evolved to meet national development goals and global climate change objectives. By mid-1999, 72 energy efficiency and renewable energy projects had been approved for assistance to a variety of beneficiaries, including government agencies, private-sector firms, community organizations, households, and providers of public services.

GEF projects are innovative and are often the first of their kind in the countries where they occur. The experience and knowledge incorporated into project designs is extensive; projects are developed by country governments and experts and then undergo technical reviews by the GEF Council, the GEF's Scientific and Technical Advisory Panel (STAP), GEF secretariat staff, all three implementing agencies, and the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat. Indeed, the first GEF Assembly in 1998 agreed that the "GEF should remain a facility at the cutting edge, innovative, flexible and responsive to the needs of its recipient countries, as well as a catalyst for other institutions and efforts" (GEF 1998d, p.9).

GEF climate change projects represent an emerging body of experimental, case-oriented information on innovative approaches to promoting energy efficiency and renewable energy technologies in developing countries and countries in transition. Although much project information exists in published and electronic form, no systematic review of these projects exists.[1] This paper provides the first such systematic review, beginning with evolving GEF climate change strategies and ending with emerging project impacts. The paper covers both *long-term projects* and *short-term response measures* but does not discuss other GEF climate change initiatives such as *enabling activities* and the *small grants program*.

Section A sets the context for understanding the GEF project portfolio by describing current and past GEF strategies for climate change. Section B describes the climate change projects that have been approved by the GEF and synthesizes the general approaches taken and the specific mechanisms used in project designs. Section B also discusses the roles of public-sector agencies, private-sector firms, and non-governmental organizations in GEF project designs. Section C reviews emerging impacts from completed or continuing projects and suggests an analytical framework for understanding and evaluating project impacts and replication.

Three annexes present supplementary material. Annex A reviews technical-economic opportunities for energy efficiency and renewable energy and barriers to technology diffusion. Annex B reviews the detailed characteristics and approaches of all existing projects in the GEF portfolio, separated into nine different project clusters. Annex C gives narrative descriptions of emerging project impacts for four specific clusters of projects based on published evaluation reports and unpublished data.

Several related topics are not covered in this paper, such as project implementation performance (project management, schedules, budgets, stakeholder involvement, etc.), the adequacy and coverage of existing strategies, the adequacy of monitoring and evaluation efforts, and the quantification of greenhouse gas emissions reductions (see Porter et al. 1998; World Bank 1998; GEF 1999a; Kaufman 2000). Nevertheless, the descriptive information contained in this paper provides a good foundation for addressing these issues.

Section A: Climate Change Mitigation Strategies

1. National Development and Global Climate Change

Energy-efficiency and renewable energy technologies are prominent in most sustainable development programs, for example Agenda 21 (UN 1993). According to the Intergovernmental Panel on Climate Change (IPCC) second assessment report, stabilization of atmospheric greenhouse gas concentrations at levels that will prevent serious interference with the climate system can only be achieved by dramatically increasing utilization of renewable energy supplies. In one IPCC scenario, in which greenhouse gases are stabilized by the year 2050, the share of renewable energy in the global energy balance must increase by tenfold from current levels. In developing countries, the required increase is even more dramatic, estimated at twenty-fold between 1990 and 2050. Further, improvements in energy efficiency and energy conservation can reduce emissions in the shorter term, thus "buying time" for the required changes in energy production (IPCC 1996a, 1996b and 1996c).

Energy-efficiency and renewable energy technologies can also advance important national development goals, such as clean air, energy services for rural populations, fuel import reductions, and more efficient domestic industries. For example, solar home systems (SHS) can supply energy for lighting, radio, television, and operation of small appliances in rural households that lack access to electricity grids (see Annex B.1). Solar home systems use photovoltaic solar panels and storage batteries to provide modest amounts of electricity that can eliminate the need for candles, kerosene, liquid propane gas, and/or battery charging. Besides the avoided costs of these fuels, benefits include increased convenience and safety, improved indoor air quality, and a higher quality of light than kerosene lamps for reading. Large rural populations without access to electric grids could make use of SHS at costs that are competitive with existing energy sources, and are less expensive than extending rural electricity grids (Goldemberg and Johansson 1995; Foley 1995; World Bank 1996).

Energy efficiency also provides domestic benefits, reducing costs and enhancing competitiveness. Energy-intensity improvements in industry can lower production costs, and energy efficiency improvements in manufactured product designs can reduce operation costs for a wide variety of consumers. Improvements can also delay or avoid the costs of building new power plants. All of these opportunities can help make domestic industries more competitive abroad. These improvements are important; although energy intensities (energy consumption per unit of GNP) have fallen in the developed world during the past two decades, in part because of energy efficiency improvements, energy intensities have not similarly decreased in many developing countries and countries in transition (World Bank 1993). Even in countries such as China, where great gains have been made in energy efficiency during the past two decades, the potential remains to do much more (Sinton and Levine 1998).

2. Energy Efficiency and Renewable Energy Opportunities and Barriers

Many opportunities to improve energy efficiency are cost-effective at current energy and technology costs in developing countries and countries in transition, using off-the-shelf commercial technologies. Such *technical-economic opportunities* are defined by their technical characteristics for reducing energy consumption and by indicators of their cost-effectiveness, such as cost of conserved energy, simple pay-back time, and economic rate of return.[2] These opportunities have been called "win-win" for their potential to provide both global and domestic benefits.

As noted by the IPCC in its second assessment report, several renewable energy technologies already have become cost-competitive with fossil-fuel-based technologies in many applications, or would become competitive if implementation costs could be lowered through practical experience and commercialization in the marketplace (IPCC 1996c). In other words, renewable energy options can be deployed profitably today in a wide-range of applications, particularly in remote and rural areas. Still, in many applications and resource conditions, the costs of renewable energy technologies are not yet competitive with those of conventional energy supplies. In these cases, further intervention is needed to reduce the costs of the technologies themselves. Cost-effective and near-commercial opportunities for energy efficiency and renewable energy are elaborated below.

Energy Efficiency. A large number of scientific studies combined with the extensive practical experience of the past 30 years point to many technology applications and markets that meet cost-effectiveness criteria (such as 20% rate of return on investment or five-year simple payback time), and that offer large potential for CO_2 emissions reduction.[3] For many electricity-efficiency opportunities, conserving a kWh of electricity costs less than producing it. Ten to 30 percent (or more) of energy consumption can be saved in many sectors in developing countries and countries in transition using measures that have already been commercialized and that are cost-effective to consumers and society. Opportunities to reduce energy use include (see Annex A for details and references):

- electricity consumption in industry and in buildings;
- coal, oil, and gas consumption in industry;
- space-heat consumption in buildings;
- fuelwood and coal consumption in household cooking;
- electricity consumption in irrigation pump-sets in agriculture;
- fuel use in automobiles, buses, and trucks;
- losses in electricity production, transmission, and distribution; and
- losses in oil and gas transmission and distribution pipelines.

Renewable Energy. Renewable-energy technologies that are already or nearly commercialized and are cost-competitive with conventional energy sources in many applications include solar water heating, off-grid electrification with solar photovoltaics (PVs), small-scale biomass power generation, biofuels, grid-connected and off-grid wind power, small hydropower, geothermal power, and methane utilization from urban and industrial waste. Renewable energy sources that are site specific, such as small hydro and geothermal, are expected to play a more limited role than some of the other technologies. Potential depends greatly on geographic resources such as wind speeds, solar radiation, and biomass residues from agriculture and other industries. If good geographic resources are present, several applications offer plentiful opportunities for cost-competitive commercial or near-commercial renewable energy in developing countries and countries in transition. These applications have been identified by scientific studies and practical program and project experience (see Annex A for details and references). They include:

- home electrification with stand-alone solar photovoltaic systems;
- electricity for village-power applications from mini-hydro, wind, and solar;
- electricity for electric power grids from biomass, wind, and geothermal;
- agricultural and domestic water supply with mechanical wind pumps;
- transportation fuels from biomass;
- heating, cooling, and hot water for buildings using solar technologies;
- district heating from biomass and geothermal; and
- biogas digesters for lighting and water pumping.

Other renewable energy technologies are not yet commercial but show promise if their costs decrease relative to the costs of conventional fuels (Johansson et al. 1993; Williams et al. 1998). Examples include:

- photovoltaics for grid-connected bulk power and distributed power applications;
- advanced biomass power through biomass gasification and gas turbines;

- solar thermal electric technologies in high-insolation regions.

Many of the above opportunities for energy efficiency and renewable energy are not being realized fully because barriers of many types limit or prevent technology diffusion and investment (see Annex A for details and references). Barriers have been well characterized in energy efficiency and renewable energy literature and are often referred to as "market barriers," "transaction barriers," "market failures," and "market imperfections." The Intergovernmental Panel on Climate Change (IPCC) noted in its second assessment report that:

> Most studies suggest that a large potential exists [for energy efficiency] in many sectors and regions, while at the same time acknowledging that institutional, economic, and social barriers may delay or inhibit the achievement of full efficiency potentials in the near future. (IPCC 1996a, p.12)

Barriers may be well known, but overcoming them is a daunting challenge. For example, many point out that diffusion of renewable energy technologies among commercially viable applications has been slower than might be expected based upon technology development progress and economic costs alone (Kozloff and Shobowale 1994; Jackson 1993). The lag in the adoption of renewable energy technologies is frequently attributed to the difficulties of overcoming barriers—including imperfect capital markets, institutional barriers, poor market acceptance, financing risks and uncertainties, transactions costs not included in market prices, and lack of skilled personnel.

3. GEF Strategies for Climate Change

In 1992, the UN Framework Convention on Climate Change (UNFCCC) designated the GEF as an interim financial mechanism to fund mitigation and response strategies in eligible developing countries and countries in transition.[4] This decision was the culmination of a remarkable international process to find mechanisms for global environmental improvement (Sjoberg 1994). GEF assistance is "additional" to existing development processes and the GEF funds only the "incremental costs" of greenhouse gas reductions (Ahuja 1993; GEF 1996d). GEF assistance takes the form of a series of projects conducted by the three GEF implementing agencies: the UN Development Program, the UN Environment Program, and the World Bank (including the International Finance Corporation). Projects also leverage financing and other resources from governments, bilateral donor agencies, the private sector, and the three GEF implementing agencies.

The first three years of the GEF were considered a pilot phase, in which projects demonstrated greenhouse gas emissions reductions with low costs per ton of direct carbon abatement.[5] Although the GEF has continued to finance *short-term response measures* in the tradition of the pilot phase, it was clear that the GEF's limited resources could not significantly affect greenhouse gas emissions in the short term. Thus, following the pilot phase, GEF strategies began to evolve in order to attain higher leverage of limited resources (Anderson and Williams 1993). GEF projects began to enhance public-sector capacities, promote project sustainability and replication (i.e., technology diffusion), and develop global, national, and local markets for technologies in which the private sector could play a major role. These goals were codified in 1996-97 when the GEF adopted an *operational strategy* and three *long-term operational programs* designed to promote energy efficiency and renewable energy by removing barriers, reducing implementation costs, and reducing long-term technology costs (GEF 1996a, 1997a). A significant goal of these programs is to catalyze sustainable markets in the long term and enable the private sector to finance and diffuse technologies.

The three long-term operational programs for climate change are:[6]

(i) Removing Barriers to Energy Conservation and Energy Efficiency. This program is designed to remove barriers to the large-scale application, implementation, and dissemination of least-economic-cost, commercially established or

newly developed energy-efficient technologies; and to promote more efficient energy use where a reduction in greenhouse gas emissions will result.

(ii) Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs. This program is designed to remove barriers to the use of commercial and near-commercial renewable energy technologies, and to reduce additional implementation costs for renewable energy technologies that result from lack of practical experience, initial low-volume markets, or the dispersed nature of applications.

(iii) Reducing the Long-Term Costs of Low-Greenhouse-Gas-Emitting Technologies. This program is designed to accelerate technological development and increase the market share of low-greenhouse-gas-emitting technologies that have not yet become commercial, lower-cost alternatives to fossil fuels but which show promise of becoming so in the future.

The goals of the first two programs are similar. Both aim to reduce long-term CO_2 emissions associated with energy consumption and production by promoting increased use of commercial or near-commercial technologies, removing barriers to market-oriented transactions and policies, and catalyzing public- and private-sector investments in profitable mitigation projects. Both programs encourage sustainability and replication of project impacts by demonstrating cost recovery and facilitating mainstream financial support, including support from the multilateral development banks. Both programs also facilitate the learning process required for widespread replication of technologies and project approaches. The programs differ in that they address different technologies that often face different key barriers.

The goal of the third program is cost reduction. The GEF expects that technological learning and economies of scale (also called cost "buy-down"), achieved at least in part through GEF projects, will reduce long-term costs to commercially competitive levels. Such industrial "learning curves" have been documented for a range of technologies and have been applied to renewable energy technologies as well (Krawiec 1980; Christiansson 1995). This program assumes that when technology costs decline sufficiently, technologies will be adopted and replicated by the private sector. For many technologies in this program, the "buy-down" process will take many years or even decades; the GEF's goal is to accelerate this process.

The GEF continues to explore and adopt new strategic and policy directions. For example, a *medium-sized project* category was recently added to the long-term operational programs to facilitate expedited, flexible projects up to $750,000 for a wide range of beneficiaries (GEF 1997d). This followed the establishment of a GEF-supported *small grants program* by the UNDP that provides quick-response grants up to $50,000 (Richards et al. 1995; GEF 1997c; Wells et al. 1998). The GEF is considering how to further engage the private sector in GEF activities, at both project and strategic levels, such as with non-grant financing, support for investment feasibility studies, and long-term partnerships (GEF 1999b). Contingent financing (e.g., contingent grants and loans, partial credit guarantees) is being piloted as a way to reduce financing risk without the need for direct grants (Ashford 1999). The GEF is also considering how to strengthen the roles of non-governmental organizations and other stakeholders (GEF 1996b, 1996c). Additional programs for sustainable transport and integrated ecosystem management related to climate change are also being developed.

4. GEF Strategies in a "Logical Framework" Approach

GEF strategies can be understood in a "logical framework" that illustrates how project activities are expected to meet GEF objectives (see Table 1). Projects provide services to public- and private-sector beneficiaries, who in turn generate project outputs or results (e.g., demonstration installations, new commercial services, enhanced capacities, new policy frameworks, and targeted research results). These outputs help to create sustainable technology diffusion and market development, particularly through replication (e.g., lower costs, more investments or sales, more domestic firms or joint ventures, greater public acceptance and demand for technologies). Finally, as public and private entities adopt technologies and place them in service, greenhouse gas emissions decline relative to baseline or "business as usual" situations.

For example, a project to promote high-efficiency refrigerators could include activities like consumer education, support for product labeling, provision of dealer incentives, and technical assistance to producers to upgrade refrigerator designs. Project outputs would be more aware consumers, labeled products in stores, dealers who carry high-efficiency refrigerators, and greater production of high-efficiency models by some manufacturers. Replication would mean expansion of the number of manufacturers, regions, dealers and/or consumers (see also Section C). National market impacts would be expected as high-efficiency refrigerators are produced and purchased (measured at the development objective level). Other development impacts could include reduced consumer energy bills, reduced local air pollution resulting from lower energy consumption, and greater international competitiveness of domestic manufacturers. Global impacts would result from lower CO_2 emissions associated with lower energy consumption.

The logical framework is understood "from the bottom up," according to how fulfillment of objectives at lower levels leads to fulfillment of objectives at higher levels. Each level in the logical framework is designed to support the objective of the next higher level, provided that the assumptions hold true and risks prove manageable. For example, on the project-inputs level, risks and uncertainties exist about how effectively the specific project activities will achieve expected project outputs. On the project-outputs level, a key assumption is that removal of specific targeted barriers in a specific market is necessary and also sufficient to stimulate markets. So appliance standards could be enacted, but manufacturers might not adhere to them because of other barriers that are not addressed; or energy service companies could be formed and trained but might still lack access to capital; or efficient cook stoves could be demonstrated but no firms might be willing to produce and sell them; or incentives could be created, but individuals or organizations might not respond as predicted because of unanticipated political, social, cultural, or institutional factors, or because of inaccurate understanding of consumer needs and preferences.

Table 1: Program Objectives in a Logical Framework

Framework level	Objective	Indicators and monitoring	Assumptions and risks
Global objective (Avoided GHG emissions)	Reduce CO_2 emissions from energy consumption and production	Avoided GHG emissions that result from market development and other changes in practices and infrastructure	
Development objective (National market and other development impacts)	Build markets for energy efficiency and renewable energy technologies	Market development indicators (see Section C) measure indirect project impacts	Changes in products, sales, and investments will avoid or reduce energy production from GHG-emitting sources
Project outputs (The direct or intended results of projects)	Remove barriers as a consequence of project outputs	Market intervention indicators (see Section C) measure project outputs and direct impacts	Project outputs are necessary and sufficient to build markets
Project inputs (Specific project activities)	Complete specific activities within a project (e.g., training, institution building, research, demonstration, technical assistance, information dissemination, etc.)	Project performance monitoring	Project activities taken together are sufficient and necessary to produce project outputs

Section B: GEF Climate Change Projects

1. The GEF Project Portfolio

From 1991 to mid-1999, the GEF Council approved grants totaling $706 million for 72 energy efficiency and renewable energy projects in 45 countries. The total cost of these projects exceeds $5 billion because the GEF grants have leveraged financing through loans and other resources from governments, other donor agencies, regional development banks, the private sector, and the three GEF project implementing agencies (UN Development Program, UN Environment Program, and World Bank Group). An additional $121 million has been approved in grants for 20 climate change "short-term response measures" (GEF 1999c).

Existing project designs from the past eight years represent an extensive knowledge base with a diverse range of approaches to promoting energy efficiency and renewable energy. The designs of approved projects reflect innovative and experimental attempts to promote technologies through new approaches and best practices. Designs continue to evolve based on lessons learned from earlier projects, international best practices, and improved understanding of how to accomplish the GEF's strategic goals. The climate change project portfolio continues to grow as new projects are approved by the GEF Council on a regular basis.

In order to make the project portfolio easily accessible, we organize it into clusters and synthesize project approaches within clusters (see Annex B and Table 2). Projects within a cluster share many common approaches that can be highlighted despite their diversity.[7] Examples of project approaches include demonstrating technical or commercial feasibility by installing demonstration equipment; catalyzing sustainable markets by increasing market volume, reducing technology costs, and raising consumer awareness; building capacities of public agencies, private-sector firms, and non-governmental organizations; creating or strengthening technology intermediation centers; disseminating information; conducting studies or targeted research; developing national strategies or policy frameworks; creating new financing services; and creating new institutions.

We define nine project clusters: solar home systems and rural energy services, grid-connected renewable energy, solar hot-water supply, precommercial renewable energy technologies, energy-efficient product manufacturing and markets, energy efficiency investments in industry, energy-efficient building codes and construction, district-heating energy efficiency improvements in countries in transition, and fuel switching and production/recovery.[8] A few projects appear in more than one cluster because of the diverse nature of their components (thus cluster totals add up to more than the portfolio total).[9]

2. Project Designs and Mechanisms for Promoting Technologies

The project approaches described above represent a wide variety of mechanisms for promoting energy efficiency and renewable energy. This diversity results in part from the experimental nature of GEF projects, which are often the first of their kind in the countries where they take place. Projects are experimental because of the wide diversity of national contexts in which projects take place and because historical experience and accumulated international lessons are still far from providing definitive answers about how to accomplish GEF objectives in developing countries and countries in transition.

For example, although much has been written about energy efficiency policies and programs, including utility-based demand-side management and market transformation programs, much of the actual experience has occurred in developed countries (Cavanagh 1989; Philips 1991; Levine et al. 1991 and 1992; Nadel 1992; World Bank 1993; Geller and Nadel 1994; Nadel and Latham

Table 2: Project Clusters and Approaches

Project Clusters	Project Approaches
Solar home systems and rural energy services 21 projects; see Annex B.1	• Pilot private-sector delivery models • Pilot credit mechanisms and make systems affordable • Pay first-cost subsidies and lower import duties to make systems economically competitive and to amass an installed base to lower future implementation costs • Build capacities of public agencies and private-sector firms • Enact codes and standards and put in place certification and testing institutions • Conduct consumer awareness and marketing programs
Grid-connected renewable energy (wind, small hydro, biomass, geothermal) 12 projects; see Annex B.2	• Demonstrate technologies and their commercial and economic potential • Build capacities of project developers, plant operators, and regulatory agencies • Develop regulatory and legal frameworks that encourage independent power producers and establish transparent, non-negotiable tariff structures • Create financing mechanisms for project developers
Solar hot-water supply 2 projects; see Annex B.3	• Reduce installed costs and make systems affordable • Raise awareness among consumers and policy makers • Promote a favorable policy framework • Improve product quality
Precommercial renewable energy technologies (BIG/GT, solar thermal, PV) 6 projects; see Annex B.4	• Select and install technologies for attractive niche markets with good cost-reduction potential • Catalyze demonstration effects
Energy-efficient product manufacturing and markets (lights, boilers, refrigerators, chillers) 8 projects; see Annex B.5	• Provide technical assistance and technology transfer to manufacturers to upgrade product designs to be more energy efficient • Reduce retail prices of technology through subsidies, bulk procurement, or manufacturer contributions • Pilot new distribution mechanisms through retailers, dealers, or electric utilities • Educate consumers/users about the characteristics, costs, and benefits of energy efficiency technologies • Develop technology standards and/or certification mechanisms • Conduct utility-based DSM programs
Energy efficiency investments in industry 14 projects; see Annex B.6	• Pilot innovative financing mechanisms • Promote or create energy service companies • Create or strengthen dedicated energy efficiency centers • Build capacity of industrial enterprises to understand, select, finance, and install energy-efficient technologies • Demonstrate the technical, economic, and commercial viability of energy efficiency and energy conservation measures
Energy-efficient building codes and construction 4 projects; see Annex B.7	• Collect and disseminate data on building characteristics • Develop new codes and standards and establish new agencies or institutional mechanisms to enforce the standards and/or certify equipment • Demonstrate and/or test technical measures for improving energy efficiency • Conduct studies of potential energy savings and audit selected buildings
District-heating energy efficiency and biomass/geothermal heat production 5 projects; see Annex B.8	• Create new financing mechanisms, particularly involving the private sector • Build capacities among municipal governments, district heating companies, and households to understand, finance, and implement energy efficiency projects • Create new regulatory frameworks that provide incentives to improve energy efficiency and conserve energy for households and heat suppliers • Demonstrate technologies and disseminate information on technology characteristics, costs, and benefits to households and heat suppliers
Fuel switching and production/recovery 18 projects; see Annex B.9	• Demonstrate technical, economic, and commercial feasibility of low-carbon-fuel plants or fuel production/recovery techniques • Develop national strategies, plans, and institutions for promoting fuel switching and production/recovery technologies

1994; Reddy et al. 1997; Martinot and Borg 1998; IPCC 1996b and 2000). Still, there are good examples where developing countries have made great progress with energy efficiency programs (Sinton and Levine 1998; Januzzi et al. 1997).

Many policies for promoting renewable energy that have been adopted in developed countries have not yet been tried in developing countries, such as PURPA (Public Utility and Regulatory Policy Act) in the United States, NFFO (non-fossil-fuel obligation) in the United Kingdom, and electricity-feed laws in Germany (Shepherd 1998). Nevertheless, experience with development assistance for renewable energy projects in developing countries during the past 25 years is substantial and has taught many lessons (World Bank 1981; Barnett 1990, Hurst 1990; Qiu et al. 1990; Jackson 1993; Saunders 1993; Foley 1993; Kozloff and Shobowale 1994; Liebenthal et al. 1994; Goldemberg and Johansson 1995; World Bank 1996; IPCC 2000).

Among the lessons learned from development assistance for renewable energy are that failures occurred because projects emphasized one-time technology demonstrations that did not demonstrate incentive structures and institutional and commercial viability (including maintenance requirements), and did not create sustainable markets for the technologies demonstrated. It has become clear that overall assistance plans should incorporate ways to develop commercial markets and local production capabilities, create access to financing, facilitate stakeholder partnerships, and develop information channels and institutional capacities. All of these features are all part of properly functioning markets.

Through extensive technical reviews, including those by a scientific and technical advisory panel (STAP), the GEF has benefited from this historical experience. GEF projects are also creating a new knowledge base that can add to ongoing policy research, future projects, and other technology diffusion efforts by national and international and national agencies concerned with climate change (see Section C and Annex C).[10]

The diversity of project approaches to fit a diversity of national contexts is illustrated by the 20 GEF projects to diffuse photovoltaic technologies in rural areas (see Annex B.1). These projects use a variety of diffusion (or "delivery") mechanisms: through local community organizations in Bolivia; through private-sector financial intermediaries in India and Sri Lanka; through local photovoltaic dealers/entrepreneurs in Peru, China, Zimbabwe, Vietnam, and Indonesia; and through rural energy-service concessions in Argentina, Benin, and Togo.

The diversity of approaches also highlights the wide range of public-sector, private-sector, and non-governmental beneficiaries of GEF assistance that are responsible for building, operating, and replicating these diffusion mechanisms. For example, on the public-sector side, the GEF provides technical assistance and capacity building to strengthen public agencies in regulating, promoting, financing, and sustaining technologies. On the private-sector side, GEF projects provide technical and commercial information and training/advisory services to private-sector entities. GEF projects also provide combinations of different types of financing to the private sector, including grants, concessional loans (no- or low-interest loans), and contingent loans (forgivable under specified conditions).

Tables 3 and 4 present mechanisms for promoting technologies and removing barriers and give examples of GEF projects utilizing these mechanisms. The following sections and Annex B elaborate on key aspects of GEF project designs.

Table 3: Mechanisms for Promoting Energy Efficiency

Mechanism	Description	GEF Project Examples
National, regional, and local energy strategies and planning	Policy makers can formulate least-cost integrated energy strategies that consider both demand and supply sides. Policies can include capital investments, energy price reforms, institutional and regulatory reforms, and energy-sector privatization.	Egypt, Palestinian Authority, Syria (national energy conservation programs) Syria (integrated resources planning)
Sectoral policy development at national, regional, and local levels	Sectoral policies affecting energy use can be designed to reduce energy consumption. Examples include transportation planning; road and parking fees and taxes; land-use planning and zoning; building codes and standards; housing policies and institutional reforms affecting ownership and responsibility; industrial equipment and consumer appliance standards; and agricultural water policies affecting irrigation.	Brazil, Côte d'Ivoire, Mexico, Senegal, Thailand, Tunisia (building efficiency codes and standards) Lebanon (industrial equipment standards) Russia (municipal heat supply regulations) Peru (industrial air emissions)
Energy service companies	Energy service companies can provide information; training; project identification; financial and technical analysis; financing, contracting and installation services; monitoring; and shared savings arrangements. GEF support can facilitate creation and strengthening of energy services companies with training, business and contractual models, market studies, and financing.	Brazil, Chile, China, Hungary, India, Lebanon, Malaysia, Mexico/SME (industrial energy efficiency improvements)
Demand-side management programs by electric utilities	Demand-side management (DSM) programs by electric utilities can reduce electricity demand and provide direct financial benefits to the utility. Programs may include direct investments, appliance and lighting equipment rebate/sales programs, improved energy management systems, and time-of-use rates and controls. Utilities' low cost of capital and understanding of the opportunities combined with regulatory incentives can make utilities successful intermediaries for electricity efficiency improvements.	Jamaica, Mexico, Thailand (DSM office, sales of efficient lighting products, commercial building codes, appliance and equipment standards and labels) Argentina, Czech Republic, Hungary, Latvia, Peru, Philippines, South Africa (efficient lighting)
Market transformation	A market transformation approach simultaneously provides both "market push" and "market pull" for a particular technology. Market research, information, technology promotion, and technical assistance can boost market demand for more efficient products while simultaneously increasing the willingness of suppliers to produce them. Otherwise, producers are unwilling to produce because no established market exists and consumers do not demand the product because it is not produced or sold. Revised product designs, appliance standards, product labeling, and consumer education (see below) are often part of market transformation.	Argentina, Czech Republic, Hungary, Jamaica, Latvia, Mexico, Peru, Poland, Philippines, South Africa, Thailand (efficient lighting) Thailand (chillers for buildings) China (industrial boilers) China (household refrigerators)
Revised product designs	Technology transfer and technical assistance to manufacturers can allow them to upgrade product designs to more-energy-efficient models. Capacity building to assist manufacturers in marketing more-efficient models is also important.	China (efficient industrial boilers) China (efficient household refrigerators)

Table 3: Mechanisms for Promoting Energy Efficiency (continued)

Mechanism	Description	GEF Project Examples
Appliance standards, product labeling, and consumer information	Appliance standards can push average appliance efficiencies closer to levels of minimum total life-cycle costs. At the same time, labels for appliances and lighting, along with consumer information campaigns, can pull consumer demand in the direction of higher efficiency models.	Poland (CFL labeling) China (refrigerator labeling) Thailand (appliance and industrial motor standards, labeling, testing, and certification) Argentina, Czech Republic, Hungary, Latvia, Peru, Philippines, South Africa (Efficient Lighting Initiative)
Collection and synthesis of new data and information	Individual audits, surveys, and analysis of end-use energy consumption and technical-economic opportunities; end-user preference surveys; cost estimations; reliability estimations; and preliminary designs can all reduce generic information barriers if the information obtained is widely applicable in a particular market and distribution mechanisms exist.	Peru (survey of industrial and diesel vehicle emissions) Jamaica (building energy audits) Lebanon (industrial energy audits) Côte d'Ivoire, Senegal (benchmark data on building energy efficiency) Malaysia (industrial energy efficiency performance benchmarks)
Financing mechanism innovations	Specific financial-institutional transaction models can be designed to provide capital under conditions acceptable to both lender and borrower and to overcome barriers of capital availability, perceptions of risk, lack of collateral or guarantees, and high front-end capital costs.	Hungary (commercial cofinancing and guarantee mechanism) Chile, Brazil (revolving funds) India (financing through specialized government agency) Kenya (commercial financiers) China (industrial TVE capital fund)
Information centers and services	Information about opportunities, costs and benefits, sources of financing, and sources of procurement and installation skills can be provided through a variety of channels. Services that provide indicators of energy performance and promote awareness of these indicators can lead to greater demand for energy-efficient equipment and buildings. Information and design tools and services can also be provided directly to architects and builders to enable them to make their designs more energy efficient.	China (energy-efficiency and performance-contracting information dissemination centers) China (dissemination of high-efficiency industrial boiler designs) Syria (energy services center) Bulgaria (energy and environment offices)
Awareness campaigns	Increased awareness by potential end-users about costs, benefits, performance, and maintenance of commercially available technologies can provide an important stimulus to market demand.	Almost all GEF projects
Training programs	Training can provide technical, business, regulatory, managerial, financial, and legal skills needed for purchasing, promoting, regulating, financing, and commercializing technologies.	Almost all GEF projects

Table 4: Mechanisms for Promoting Renewable Energy

Mechanism	Description	GEF Project Examples
National, regional, and local energy strategies and planning	Policy-makers can plan least-cost energy strategies and enact or revise policies that "level the playing field" for renewable energy relative to conventional energy sources, by means of government investments, energy price reforms, institutional and regulatory reforms, tax incentives, and privatization and competition in the energy sector.	Sri Lanka, Zimbabwe (lower import duties on PV components) India, Morocco (macroeconomic, investment, and tax policies) India (national bioenergy board, national small hydro strategy) Lao PDR (national rural electrification plan)
Electric power utility regulation	Changes to regulatory and legal frameworks can encourage independent power producers to finance and install new renewable generation sources in existing grids and sell the power to electric utilities.	China, India, Indonesia, Sri Lanka (non-negotiable power tariffs and/or power purchase agreements)
Codes and standards	Codes, standards, and certification can reduce commercial and purchase risks as well as negative perceptions of technology performance. Certification and testing agencies can allow manufacturers to easily verify compliance with standards and provide purchasers with performance assurance.	Argentina, Benin, China, Ghana, Indonesia, Mexico, Morocco, Peru, Sri Lanka, Togo, Uganda (solar home systems and solar-hot-water heating equipment standards) China, Indonesia, Morocco (test and certification facilities or agencies)
Information centers	Information centers can provide education, analytical design tools, market analysis, and information for evaluating technological options, determining relative costs and benefits, and understanding implementation requirements and operation and maintenance of renewable energy technologies. These centers can actively promote information dissemination among government officials, electric utilities, potential end-users, and the general public.	China (technology center for solar home systems)
Resource assessments	Access to existing resource assessments, resource assessment tools and techniques (including training and assistance in using the tools), and resource monitoring and data-acquisition programs can reduce risks associated with renewable energy-resource uncertainty.	China, Ghana, Peru (solar resource measurement and databases) Sri Lanka (wind, small hydro, and biomass resources) Indonesia (hydro and geothermal resources)
Financing mechanisms and guarantee innovations	Innovative financing mechanisms and financial intermediaries can connect end-users to sources of capital and bundle small projects for commercial financing. Successful examples of revolving loan funds or microcredit for renewable energy already exist in many developing countries. Intermediaries can take many forms, including local development NGOs and energy service companies.	Uganda, Zimbabwe (revolving funds for consumer credit) India (financing through specialized government agency) Dominican Republic (SME), India, Indonesia, Kenya, Morocco, Sri Lanka, Vietnam (SME) (commercial financing of private entrepreneurs)

Table 4: Mechanisms for Promoting Renewable Energy (continued)

Mechanism	Description	GEF Project Examples
Technology research and demonstration	Technology research and demonstration can lower long-term technology costs, improve available information, and reduce uncertainty. Some technologies may require further application-oriented research, for example to better understand and demonstrate installation costs, performance, reliability, and institutional issues in a specific context.	Brazil (BIG/GT power plant) India and Morocco (solar thermal hybrid power plant) Philippines (distributed on-grid PV in conjunction with hydropower)
Local development or community organizations	Local organizations, whether municipal agencies, cooperatives, or non-governmental organizations, can promote renewable energy locally and provide resources for energy enterprise development, financing, and technology assessment, as well as adaptation for local needs and conditions.	Uganda, Zimbabwe (solar energy industries associations) Bolivia (installation and maintenance of village-power and household systems)
Energy service companies	Energy service companies can be especially important for small-scale dispersed renewable energy applications. An energy service company should integrate technical, legal, managerial, and financial capacities for identifying, assessing, proposing, financing, and implementing renewable energy projects.[11]	Argentina, Benin, Peru, Togo (regulated rural energy-service concessions) Sri Lanka (private SHS dealer providing fee-for-service systems) Ghana (public utility, private sector)
Awareness campaigns	Increased awareness by potential end-users about costs, benefits, performance, and maintenance of commercially available technologies can provide an important stimulus to market demand.	Almost all GEF projects
Training	Training can provide technical, business, regulatory, managerial, financial, and legal skills needed for purchasing, promoting, regulating, financing, and commercializing technologies.	Almost all GEF projects

3. Equipment Installations and Demonstration

Many GEF projects install and demonstrate equipment, such as solar home systems, compact fluorescent lamps, and energy-efficient motors. The directly installed capacity and energy savings from these projects can be significant, but these installations are fundamentally intended as demonstrations and must be replicated in order to achieve large-scale indirect impacts.

Energy efficiency projects target substantial direct energy savings and installed energy efficiency equipment. For example, three projects in Mexico, Poland, and Thailand target sales of more than 3 million compact-fluorescent lamps (Annex B.5). The China Efficient Industrial Boilers project expects that by 2002, annual production of more-efficient boilers by participating manufacturers will reach 35% (by capacity) of their total boiler production (Annex B.5). In another China project, refrigerator and compressor manufacturers will upgrade designs and sell an expected 20 million higher-efficiency refrigerators by 2012 (Annex B.5). A demand-side management program in Thailand expects to reduce peak load by more than 200 megawatts and save more than 1,000 GWh of electric power annually through energy efficiency programs (Annex B.6). The Hungary Energy Efficiency Co-Financing project expects total direct greenhouse gas emissions reductions associated with energy efficiency improvements over the fund's expected life to be in the range of 750,000 to 1 million tons of carbon (Annex B.6). In Tunisia, service-sector buildings and residential housing are being retrofitted with energy efficiency measures. And in Russia, a municipal government is installing autonomous heating boilers in apartment buildings to demonstrate the technical and commercial viability of this technology (Annex B.8).

Renewable energy capacity installations expected from GEF-supported projects is small but still significant relative to world markets (IEA 1996; USEIA 1998). For example, installation of 350 megawatts of wind and biomass power capacity is expected; this total is relative to a total installed worldwide capacity of 7,200 megawatts, and relative to the total installed capacity in developing countries of 1,200 megawatts (Annex B.2). Solar thermal capacity expected from approved projects is 165 megawatts, while planned installations by the private sector (there is one major global supplier of solar thermal technology) from 1995 through the early 2000s total 400 megawatts (Annex B.4). The GEF has approved 440 megawatts of geothermal electricity projects, about half of the 1,100 megawatts installed worldwide from 1991 to 1996 (Annex B.2). In Tunisia and Morocco, two projects expect 150,000 m^2 of installed solar collector area for household and commercial solar hot-water heaters (Annex B.3). An estimated 300,000 to 500,000 solar home systems are now installed in developing countries; approved GEF projects expect to greatly expand this number, adding more than 700,000 systems during the next several years (Annex B.1).

The above figures have been called “paper megawatts” by some. Many of these projects were only approved during the past few years, which, coupled with slow implementation progress in many older projects, has meant that actual installed capacities as of 1998 were still a small fraction of the total expected capacities from these approved projects (see Section C and Annex C).

4. Capacity Building

Capacity building is a central feature of most GEF projects and is resulting in indirect impacts on countries’ abilities to understand, absorb, and diffuse technologies. Projects build the human resources and institutional capabilities that are widely recognized as important conditions for technology diffusion. Projects target a wide range of capacity building among public agencies, private-sector firms, financiers, consumers, community organizations, and non-governmental organizations. In the public sector, projects strengthen the ability of agencies to regulate, promote, finance, and sustain technologies. In the private sector, projects provide technical and commercial information and training/advisory services. Capacity building is discussed below, broken down into several categories.

Technical, Financial, and Regulatory Skills. Projects build specific skills among policy-makers and individuals in the private sector (see Box 1 for examples). Common technical and environmental skills targeted include: energy auditing and management, power plant operations and maintenance, integrated energy planning, renewable energy resource assessment, project preparation and appraisal, project evaluation, and environmental assessment. Many projects increase the business development skills of public and private enterprises and financiers to manage, finance, and/or market energy efficiency and renewable energy technologies. Many projects also develop public agencies’ regulatory skills.

Consumer and Policy-Maker Awareness. Many projects specifically include activities to build awareness of renewable energy and energy efficiency technologies and their commercial viability. Such activities target government policy makers, industrial enterprises, energy suppliers, and commercial and residential consumers. Awareness is also enhanced through information dissemination, which may occur through the media or specialized technology centers, conferences, and workshops. Examples include:

Solar home systems and solar hot-water heating. Most solar home systems projects incorporate extensive media campaigns, information dissemination, or other forms of outreach to rural households to educate residents about the technology and its cost and benefits. Some projects, like one in China, explicitly assist solar home systems dealers with marketing to rural households. Two solar hot-water projects in Tunisia and Morocco conduct awareness campaigns among a wide variety of private and public establishments (e.g., hotels, government buildings, mosques, schools, and apartment buildings). Awareness campaigns target policy-makers to influence their decision making and target opinion leaders in the architecture and engineering communities to influence professional practices (Annexes B.1 and B.3).

Energy efficiency. Energy-efficient lighting projects in Mexico, Poland, and Jamaica all include consumer education and outreach programs to promote lamp sales. Projects conduct television, newspaper, and radio campaigns and conduct outreach through utilities. The Poland project used a special "green" product logo to promote lamp sales and conducted an energy and environmental education program in primary and secondary schools. The Tunisia Building Codes project conducts a public awareness campaign to promote support for building codes and standards. The Romania Capacity Building project disseminates information about energy consumption and energy efficiency to municipal councils, large industrial consumers, small- and medium-size enterprises, the general public, trade unions, associations, and school children. Information is disseminated through energy exhibitions, school curricula, and publications (Annexes B.5, B.7 and B.8).

Fuel production/recovery. The China Coal-Bed Methane project builds awareness of coal-bed methane technology among state policy makers, coal-mine engineers, and coal-mine managers. Similarly, the India Biomethanation project disseminates information through national workshops, publishes promotional literature, and conducts a media campaign to raise public awareness of biomethanation and biogas (Annex B.9).

Regulatory Frameworks. Some projects promote or pilot new regulatory frameworks for independent power production to assist public and private project developers in installing grid-based wind, biomass and geothermal technologies (China, India, Philippines, Sri Lanka, Indonesia, Mauritania, Mauritius; see Annex B.2). In Bulgaria, Romania, and Russia, projects assist government agencies to develop and strengthen regulatory frameworks for municipal heating markets in formerly planned economies (Annex B.8). Regulatory frameworks are direct outputs in several projects, for example:

Building codes and standards and implementation/enforcement mechanisms. The Thailand Electricity Efficiency project institutes a mandatory energy code for commercial buildings. The West Africa (Côte d'Ivoire and Senegal) Building Energy Efficiency project helps finalize an existing energy efficiency code for air-conditioned buildings and drafts a thermal comfort code for buildings without air conditioning; in both cases the project assists with implementation of the codes. And the Tunisia Building Codes project helps validate energy efficiency standards for all new buildings in the commercial and residential sectors (Annex B.7).

District heating regulatory frameworks. Projects in Russia and Bulgaria develop regulatory frameworks for metered heat consumption in residential buildings, including new institutions for consumption-based heat-meter reading and billing. The Russia project studies unresolved regulatory, institutional, and technical questions surrounding installation of autonomous, decentralized heat-production units in buildings, and the implications of heat-supply customers disconnecting from centralized heating networks. The Bulgaria project recommends a new legal framework for energy efficiency investments, including legislative and regulatory measures, taxation and fee structures, and utility infrastructure requirements (Annex B.8).

Box 1. Beneficiaries of Capacity Building (Technical, Financial, and Regulatory Skills)

Technical Skills

Engineering and environmental management departments of the Philippine National Power Corporation trained to perform social and environmental impact assessments of the corporation's activities (Philippine Leyte-Luzon Geothermal project; Annex B.2).

Indian Ministry for Non-Conventional Energy Sources, state agencies, equipment manufacturers, industry associations, and NGOs trained in the planning, design, construction, operation, maintenance, management, and revenue collection and expenditure related to small hydel projects (India Hilly Hydel project; Annex B.2).

Technical and managerial staff at bagasse and coal plants trained in plant operation and maintenance (Mauritius Sugar Bioenergy project; Annex B.2).

Technicians from local Mauritanian enterprises trained to assemble, manufacture, install, operate, and maintain wind turbines (Mauritania Windpower project, Annex B.2).

Private-sector project developers (independent power producers) trained to conduct feasibility studies and undertake projects. State Electricity Board, private-sector firms and NGO trained in technical, financial, institutional, and business aspects of renewable energy project design (Sri Lanka Energy Service Delivery project, Annex B.2).

Staff of provincial power companies trained to measure wind resources, conduct feasibility studies, and construct wind-farm subprojects (China Renewable Energy Development project, Annex B.2).

Government agencies and private firms trained to promote, evaluate, and install solar hot-water systems (Morocco and Tunisia solar hot-water projects, Annex B.3).

Existing Town and Village Enterprise regional energy conservation centers in China provided with basic computing and teaching materials, library facilities on domestic and international technologies, and technical assistance on how to develop training programs and materials; also trained to perform energy audits (China Town and Village Enterprise project, Annex B.6).

A national network of energy auditors from small- and medium-size enterprises trained to identify and evaluate energy efficiency opportunities and prepare and implement energy-saving measures. Kenyan Association of Manufacturers trained in energy management and efficiency (Kenya energy efficiency project, Annex B.6).

Peru Center for Energy Conservation (CENERGIA), having already earned the trust of the private sector, trained to provide advice and support to clients in the public and private industrial sectors on potential energy efficiency and conservation savings (Peru energy conservation project, Annex B.6).

China Coal-Bed Methane Company trained in coal-bed methane technology; coal geology companies, research institutes, and coal-mining administrations trained in vertical well-drilling techniques for coal-bed methane recovery (China Coal-Bed Methane project, Annex B.9).

Government and national laboratory personnel exposed to foreign biomethanation technologies through study tours and fellowship opportunities (India Biomethanation project, Annex B.9)

Central Mine Planning and Design Institute trained to identify, design, and implement programs to recover and utilize coal-bed methane (India Coal-Bed Methane project, Annex B.9)

Sichuan Petroleum Administration trained to manage, operate, and maintain the gas transmission and distribution system (China Sichuan Gas project, Annex B.9).

(Box 1 Continued)

Financial/Business Skills

Solar home system dealers/installers/entrepreneurs and rural energy-service concessions trained in business and entrepreneurship and solar PV technologies (solar home systems projects, Annex B.1).

Rural community-based organizations and households trained to finance, contract, and oversee installation and maintenance of renewable energy systems (Bolivia PV project, Annex B.1).

Policy makers, energy professionals and businessmen trained in market-based renewable energy development through study tours, international workshops, and local consultants (China Rapid Commercialization of Renewable Energy project, Annex B.1).

India Renewable Energy Development Agency trained in renewable energy project finance (India Alternate Energy project, Annex B.2).

India Renewable Energy Development Agency trained to finance and market the concept of performance-based energy efficiency contracting with energy service companies, clients in end-user industries, equipment manufacturers, state electricity boards, and private electric utilities (India Energy Efficiency project, Annex B.6).

Three energy service companies trained to undertake performance contracts with industrial enterprises (China Energy Conservation project, Annex B.6).

City of Vladimir government, district heating companies, gas companies, and major local private enterprises trained to conduct financial and economic analysis and feasibility studies of energy efficiency projects and to monitor energy efficiency projects (Russia Capacity Building project, Annex B.8).

Municipal employees, architects, engineers, and industry managers trained to design, conduct, implement and evaluate energy efficiency projects (Bulgaria Energy Efficiency project, Annex B.8).

Romania Agency for Energy Conservation (a central state entity with regional offices) trained to identify and develop energy efficiency projects and present them to potential financiers (Romania Capacity Building project, Annex B.8).

Private entrepreneurs and financiers trained to understand, propose, and finance energy efficiency and renewable energy investments (investment-fund projects executed through the IFC, Annexes A.1 and A.6).

Regulatory Skills

National and regional regulatory agencies trained in rural energy-service concession bidding and contracting, tariff setting, and monitoring and regulation of concessions (solar home systems projects using an energy-service concession model, Annex B.1).

Electric utilities and government regulators assisted in establishing small-power-purchase tariffs and model power purchase agreements for renewable energy projects installed by private independent power producers (Indonesia Solar Home Systems and Sri Lanka Energy Services Delivery projects, Annex B.2).

State Electricity Board assisted in strengthening regulatory frameworks for service quality standards, tariff approval, environmental protection, and technical and performance norms (Cape Verde Energy Sector Reform project, Annex B.2).

Government of Morocco assisted in reviewing the overall policy/regulatory framework and recommending possible changes such as reduced VAT and import duties, electric utility regulation, energy price changes, public-sector procurement guidelines, and equipment standards and codes) (Morocco solar hot-water project, Annex B.3).

5. New Institutions and Financing Services

Projects are testing and demonstrating a variety of new institutions and financing services for promoting technology diffusion. For example, projects provide financing to local community organizations, private-sector financiers, local entrepreneurs, public or private revolving funds, and private-sector renewable energy project developers. Projects promote industrial-sector energy service companies, rural energy-service concessions, and utility-based demand-side management programs. Projects also provide combinations of different types of financing for private-sector activities, such as grants, concessional loans (no- or low-interest loans), or contingent loans (forgivable under specified conditions). Box 2 provides examples of new institutions created in GEF projects.

New financing services are an important aspect of GEF renewable energy projects. In many solar home systems projects, new credit mechanisms are developed that can make systems more affordable to consumers. In some projects, private dealers obtain commercial financing and then extend credit to their customers; in others, existing microcredit organizations offer financing; and still others involve rural energy service companies operating on a fee-for-service basis with low monthly payments so that poor customers can afford the technology. In India, the Alternate Energy project develops the institutional capacity of the India Renewable Energy Development Agency to finance renewable energy subprojects. In Sri Lanka, the Energy Services Delivery project develops a non-negotiable power-purchase tariff and standard power-purchase agreements so that project developers can obtain commercial financing for grid-connected renewable energy projects (Annexes B.1 and B.2).

For energy efficiency improvements in industry, energy service companies (ESCOs) are being piloted in several countries to demonstrate their commercial viability to financiers, in order to facilitate future energy efficiency investments. The China Energy Conservation project is especially noteworthy. No energy service companies exist yet in China, but provincial energy efficiency centers previously operating under public funds are coming under increasing pressure to operate as commercial entities, possibly using an ESCO model (Sinton and Levine 1998; see Annex B.6). In other words, the potential for replication is large. The project aims to achieve sustainable investments and increases in energy efficiency in part through the demonstration of energy performance contracting by three pilot energy service companies (in the project called "Energy Management Companies"), followed by a program to support proliferation of the performance contracting concept.

Investment funds are another financing mechanism used in several projects to solicit cofinancing from the private sector (see Box 3 in Section B.8).

6. Market Transformation

Seven projects assist manufacturing firms to develop and market energy-efficient products as part of so-called "market transformation" approaches in which both supply and demand sides of a market for more efficient technologies are stimulated simultaneously.[12] These approaches can include technical and financial assistance to producers, new equipment standards and certification, consumer information and education, regulatory changes, and other incentives.

Two projects provide direct assistance to Chinese manufacturers for developing and marketing energy-efficient refrigerators and industrial boilers through foreign technology transfer (Annex B.5), along with consumer education and incentives. The China Efficient Industrial Boilers project aims to develop cleaner, affordable, and energy-efficient industrial boiler designs; to mass produce and market these designs; and to disseminate them throughout China. The project provides technology transfer and technical assistance to nine competitively selected participating boiler manufacturers who will develop high-efficiency boiler models. GEF grants pay for advanced equipment from abroad to upgrade production with the new boiler models.

Box 2: New Institutions

Courses on PV technology at two colleges and one polytechnic institute; M.Sc degree in Renewable Energy Systems offered at University of Zimbabwe (Zimbabwe Photovoltaics for Household and Community Use project, Annexes B.1 and C.1).

Renewable energy center/clearinghouse for information, training, and market facilitation programs (China Rapid Commercialization of Renewable Energy project, Annexes B.1 and B.2).

A Demand-Side Management Office within the national electric utility (EGAT) to conduct a variety of end-use efficiency programs in the residential, commercial, and industrial sectors (Thailand Electricity Efficiency project, Annex B.5).

Syrian Energy Services Center with expertise in energy auditing, heat engineering, power system planning, ventilation, refrigeration, air conditioning, motor systems, marketing, and financial and economic analysis (Syria Supply-Side Efficiency and Energy Conservation Planning project, Annex B.6).

Energy Conservation Information Dissemination Center for providing industry with information and best practices on energy efficiency improvements (China Energy Conservation project, Annex B.6).

Energy audit program, with energy audit teams formed in the cement, ceramic, food, glass, iron, steel, pulp, paper, and rubber subsectors. Audit teams receive training in energy management and auditing, conduct audits, and train other auditors (Malaysia Industrial Energy Efficiency Improvement project, Annex B.6).

Energy conservation centers in the Egyptian government and Palestinian Administration to serve as focal points for measures to establish codes and standards and activities for energy efficiency and energy conservation in Egypt, the West Bank, and Gaza (Palestinian/Egyptian Regional Energy Efficiency project, Annex B.6).

A network of Energy and Environment Offices (EEOs) in 20 municipalities to share information and experiences about energy efficiency programs and a central Demonstration Zone Support Office to act as liaison with the national government and to coordinate with regional EEOs (Bulgaria Energy Efficiency project, Annex B.8).

A new department within the City of Vladimir administration to implement consumption-based heat billing; this department will create and maintain a database of apartments, read heat-meters, perform accounting and billing, and conduct media campaigns (Russian Capacity Building project, Annex B.8).

A National Bioenergy Board to coordinate research and operational activities in biomethanation and eventually oversee implementation of a national bioenergy strategy. The board seeks national-level awareness of the benefits of recovering and using biogas (India Biomethanation project, Annex B.9).

A research, training and information center to educate, train, and assist landfill operators, energy service companies, and municipalities to build and operate landfill energy plants and to conduct research to improve methane recovery technology (China Methane Recovery project, Annex B.9).

China National Petroleum Corporation and Sichuan Petroleum Administration restructured into joint-stock companies with commercial accounting systems and an independent regulatory agency to set, monitor, and enforce safety standards on gas production in Sichuan (China Sichuan Gas project, Annex B.9).

Technical assistance is provided for developing production, marketing, and financing plans for the new boiler models and for strengthening customer service. The project also provides technical assistance and training for industrial enterprises to understand, procure, and operate the higher-efficiency boilers, and for design and research institutes and government agencies to disseminate the technologies to other boiler manufacturers.

The China Efficient Refrigerators project takes a similar approach to that of the Efficient Boilers project in addressing both the demand side of the refrigerator market in China and upgrading the technologies used by Chinese refrigerator manufacturers. The project addresses the key market, technological, social, and commercial barriers both to the adoption of high-efficiency refrigerator technology by Chinese manufacturers and to the acceptance of high-efficiency refrigerators by Chinese consumers. Activities include technical assistance and training for compressor and refrigerator manufacturers, incentives for energy-efficient product design and modification and conversion of factory production lines, national efficiency standards, a national labeling program, consumer education and outreach, dealer and manufacturer incentive programs, and a consumer buyback/recycling program.

Transformation of markets for energy-efficient lighting products is part of utility-based demand-side management programs in Thailand, Mexico, and Jamaica (Annexes B.5 and C.3). The Poland Energy Efficiency Lighting project and the Efficient Lighting Initiative also use a market-transformation approach to promote private-sector sales of efficient lighting products (Annex B.5).

7. Technology Research and Development

Four projects under the operational program *Reducing the Long-Term Costs of Low-Greenhouse-Gas-Emitting Technologies* support research and development for renewable energy applications that show promise for reducing long-term technology costs. In Brazil, a $137 million R&D investment in a 40-megawatt-electric (MWe) biomass integrated gasification/gas turbine power plant is expected to reduce the costs of future plants. Cost reductions from both design and operational experience are expected. Once a gas-turbine design is developed to utilize the low-calorific gas produced from the gasifier, the turbine design can become standard ("off the shelf") and can be produced at roughly half the cost of the original gas turbine utilized in the project. The gasifier component will undergo continual performance improvement during the project as the plant operates, so that future, higher-performance gasifiers can be produced more cheaply based upon the project's experience.

In the Philippines, an $8 million R&D investment in a grid-connected 1-megawatt-peak (MWp) solar photovoltaic power plant is demonstrating expected near-commercial economic benefits in a niche application that shows widespread promise in many countries. In this application the photovoltaic power plant is coupled with a hydroelectric power plant on the distribution system to achieve firm baseload power without having to strengthen the transmission system or incur high transmission/distribution losses. In India and Morocco, a combined $360 million R&D investment in two grid-connected 150-megawatt (MW) solar thermal power plants is demonstrating the economic and technical feasibility of integrating solar-thermal-trough arrays with combined-cycle natural-gas-fueled power plants.

8. Engaging the Private Sector in Projects

Private-sector entities participate in GEF projects as manufacturers, dealers, consultants, local project developers, financial intermediaries, recipients of technical assistance, technology suppliers and contractors, and project executors. Significant aspects of private-sector involvement include:

New commercial entities. In some projects, creation of a new commercial entity is a primary output. Three projects in China have this feature: the Coal-Bed Methane project establishes the first commercial company in China to focus on exploiting coal-bed methane-recovery technology; the Energy Conservation project establishes pilot, quasi-private energy service companies to demonstrate the feasibility of energy performance contracting; and the Sichuan Gas project creates a Sichuan Gas Transmission and Distribution Company (Annexes B.6 and B.9). The Ukraine Coal-Bed Methane project also creates a commercial coal-bed methane recovery company (Annex B.9).

Financing from the private sector. Several projects are designed to mobilize financing directly from the private sector. Some projects competitively solicit manufacturer contributions to reduce retail equipment prices, such as the Poland Efficient Lighting project and the Efficient Lighting Initiative (Annex B.5). Others establish investments funds. In particular, the International Finance Corporation is executing five investment-fund projects designed to leverage $375 million in financing from the private sector with $95 million in GEF grants (see Box 3).

Renewable energy developers/dealers. In most renewable energy projects, private-sector firms develop subprojects or sell equipment to end-users within the framework of the project. In most solar home systems projects, private-sector entrepreneurs and/or energy service companies are the specified purveyors of technology to households (Annexes B.1 and C.1). Private-sector project developers install grid-connected renewable energy technologies in several projects (Annexes B.2 and C.2). In some of these same projects, like Sri Lanka Energy Services Delivery, commercial financiers "on-lend" World-Bank-provided financing to project developers.[13]

Product manufacturers. In two energy efficiency projects in China, the Efficient Industrial Boilers project and Efficient Refrigerators project, a competitively selected group of manufacturing companies are the project's direct beneficiaries; the project assists them in improving the energy efficiency of their product designs (Annex B.5).

Voluntary agreements. In Thailand, a DSM project successfully orchestrated a voluntary agreement among Thai fluorescent lighting manufacturers and importers to convert production and imports to more efficient models. In exchange for the project providing consumer education and promotional campaigns related to the switchover, these manufacturers and importers agreed to convert their production and imports at their own expense. The entire Thai market of 45 million fluorescent lamps per year was converted to production and sales of more efficient lamps in a short period of time (Annex B.5 and Annex C.3).

Project executing agencies. Private-sector electric utilities are executing agencies for several IFC-executed projects, such as the Philippines Distributed Generation PV Power Plant project (Annex B.3) and the Poland Efficient Lighting project and Efficient Lighting Initiative (Annexes B.5 and C.3). A private heat-supply company is the executing agency for the Czech Republic Waste Heat Utilization project (Annex A.9).

Box 3: Leveraged Financing from the Private Sector

Executed through the International Finance Corporation, five GEF projects are designed to leverage $375 million total financing from the private sector with $95 million total in GEF grants: [14]

1. *Hungary Energy-Efficiency Cofinancing Program (HEECP)*. This program provides partial credit guarantees (with funds reserved to cover guarantee liabilities) and cofinancing loans for eligible local financial intermediaries. The program is designed to facilitate and leverage private-sector financing for energy efficiency investments (i.e., by energy service companies, project developers, and equipment manufacturers), including domestic bank capital and credit lines from international financial institutions (Annex B.6).

2. *Renewable Energy and Energy Efficiency Fund (REEF)*. This fund makes debt and equity investments in private-sector renewable energy and energy efficiency projects. The fund targets projects in the $5-30 million range, a range that is often considered too small, too complex, or too risky by institutional investors. The fund is cofinanced from other private-sector sources (Annexes B.2 and B.6).

3. *Photovoltaics Market Transformation Initiative (PVMTI)*. This project finances the business plans of commercial PV entrepreneurs in three countries with commercial loans at below-market rates or using other financing methods such as partial guarantees or equity. Business plans are selected according to a competitive solicitation process. The primary purpose of the project is to stimulate PV business activities (Annex B.1).

4. *Solar Development Group (SDG)*. Similar to the Photovoltaics Market Transformation Initiative, this project provides debt and equity financing to PV-related businesses (Annex B.1).

5. *Small and Medium Scale Enterprise Program (SME)*. Financial intermediaries on-lend GEF funds to small- and medium-scale enterprises for GEF-eligible subprojects (including energy efficiency and renewable energy). The intermediaries ultimately repay the GEF at a low interest rate, after being repaid by the enterprises. Subprojects may also be cofinanced by other sources. The program supports investments in relatively high-risk experimental subprojects where normally priced capital may be unobtainable (Annexes B.1 and B.6).

9. Roles of Non-Governmental Organizations

GEF projects involve international and national NGOs, community-based organizations, industry associations, consumer groups, and educational institutions. More than 25 climate change projects explicitly involve NGOs in roles such as:[15]

- project design and preparation;
- project execution;
- project implementation or advisory committee participation;
- training, education, and awareness building for project beneficiaries;
- service and equipment supply;
- social research;
- technical, business, and policy support; and
- demand-side management program implementation.

Examples of these NGO roles are described below.

Project design and preparation. NGOs assist with the design and preparation of many projects. For example, in Mauritania, the international NGO GRET, created to provide technical assistance to developing countries, has worked closely with UNDP in the preparation and technical design of the Wind Electric project. GRET has assisted with project pre-identification, drafting of the project brief and project document, a study of existing windpower equipment, and testing of three pilot wind systems with electronic data acquisition.

Project execution. GRET is also the principal executing agency for the Mauritania Wind Electric project. In addition to GRET, Espace

Eolien Regional, a French NGO, is conducting pre-feasibility studies; IDM, a local subsidiary of another French NGO, is identifying and developing appropriate financing mechanisms between windpower developers and rural end-users; and CARITAS, an international Catholic NGO, is assisting in bringing windpower to outreach health clinics. In Kenya, the Kenyan Association of Manufacturers is executing an energy efficiency project for small- and medium-scale enterprises. Finally, in the Small and Medium Scale Enterprise (SME) project (an IFC global project), NGOs execute some of the subprojects; the project has also selected NGOs as some of the financial intermediaries that on-lend and manage GEF funding to subproject executors.

Project implementation or advisory committee participation. In some projects, NGO representatives sit on project implementation committees along with government and industry representatives (for example in the India Hilly Hydel project), or on project coordinating or advisory committees. This process increases local ownership of projects and can be a significant factor in sustainability and replication. For example, in the Mauritania Wind Electric project, many NGOs are represented on the project steering committee (some of these are international NGOs with local offices).

Training, education, and awareness building for project beneficiaries. In many projects, NGOs provide consulting or training services to beneficiaries. For example, in the India Hilly Hydel project, NGOs train rural households to use new, low-wattage appliances for cooking, heating, and storage using the hydel power provided by the project. They also train local groups, such as village committees, in planning, design, construction, operation, maintenance, and revenue-collection for small hydel projects. In the India biomethanation project, NGOs train private-sector, municipal agency, and village personnel in bioenergy technologies. In the Malaysia Energy Efficiency project, various industry associations help identify and train technicians in energy auditing and energy management. In the Syrian Energy Efficiency and Conservation project, a university conducts seminars to promote energy efficiency awareness among managers in the private and public sectors. In Kenya, the Kenyan Association of Manufacturers is responsible for coordinating enterprise audits and conducting seminars and workshops. And in the Regional West Africa Building Efficiency project, NGOs build consumers' and decision-makers' awareness of demand-side management and least-cost planning.

Service and equipment supply. NGOs act as equipment suppliers/dealers or energy service companies in several solar home systems (SHS) projects. In Sri Lanka, NGOs are allowed to serve as SHS dealers. Two NGOs are selling SHS; one of these, Sarovodia, is a large, national organization that has been well established in Sri Lanka for many years while another is an existing NGO that was an established SHS dealer before the project began. In Bolivia, a project attempts to create new institutional and legal models so NGOs can become renewable-energy-based rural electricity providers. In its last phase, the India Alternate Energy project is similarly attempting to enlist local community-based religious organizations to become energy service companies to lease SHS to rural households.

Social research. In some projects, NGOs and/or university researchers conduct social studies. For example, in the Regional West Africa Building Efficiency project, NGOs study social and economic impacts of the project. In the Syrian Energy Efficiency project, a local evaluation institute collects feedback from consumer groups regarding attitudes about energy efficiency and conservation.

Technical, business, and policy support. The Peru Energy Conservation project increases the technical capacities of the non-profit Center for Energy Efficiency (CENERGIA) to assist the Department of Energy and Mines in implementing a national energy conservation policy. After the project trains CENERGIA staff to conduct energy audits, conduct project feasibility studies, and evaluate industrial emissions abatement, CENERGIA will become a center to train technicians from other parts of Latin America in similar skills. In Zimbabwe and Sri Lanka, solar energy industry associations have formed to support the business activities of private-sector PV firms, develop equipment standards and certification procedures, and/or provide education and outreach to households. In Morocco, a solar energy industry association also supports the activities of the solar hot-water industry.

Demand-side management program implementation. The Jamaican Demand-Side Management (DSM) project utilizes local NGOs in four areas: (1) to identify and contact local organizations and associations with interests in DSM; (2) to organize public forums for local communities to express their views; (3) to disseminate information to the public on the DSM program; and (4) to assist in program design and implementation by providing a forum for public participation and education. These local NGOs will be supported with technical know-how from international NGOs with experience in energy efficiency.

Section C: Project Impacts and Replication

1. Emerging Impacts of Completed or Continuing GEF Projects

Although most approved projects are still being implemented, project experiences, impacts, and lessons are emerging. Out of 72 energy efficiency and renewable energy projects approved since 1991, eight were fully completed by mid-1999.[16] This section and Annex C describe emerging impacts of completed and continuing projects, organized into four clusters.[17] Data sources for these evaluations vary. The GEF conducts an annual Project Implementation Review (PIR), which primarily reflects status reports from project implementing agencies. Where possible, we have supplemented information from the PIR with project supervision reports and other internal documents, published material, field visits, and interviews with project managers and stakeholders (see Porter et al. 1998; Martinot 1998a; Martinot and Borg 1998; GEF 1997b, 1998b, 1998c, 1999a; and other references given in Annex C).

We summarize below and detail in Annex C the available information on GEF project impacts from these sources. This summary and Annex C are neither exhaustive nor definitive, but do present the bulk of available information on impacts achieved to date. Obviously, much more extensive data collection and analysis are warranted, and the reader is likely to be left unsatisfied. On a positive note, GEF evaluation activities are escalating, including thematic reviews by project cluster, and implementing-agency evaluation activities should expand as the portfolio matures.[18] Project implementation and management lessons and difficulties are not discussed in this paper but are also the subject of numerous other GEF monitoring and evaluation activities.

Very little post-project evaluation has been done on completed projects because insufficient time has elapsed since project completion to judge indirect impacts on markets and stakeholders through replication (see next section). Nevertheless, evidence of impacts is emerging in two key areas: (1) direct and indirect energy capacity installed or energy savings realized; (2) capacity-building and institutional development activities. At this juncture, project sustainability and replication are usually difficult to judge; future GEF evaluation activities are expected to address these issues.

Solar Home Systems Projects (Annex B.1, Annex C.1). Through the Zimbabwe solar home systems project, private-sector dealers installed about 10,000 solar home systems, as a result of direct subsidies, lower import duties, and growth of the country's dealer/installer industry. Many other market changes have taken place, including increased numbers of producers and dealers, reduced prices, new equipment standards, new certification institutions, changes in perceptions about the technology among consumers and financiers, increased technical skills, and a demonstration of a revolving fund mechanism through the Agricultural Finance Corporation. In Sri Lanka, Bangladesh, the Dominican Republic and Vietnam, solar home system delivery models using private-sector entrepreneurs and microcredit facilities appear to be working in the initial phases; several hundred systems have been installed.

Grid-Connected Renewable Energy Projects (Annex B.2; Annex C.2). In India, more than 900 megawatts (MW) of wind turbines have been installed in recent years through joint ventures with western wind turbine manufacturers and by domestic Indian producers and private-sector project developers. These installations were in part a result of favorable tax regimes and enhanced willingness of commercial banks to provide financing, outcomes that the GEF helped catalyze. In Costa Rica, a significant private-sector wind-power industry has emerged from dialogue and policy frameworks fostered by the GEF project there even though the project itself has not yet installed a planned wind farm. So far, 20 MW have been installed by the private sector, and other countries in Central America are taking note of Costa Rica's experience. In the

Philippines, 385 MW of geothermal power capacity have been installed, and the project there anticipates that installed facilities will be able to supply the power-purchase-agreement target of 3,000 GWh per year (however, power pricing may affect the viability of the power production entities involved). In India, the approaches being developed in the Hydel project for involving local decision-makers in the planning process are being considered for inclusion in the government's standard practice for small hydro initiatives. In addition, a local educational establishment now offers a postgraduate program on alternate hydro energy, and 18 out of 100 planned watermills have been built. In Mauritania, 19 villages have been electrified with decentralized village-scale wind power, and the implementation approach from the GEF project has been adopted in a follow-on project and has influenced government approaches to rural electrification.

Solar Hot-Water Supply (Annex B.3). In Tunisia, a GEF project has installed approximately 10% of the 50,000 m^2 target for SWH collectors. Indirectly, a private-sector market for SWH installations is slowly emerging, with 3,600 m^2 having been installed independently of the project but influenced by the project's public awareness campaign. The project launched a promotional campaign in newspapers, radio and television; the television campaign in particular was deemed effective, generating more than 80 telephone calls per day from interested households at one point in the campaign. A robust competitive equipment market is emerging with several different equipment brands now on the market.

Energy-Efficient Product Manufacturing and Markets (Annex B.4; Annex C.3). In Thailand, a DSM project successfully orchestrated a voluntary agreement among Thai fluorescent lighting manufacturers and importers to convert their production and imports to more efficient models; the entire Thai market of 45 million fluorescent lamps per year was converted to production and sales of more efficient lamps in a short period of time. In Poland and Mexico, efficient lighting programs successfully sold to households the targeted number of compact fluorescent lamps (CFLs), 3 million total, during the project implementation periods (through the private sector in Poland and through an electric utility in Mexico). Other indirect market effects are visible in Poland. For example, consumers surveyed reported that the special "environmentally friendly" label developed during the project was of "great or decisive importance" in their purchases. A school education program was commended by the Polish Ministry of National Education, which wrote that "it is apparent that as a result of the project large numbers of students and teachers have gained a useful insight into the use of energy and its impact on the environment."

Energy Efficiency Investments in Industry (Annex B.6). In Hungary, the GEF has helped establish a new private-sector energy service company (ESCO) for energy efficiency investments and is supporting development of other ESCOs in partnership with local banks. Domestic commercial financiers are showing strong interest in financing ESCOs, in part because of the training provided to financiers for energy efficiency project evaluation. Another GEF-financed ESCO in Mexico is pioneering "performance contracting" there and has begun to make investments in industry. In Chile, a GEF project has shown that ESCOs are probably not a viable mechanism for energy efficiency in the mining industry, and alternative models are needed.

Energy-Efficient Building Codes and Construction (Annex B.7). In the African countries of Senegal and Côte d'Ivoire, a GEF project has increased human and institutional capacities for achieving energy efficiency and conservation in buildings. For example, an Energy Operation Committee was established in several major urban buildings to oversee energy management. The project retrofitted several buildings to demonstrate the energy savings and cost-effectiveness of energy efficiency and conservation measures. Almost 200 people in the private and public sectors received training in energy efficiency and conservation techniques. The project contributed to texts on energy efficiency in buildings in a 1997 National Environmental Code.

Demand-Side Management Programs (Annex B.5; Annex B.6; Annex B.7). In Thailand, the national utility's DSM program, supported by a GEF project, has exceeded targets, with a 383-MW peak load reduction and 1,868 GWh annual energy savings. The utility created a dedicated DSM office that now has a staff of 375 people. The DSM office is implementing 13 different energy efficiency programs for refrigerators, air conditioners, green buildings, industrial cost reduction, industrial ESCO development, motors, compact fluorescent lamps, street lighting, thermal storage, stand-by generation, interruptible loads, time-of-use tariffs, and public awareness campaigns. The private sector has been engaged, through workshops with distributors and retailers, to encourage sale of high-efficiency refrigerators and air conditioners and through negotiations with manufacturers to produce high-efficiency equipment. In Jamaica, 1,200 MWh/year energy savings have been realized through a DSM program targeting office lighting and air conditioning conversion. An additional 3,050 MWh/year energy savings have been achieved among 25,000 participating residential customers.

Fuel Switching and Production/Recovery (Annex B.9; Annex C.4). In China, a GEF project at three sites has demonstrated technologies to reduce atmospheric methane emissions from coal mines and to recover these emissions for use as a fuel. The project published a detailed assessment of China's coal-bed methane resources and strengthened national capacity to conduct such assessments routinely. The project created the China United Coal-Bed Methane Development Corporation as a venture among three Chinese government agencies and has been actively seeking new business opportunities to exploit coal-bed methane. Several additional exploration and development agreements have been negotiated with foreign partners. Gas pricing policies (i.e., higher prices more closely reflecting production costs) have been identified as a key factor for sustaining incentives to reduce pipeline leakage. Also in China, landfill-gas recovery demonstrations at three different sites were successful in building understanding of the economic and environmental benefits of landfill gas recovery and utilization. In India, four of a targeted 29 biomethanation units have been completed. In Poland, a large coal-to-gas industry has emerged, along with significant sources of government and private financing, influenced at least partly by increased awareness among government officials engendered by the early stages of the GEF project.

2. Project Sustainability and Replication

Replication of project impacts on larger scales is integral to GEF climate change strategies. Replication may occur, for example, from local markets to national markets, from one private-sector firm to others, from one local government to another, and from one country to another. Although there are a variety of mechanisms to promote replication that can be incorporated into projects, replication ultimately depends on actions of governments, consumers, NGOs, and/or the private sector after a project is completed. Replication also requires a lengthy time period to monitor and evaluate (i.e., several years after project completion).

Directly installed capacity, direct energy savings, and directly avoided CO_2 emissions in GEF projects are important to measure and track, but these outputs constitute only a portion of GEF project impacts.[19] Indirect impacts may be quite large. Indirect impacts occur if project outputs are sustainable and have been replicated beyond the scope of the original project. Several factors contribute to project sustainability and replication:

- ability to meet user needs
- favorable technology performance
- availability of maintenance services and spare parts
- demonstrated cost recovery
- permanence and viability of new institutions
- retention of skilled personnel
- continued operation and viability of financing mechanisms or services
- participation of local stakeholders

These factors suggest that it may take several years to build up sustainable programs. For example, the Chinese biogas program, which has resulted in more than 5 million household biogas digesters in operation today, shows that biogas diffusion is a long-term process that requires dedicated personnel in all aspects of the program.

Approximately 40,000 people have been trained in China as "biogas doctors" for construction, operation, and maintenance of biogas digesters over several years (Qiu 1990).

Stakeholder participation is equally important for sustainability and replication. As the World Bank (1996) notes, "the development of micro-grids, whatever their primary source of energy, requires a significant level of community consensus and support regarding such factors as billing, service, and organization. Local participation is a key ingredient in the design of such isolated systems, in their implementation, and in their day-to-day operation" (p.46).

Macroeconomic policies and conditions also affect project sustainability and replication. For example, in Zimbabwe, a sustained reduction in import duties for PV components appears to be key to sustaining the market development fostered by the GEF project there (Annex C.1). Also important in Zimbabwe are continued commercial viability of PV dealers and continued ability of the Agriculture Finance Corporation to extend credit beyond the project's completion. In India, continued growth of the wind industry may depend upon continued government investment tax credits (Annex C.2). In the Philippines, although the National Power Corporation has established a new tariff structure to reflect its operational costs and debt service, the region's financial crisis has raised questions about future electric power capacity investments.

In DSM projects such as those in Jamaica, Thailand, and Mexico, project sustainability is contingent on the institutional strength of the DSM unit and/or program created in the utility and on continued financing (although in Jamaica the DSM unit will be transformed into a financially autonomous ESCO) (Annex A.5).

Replication lessons can also be learned from historical development assistance programs. Agencies such as the German assistance agency Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), which has promoted renewable energy in developing countries since the late 1970s, can offer a wealth of experience valuable to ensuring replication and sustainability. For example, GTZ has concluded that purely technical solutions fail without a commercial infrastructure, access to capital, and regional planning (Kozloff and Shobowale 1994).

Finally, replication also depends upon how well users' needs are met. Hurst (1990) argues that solar hot-water heaters in several countries, micro-hydro in Nepal, and wind-turbine water pumps in Argentina were successful because "relatively little change of behavior was involved. People were already heating water, treating agricultural produce, and pumping water for cattle before any new technology came along. The new equipment acted as a substitute to a well-practiced alternative, rather than needing a completely different activity to justify it" (p.608).

3. A Proposed Framework for Measuring Changes in Markets

GEF projects have both direct and indirect impacts. Direct impacts occur during a project itself in the form of specific project interventions ("project outputs"). Indirect impacts occur as the direct impacts of the project "ripple out" in space and time or among institutions to influence a market in a geographically broad, long-term, and/or institutionally diverse manner. Although traditional project performance monitoring usually captures direct impacts, it falls short of understanding how projects have broad, long-term impacts on market development and market sustainability. Indirect impacts are often difficult to measure.

For climate change projects financed by the GEF whose goal is removing barriers to energy efficiency and renewable energy, the problem of measuring indirect impacts is fundamentally one of measuring changes in markets. There is scant published literature on this subject and thus evaluators of GEF projects' indirect impacts tread in a relatively immature field. Demand-side-management program evaluation literature is helpful, as is a relatively new literature on "market transformation" assessment, from which much of the discussion below is derived (see Martinot 1998a for a review of this literature). [20]

Measuring changes in markets is not simple because markets are complex phenomena (Box 4). Although no overarching theory or framework has become widely accepted, research and practice have produced useful insights. According to Feldman (1994), the three key defining dimensions of a market are: (1) the number and nature of participants, (2) the variety and characteristics of the products and services available, and (3) the rules governing exchanges in the marketplace. These dimensions represent the different components of a "snapshot" of the market for a particular technology application at any given time. Changes in these dimensions can be tracked over time to provide a dynamic picture of market development. These dimensions also will vary spatially—even neighboring regions can exhibit quite different market characteristics.

Measuring changes in markets requires thinking beyond measuring direct energy savings or energy production. Saxonis (1997) argues that "evaluation may not be viewed as simply an exercise in counting kWh but as a serious examination of the marketplace before, during, and after program intervention.... It may be more important to focus on indicators such as dealer stocking patterns than actual kWh savings" (p.171). Feldman (1996) proposes that "the effectiveness of market transformation programs should *not* be judged only by savings achieved or by surrogate measures such as sales of efficient products and services. Instead, evaluation of market transformation programs should also focus on the identification and measurement of transaction costs" (p. ii).

In Table 5 and Box 5 we propose a framework for measuring changes in markets that distinguishes between "physical changes" like changes in investments and sales and "market structure/function changes" like changes in costs, transaction rules and regulations, availability of services, and human resource skills. In this framework , three different types of indicators measure *market interventions* (direct project outputs), *market development* (indirect changes catalyzed by projects), and *market sustainability* (long-term impacts). These indicators measure three different ranges of "directness" of market impacts or their "proximity" to the project, in terms of time, space and/or institutions. This framework was first proposed by Martinot (1998a). The framework has not yet been applied to completed GEF projects because of the immaturity of the GEF project portfolio and the lack of post-project evaluation information, but suggests a direction for future evaluations (Martinot, 1998a, applies indicators from the framework to several GEF projects currently in progress).

The China Efficient Boilers project (Annex B.5) can be used to illustrate the concept of "proximity" and the use of the framework and its indicators. In this project, a large group of boiler manufacturers was invited to participate in a project to upgrade the efficiency of their products. Nine manufacturers were selected. Their performance in designing, producing, and marketing more efficient boiler models through the project could be measured using market intervention indicators. Through replication and dissemination efforts (especially by the Ministry of Machinery), other manufacturers (i.e., those that were involved in the initial stages and submitted proposals for participation but were not chosen for the project) would be better able and more motivated to upgrade and market their boiler models as well. These indirect impacts would be measured by market development indicators, for example surveys of the "non-participating" manufacturers and industrial enterprises purchasing their boilers. Finally, market sustainability would be measured by identifying a sustained market share of more efficient boilers industry-wide (almost 100 manufacturers) at a level commensurate with their economic potential.

Box 4: Quantitative and Qualitative Characteristics of Markets

Quantitative Characteristics

- sales volumes of the target technology to different groups of purchasers
- stock of the target technology owned by different groups of purchasers
- prices, technical characteristics, and quality of the target technology available in the market
- number, size, and characteristics of producers, distributors, or service firms in the market
- demographics and other characteristics of different groups of purchasers in the market

Qualitative Characteristics

- accessibility of technology information, financing, purchase opportunities (stores, catalogs, etc.), and maintenance and repair services
- awareness of and attitudes toward the target technology
- motivations and incentives to purchase and install the target technology
- programs and plans to produce, market, or purchase the target technology
- distributors' and dealers' practices for stocking and promotion of the target technology
- degree to which standard practices or habits with already-established technology are entrenched among users
- capability of purchasers to assess, choose, specify, and use the target technology
- capability of producers to develop, produce, and market the target technology
- capability of distributors and service firms to market and service the target technology
- existence of opportunity information like renewable-energy geographical-resource assessments and engineering estimates of energy efficiency potential
- existence and use of standard contractual models (e.g., independent-power-purchase contracts and non-negotiable power-purchase tariffs)
- existence and use of financing (e.g., dealer or producer credit, revolving funds, commercial loans)
- existence of formal or informal industry codes of conduct for market actors (and degree of compliance with these codes)
- existence of technical codes and standards for the target technology (and degree of compliance with these codes and standards)
- existence of institutions that allow groups of individual purchasers to make collective decisions (e.g., condominium associations)
- characteristics of relevant legal institutions, regulatory frameworks, taxes, duties, and other macroeconomic and legal conditions

Source: Martinot 1998a.

Box 5: Three Types of Indicators to Measure Project Impacts

Market intervention indicators measure the specific interventions that a project makes in a market. These impacts typically occur during the project itself and will generally be known by the time a project is completed. Generally, these are direct project outputs under the control and responsibility of project management.

Market development indicators reflect changes in the broader market beyond direct project impacts. Market development impacts are facilitated by the project but are beyond the immediate control of project management and thus are considered "indirect impacts." Most market development indicators measure activity that occurs after the project is completed although some indirect impacts may occur during the project.

Market sustainability indicators reflect the degree to which a market is sustainable without the need for further interventions. There are three key aspects: (a) the degree of cost-competitiveness of a technology application in the absence of subsidies or special tax treatment; (b) the degree to which essential market functions are performed by those who profit from the market; and (c) the sustainability of public-sector institutions (including regulations) that provide essential market functions. Another way to think about market sustainability is the degree to which barriers are removed permanently—i.e., the likelihood that barriers will reemerge.

The three indicators measure different degrees of "barrier removal" in space and time and among institutions. For example, a project that pilots a financing mechanism in a specific region of a country might reduce the financing barrier by demonstrating a viable financing mechanism in that region. After the project, if the mechanism is proven successful, it could be replicated in other regions. Replication would be measured by market development indicators. Finally, the long-term persistence of such a mechanism (for example, repayment rates and reinvestment rates of revolving funds) would be measured by market sustainability indicators.

As shown in Table 5, each of the three types of indicators can measure investments or sales (*physical changes*) or changes in the institutions, capabilities, knowledge, and transaction rules that underlie markets (*market structure/function changes*). For example, physical market intervention indicators would reflect hardware installations that can be directly attributed to the project (e.g., the project procured the hardware directly, provided financing for it, or provided direct subsidies to producers or consumers). Physical market development indicators would reflect sales or investments that are not directly provided, subsidized, or financed by a project.

Source: Martinot 1998a.

Table 5: A Framework for Measuring Changes in Markets

	Time, Space, and/or Institutional Proximity to Project <<<---- Closer --- Farther --->>>		
Type of change	**Market intervention indicators**	**Market development indicators**	**Market sustainability indicators**
Physical: • investments • sales	Direct investments or sales supported by the project: • direct project subsidies • direct project financing • project financing through private-sector entities	Indirect investments or sales not financed or subsidized by the project	Evolution over time of investments and sales to a sustainable level appropriate to economic potential
Market structure and function: • institutions • capabilities • knowledge • transaction rules • types of goods and services	Direct results of technical assistance: • institutional development • enhanced capabilities • information dissemination • new contractual mechanisms • new regulations • new codes and standards	Market participants (i.e., producers, dealers, consumers, service firms, financiers): • number of participants • awareness • capabilities • perceptions • plans • decisions • satisfaction Technologies: • prices • characteristics • quality Basis of market transactions: • contract forms • codes, standards, and certification • product labeling • other regulations	Evolution over time of market characteristics that demonstrate market sustainability

Source: Martinot 1998a.

4. Programmatic Benefits from the GEF Project Portfolio

As the number of projects in the GEF portfolio grows, there is potential synergy if projects in different countries or sectors reinforce each other, and if project beneficiaries share their experiences and catalyze changes elsewhere. That is, a "critical mass" may be reached in some technology applications or for certain project approaches that provides a "programmatic benefit" from the combined portfolio of projects under a GEF operational program. Programmatic benefits largely result from replication and sustainability. Because it is still too early to assess the full indirect impacts and replication resulting from GEF projects, even recently completed ones, programmatic benefits from the GEF project portfolio (as opposed to individual project impacts) will remain elusive in the near future.

Many strategic questions remain for the GEF to address in order to achieve and measure programmatic benefits. These questions include how to achieve portfolio synergies and cross-project impacts; how to allocate resources among different operational programs; how to select future projects given the existing portfolio; how to promote strategic partnerships with other agencies; and how to define, implement, and evaluate replication and sustainability. These questions are beyond the scope of this paper but many ongoing or planned GEF efforts are addressing them. Ongoing evaluation activities like annual project implementation reviews, portfolio status reports, development of program performance indicators, thematic or programmatic reviews, workshops, and working papers are also important.

The GEF has already learned a lot from past efforts. The GEF pilot phase was evaluated by the UNDP, UNEP, and World Bank (UNDP et al. 1994). The first three years of the post-pilot ("operational") phase were similarly evaluated (Porter et al. 1998). The operational-phase evaluation highlighted the strategic trade-offs between "barrier-removal" projects for commercial applications and "cost-buy-down" projects for precommercial technologies. The evaluation also highlighted the distinct risks of each type of project: "technology risk" in the case of "cost-buy-down" projects, meaning that the "technologies now being backed may turn out to be the wrong ones" (p.82); and risks associated with sufficiently removing the right barriers so that sustainable commercial replication occurs in the case of "barrier-removal" projects. The evaluation concluded that the present emphasis in the climate portfolio on barrier removal is appropriate, and that "the increased orientation of climate projects toward technology commercialization and market transformation and accompanying private-sector financing increases the sustainability of the GEF climate portfolio" (p.36).

Overall, prospects for sustainability and replication of GEF climate change projects are still mixed and uncertain. GEF projects have attracted considerable attention from policy makers, the private sector, and NGOs. GEF strategies continue to evolve in dialogue with these and other stakeholders. Achieving and demonstrating programmatic benefits from the GEF project portfolio will depend on continued dialogue and understanding of project designs and impacts by all stakeholders. This paper should help inform that dialogue.

Annex A: Opportunities and Barriers

1. "Win-Win" Opportunities for Energy Efficiency

Many "win-win" opportunities for energy efficiency exist that can provide both global and domestic benefits (Levine et al. 1991, Schipper and Meyers 1993, Reddy and Goldemberg 1990, Levine et al. 1992, U.S. Congress 1993, World Bank 1993 and 1996, Schipper and Meyers 1993, Kammen 1995, Keyun 1995, Martinot 1998b). These opportunities include:

- *Reducing electricity consumption in industry and in buildings.* In addition to incorporating energy management systems and better industrial cost management in general, measures include: (a) incremental design improvements to improve the efficiency of equipment such as refrigerators, freezers, air conditioners, industrial motors and pumps, heating and ventilating equipment, and electric furnaces and boilers; (b) replacement of conventional lighting with high-efficiency lighting; (c) addition of variable-speed controls to existing motors; (d) improved operation and maintenance of industrial equipment such as air compressors; and (e) upgrade of entire industrial processes with more efficient processes.

- *Reducing coal, oil, and gas consumption in industry*. Measures include cogeneration, secondary process heat recovery, renovation of boilers and furnaces, insulation of process-heat system components, improved operation and maintenance practices, and many other industrial process improvements specific to each industry. Many of these measures are considered "low-cost/no-cost," meaning that they have low capital requirements or pay back in one year or less. Some of these measures, like cogeneration and boiler renovations, can also involve switching from high-carbon to lower-carbon fuels (e.g. from oil or coal to natural gas).

- *Improving the efficiency of electricity production, transmission, and distribution*. Cost-effective technical opportunities include boiler and turbine improvements, improvements to instrumentation and controls, repair and replacement of pumps and heaters, installation of distribution-line capacitor banks, and better management and scheduling of plant operation and maintenance.

- *Reducing space-heat consumption in buildings.* In many economies in transition, the efficiency of space heating supplied by centralized district heating systems is degraded by poorly insulated buildings, inadequate controls, and large production and distribution losses. Energy-efficiency measures include adding pipe and wall insulation, heating controls and valves, window weatherization, and boiler tuning and controls. In developing countries, energy efficiency can be increased by improving the insulation of building shells in new designs and in retrofits, by adding window weatherization, and by improving furnaces and heating equipment.

- *Reducing fuelwood and coal consumption in household cooking.* For coal stoves or in situations where cookstove use contributes to net deforestation, energy efficiency improvements will reduce CO_2 emissions. Experience has shown that improved cookstove designs can, realistically, improve energy efficiencies by 15-25% or more in most households, with payback times of one year or less.[21]

- *Adopting more-efficient irrigation pump-sets in agriculture.* In some countries, replacement of existing inefficient irrigation pump-sets is cost-effective (or would be with unsubsidized electricity prices).

- *Using more-efficient vehicles and changing land-use patterns*. The average fuel efficiency of domestically produced and imported automobiles, buses, and trucks can be improved. Land use and development patterns can emphasize and encourage mass-transit and reduced driving distances in private vehicles.

- *Reducing losses in oil and gas transmission and distribution pipelines.* Pipeline losses can be reduced through leak detection; improvements to pipes, valves, and seals; and more efficient pumps.

2. Opportunities for Renewable Energy

If good geographic resources are present, several applications offer plentiful opportunities for cost-competitive commercial or near-commercial renewable energy in developing countries and countries in transition. These applications have been identified by scientific studies and practical program and project experience (see U.S. Department of Energy 1990; Hurst 1990; U.S. Congress 1992 and 1994; Jackson 1993; Johansson et al. 1993; Ahmed 1994; Kozloff and Shobowale 1994; Goldemberg and Johansson 1995; IPCC 1996a and 1996b; Cabraal et al. 1996; World Bank 1997; Williams et al. 1998; Kammen 1999). Renewable energy opportunities include:

- *Home electrification with stand-alone photovoltaic systems*. Where extending the power grid to particular geographic areas is too costly, individual homes can receive electricity from small-scale (20- to 100-watt) photovoltaic/battery systems that cost roughly $300-$1,500. If economic savings from avoided battery, kerosene, candle, or diesel fuel use are considered, solar home systems are often economically competitive with these conventional energy sources. There is a potential global market for hundreds of millions of systems because an estimated 2 billion people worldwide lack access to electricity grids.

- *Electricity for village-power applications.* Where extending the power grid to specific villages is too costly, mini-grids can provide power to individual villages or groups of villages. Viable technologies for this application include wind power, biomass power (from animal, agricultural or forest industry residues), small-scale hydroelectric power, and hybrid PV/wind/diesel systems integrated with battery storage. Such systems can range in size from 1 to 1,000 kilowatts (kW).

- *Electricity for electric power grids*. For urban and industrial electricity needs, competitive and viable technologies include wind farms, biomass power (from agricultural and forest industry residues), geothermal power, and methane from urban and industrial wastes (to fuel gas turbines). Installations can range in size from one to hundreds of megawatts and may include cogeneration. These applications can produce electricity at costs from 2 to 7 cents/kWh, which can be competitive with conventional forms of base-load and/or peak-load electric power.

- *Mechanical water pumping for agriculture and domestic water with wind pumps*. Wind pumps can provide mechanical power for water pumping in areas not connected to central electric power networks. Where wind resources are good, wind pumps can be cheaper than alternative means of water pumping although their cost depends on whether they can be manufactured domestically or must be imported.

- *Transportation fuels.* Brazil's experience during the past two decades with converting sugar cane into ethanol for motor vehicles has proven this technology's commercial viability. More than 60% of sugar cane produced in Brazil goes to ethanol production (Goldemberg and Johansson 1995). Technological advances have continued to improve the economic competitiveness of ethanol and gasohol relative to conventional gasoline, but the price of oil greatly affects competitiveness.

- *Building heating, cooling, and hot-water with solar technologies*. Active and passive solar heating and cooling and solar hot-water heating can reduce the energy consumption of many types of residential and commercial buildings. Passive solar designs can be incorporated into building architectural designs. Active solar hot-water heating systems can be installed during building construction or retrofitted afterwards. Depending upon electricity prices and solar resources, solar hot-water heating can be economically competitive with electric water heating but generally not with natural gas water heating.

- *District heating from biomass and geothermal*. In many of the economies in transition, centralized district heating systems provide the majority of residential space heating. Smaller boiler plants burning coal or oil can be converted to burn biomass fuels. Geothermal sources can also feed into these systems and reduce fuel consumption. Experience in several countries demonstrates that conversions to biomass fuels are cost-effective and commercially viable.

- *Biogas digesters for lighting and water pumping*. Family-size digesters can provide fuel for home lighting (as is true in more than 5 million Chinese households) while community-size digesters coupled with engines and electric generators can provide electricity for water pumping and lighting (as has been demonstrated in India).

3. Barriers to Energy Efficiency and Renewable Energy

Tables A1-A3 describe generic barriers to energy efficiency and renewable energy. Barriers relate generally to lack of information about technologies, opportunities, costs, and benefits; imperfect capital markets; lack of human resource and institutional capacities to evaluate, finance, and conduct investment projects; technical and market risks associated with introducing established technologies into new markets; risks and difficulties of new institutional concepts and mechanisms; high transaction costs; and other institutional constraints. Many of these barriers are common to both renewable energy and energy efficiency; others apply to only one category. Still other barriers, for example those related to fuel-price risk, while theoretically applicable equally to both renewable energy and energy efficiency, are more significant in actual practice for renewable energy than for energy efficiency, partly because investment time frames on the supply-side are greater than those on the demand-side. Another example, technology prejudice and acceptance, applies to both energy efficiency and renewable energy but in practice also tends to be a more significant barrier for renewable energy.

The generic treatment of barriers in Tables A1-A3 is inadequate for the purposes of preparing projects. Only some of the barriers in Tables A1-A3 will be present in any specific situation. The challenge in preparing projects to overcome these barriers is to identify the most relevant and operative barriers in a specific context and to address only those. Barriers are extremely dependent upon local and national contexts, including macroeconomic and policy frameworks, the degree of market development, the presence of potential interest groups and proponents, and a host of other factors. Boxes A1 and A2 provide a more specific look at barriers for two clusters of projects in the GEF portfolio, and Box A3 provides a description of barriers from a specific GEF project proposal.

Table A1: Generic Barriers Relevant to Both Energy Efficiency and Renewable Energy

Subsidized or average-cost energy prices	Energy prices may be subsidized or may equal average cost rather than long-run marginal cost, thus distorting markets and reducing financial returns from energy efficiency or renewable energy. Further, the full value of wind or solar power that coincides with daily demand peaks may not be captured if energy prices reflect average rather than time-of-use marginal costs.
Lack of information	Consumers, managers, engineers, architects, lenders, or planners may lack information about technology characteristics, economic and financial costs and benefits, energy savings potentials, geographical resources for renewable energy, operating experience, maintenance requirements, potential partners and their financial health, sources of finance, and installation services. The lack of information may increase perceived uncertainties and block decisions.
Transaction costs	Many costs associated with transactions for identifying, procuring, installing, operating, and maintaining energy-efficient equipment may limit even informed, motivated actors from undertaking these transactions. Because renewable energy projects are typically smaller than conventional energy projects, the transaction costs of each project—planning and developing project proposals, assembling financing packages, and negotiating power-purchase contracts with utilities—may be much larger on a per-kW basis than for conventional power plants.
High front-end capital costs	Despite high rates of return, energy efficiency investments may require large capital expenditures at the start, necessitating credit mechanisms and making investments less attractive to first-cost-sensitive investors. Even though low operating costs may make renewable energy cost-competitive on a life-cycle-cost basis, higher initial capital costs may mean that renewable energy provides less installed capacity per initial dollar invested than do conventional generation sources. High front-end costs create additional cost-recovery risks, for which capital markets may demand a premium in lending rates.
Lack of credit	Consumers or firms may lack access to credit because of lack of collateral, poor creditworthiness, or distorted capital markets; loan terms may be also be too short relative to the investment lifetime.
High user discount rate	Consumers may have higher discount rates than prevailing market rates or than discount rates for energy supply investments.
Perceived technology performance uncertainty and risk	Proven, cost-effective technologies may still be perceived as risky if there is little experience with them in a new application or region. For example, the lack of visible installations and the lack of familiarity and experience with renewable energy technologies can lead to perceptions of greater technical risk than for conventional energy sources. These perceptions may increase required rates of return, result in less capital availability, or place more stringent requirements on technology selection and resource assessment.
Institutional mismatch of energy costs and capital costs	Equipment purchase decisions (e.g., for furnaces and appliances) or building design decisions (e.g., for thermal insulation and passive solar designs) may not be made by those who will pay the future energy costs that result from these decisions.
Lack of legal framework for cogeneration or independent power production.	Cogeneration by electric utility customers may not be legal, or cogenerators may not be allowed to sell excess power back to electric power utilities. Renewable energy project developers may not be able to obtain power purchase agreements from electric utilities or may not be able to plan and finance projects on the basis of transparent tariff and regulatory frameworks.
Lack of technical or commercial skills	A country's or region's aggregate ability to evaluate, design, and install energy efficiency improvements and energy-efficient equipment and infrastructure may be limited by the availability of appropriately trained personnel. Skilled personnel who can maintain renewable energy technologies may not exist in numbers. Project developers may lack sufficient technical, financial, and business development skills.

Sources: see sources for Table A2 and Table A3.

Table A2: Generic Barriers Relevant to Energy Efficiency

Biases toward supply-side investments and large-scale financing	Financial institutions may only extend credit for large-scale supply-side energy investments because of tradition, familiarity, and perceptions of risk. That is, institutional biases may favor a small number of large projects on the supply side rather than a large number of small projects on the demand side.
Unavailability of technology	Hardware may not be readily available in a particular region or country and may need to be imported on a case-by-case basis.
Competing purchase decision criteria	Purchasers of equipment may consider energy efficiency characteristics of equipment to be less relevant or important than other characteristics affecting performance and aesthetics
Uncertain future energy prices	Uncertainty about future energy prices may create uncertainty about the costs and benefits of energy efficiency investment decisions.
Sunk investments in inefficient equipment and infrastructure	Investments already made and equipment already purchased may have long useful lifetimes remaining; retrofits may not be possible, and complete replacement may not be cost-effective.
Disinterest or lack of attention	On both personal and organizational levels, there may be a simple lack of interest or lack of attention to consider alternatives to the status quo.
Lack of managerial incentives	Especially in monopoly and state-protected enterprises, managers may have little incentive to minimize costs or innovate.
Mismatch of energy consumption and payment of true energy costs	Consumers of energy may not pay for their own consumption, may pay fixed amounts rather than consumption-based amounts, or may pay average costs rather than true marginal costs.
Free riders	Incentives may be weakened if one consumer benefits from the energy-efficient actions of another consumer but does not share in the costs (e.g., insulation in one apartment warming neighboring apartments), or when benefits are the collective result of many individual actions (e.g., many consumers connected to the same energy meter).
Physical or technical incompatibility	Energy efficiency may be physically or technically impossible, more costly, or unreliable because of specific characteristics of the infrastructure or application.
Favoring of lowest-cost equipment	Equipment producers and builders faced with markets in which consumers are sensitive to initial capital costs ("first costs") may make purchase price the first concern rather than energy efficiency characteristics and total life-cycle costs (including energy and operating costs over the life of equipment).
Uncertain markets for higher-efficiency equipment	Market research or experience may not exist to inform manufacturers or contractors that demand for energy-efficient products and infrastructure will justify design and marketing expenses.
Narrow planning processes	Utility planning may not encompass the full range of supply- and demand-side options to produce the lowest costs for consumers for specific levels of energy services.
Lack of government interest	Governments may perceive their countries' problem as not enough energy and thus perceive reduced energy consumption as the wrong direction, equating energy consumption with energy services.
Import duties	High import duties may make unprofitable otherwise cost-effective energy-efficient technologies that are not produced domestically.
Need for multi-agency involvement	Energy ministries or other energy efficiency agencies may lack the power to influence policy decisions made by agencies in the transport, residential, agricultural, and industrial sectors that affect energy consumption.

Sources: Stern and Aronson 1984; Reddy 1991; World Bank 1993; Howarth and Andersson 1994; Levine et al. 1992 and 1994; Golove and Eto 1996.

Table A3: Generic Barriers Relevant to Renewable Energy

Lack of utility acceptance of technologies	Utilities may be hesitant to develop, acquire, and maintain unfamiliar technologies with which they have had no direct experience, and renewable energy technologies may not receive proper attention in planning frameworks.
Difficulty of firm dispatch in utility grid operations	Power from sources such as solar and wind may not provide the same levels of firm dispatch to which a utility is accustomed and may require changes to a utility's dispatch procedures.
Technical limits to utility integration of intermittent sources	There are technical limits on the degree to which intermittent sources, such as solar and wind, can be integrated into existing utility grids, depending upon the type and mixture of other existing generation sources
Competition for access to resources	Competition, real or perceived, for land use with agricultural, recreational, scenic, or development uses can occur among government agencies, agricultural interests, private interests, or environmental interest groups
Restrictions on urban siting and construction	Waste-to-energy facilities may face permit problems in urban areas. Solar hot-water heating or photovoltaic installations on rooftops may face building restrictions based upon height, aesthetics, or safety. Nearby inhabitants may perceive aesthetics and noise of wind farms as undesirable.
Lack of utility grid access to remote sites	Grid access to remote renewable energy sites may be blocked by transmission-access rulings or right-of-way disputes.
Risks of permit process	The perceived length and difficulty of the permit process for potential renewable energy projects may add risks of additional costs or delays.
Difficulty of future-fuel-price risk assessment	Risks associated with fluctuations in future fossil-fuel prices may not be quantitatively considered in decisions about new generation capacity because these risks are inherently difficult to evaluate and to weigh against other factors. Because renewable energy technologies reduce future-fuel-price risks, they do not receive the premium they might if such risk factors were explicitly and quantitatively included in economic analysis and technology assessments.
Institutional mismatch of capital costs and fuel-price risks	In many existing regulatory regimes for electric power utilities, in which fuel costs are factored into rates, consumers rather than utilities bear the burden of future-fuel-price risks for conventional energy sources; thus, renewable energy sources, without fuel-price risks, may be less attractive to utility decision-makers.
Difficulty of quantifying environmental costs	Environmental externalities may be difficult to evaluate in comparisons between conventional and renewable energy sources, so analyses may not include the reduced environmental costs from renewable energy.
Lack of detailed geographic resource data	Data may not exist on the wind, solar, geothermal or biomass resources available in different regions, which can make project feasibility assessment and preparation difficult or costly.
Prejudice against a technology because of poor past performance	Consumers who might benefit from renewable energy may be prejudiced against it because of past histories of poor performance in installations of which they may be aware.
Lack of government support	A government may see renewable energy as a low priority and unworthy of legislative or executive action or research funding.
Opposition of existing interest groups	Interest groups that benefit economically or politically from the status quo reliance on conventional energy sources may block renewable energy development through political or coercive means.
High costs of developing new infrastructure and market institutions	"Energy conversion technologies which have extensive production, delivery and maintenance systems already in place have a considerable advantage over those technologies that do not....In order for newer technologies to provide a better choice for rural users, they have to provide similar levels of service. The costs associated with such service are an essential part of the investment required to introduce a new technology" (Barnett 1990, p.550).

Sources: U.S. Department of Energy 1990; Barnett 1990; U.S. Congress 1992 and 1994; Jackson 1993; Saunders 1993; World Energy Council 1994; Goldemberg and Johansson 1995; World Bank 1996; Martinot 1998b.

Box A1: Barriers to Diffusion of Solar Home Systems and Solar Hot-Water Heating

High first cost and unaffordability. Solar home systems and solar hot-water heating represent initial capital investments that reduce or eliminate a stream of future payments for fuels and batteries. But the high “first cost” of this capital investment may make affordability an important constraint.

Lack of credit. Credit can improve affordability but there may be a lack of credit access and credit delivery mechanisms. Financiers may not perceive rural households as credit worthy. Lack of practical collateral or legal enforcement of contracts may inhibit financing.

Insufficient technological track record. There may be an insufficient technological track-record to dispel users’, financiers’ and dealers’ misconceptions about technology costs, benefits, and performance. Experience may exist elsewhere but may not be accessible, visible, or credible in the specific locality where doubts exist. For solar hot water, low quality or performance of existing systems on the market may not provide good demonstrations of the technology’s potential, and may create negative perceptions.

Lack of codes and standards. The absence of norms, standards, certification, codes of practice, and performance data hinders competition based on product price and quality.

High transactions costs. Identifying possible projects may be expensive and time consuming, especially for urban companies or financiers operating in rural areas. Numerous small-scale installations may make project implementation challenging. Pre-investment risks associated with the costs of marketing, contracting, and collecting information may be high.

Policy constraints. Subsidies for conventional fuels, inappropriate tariff structures, import duties for renewable energy equipment, lack of attention to environmental externalities, and other policy conditions can be serious obstacles. For solar hot water, different government agencies (e.g., housing vs. energy agencies) may be in conflict over responsibilities and policy influence for development of the technology.

Lack of objective market, business, and quality information. Information may be lacking about the financial condition and business track record of entrepreneurs or about the technical characteristics and quality of their systems. Market information may be needed about potential households, their incomes, their interest in SHS, and their current expenditures for candles, kerosene, and other forms of energy. Information about solar insolation in different geographical regions may also be lacking.

Lack of business capacity. Businesses wishing to produce and market solar technologies may lack capacity to develop business plans and obtain commercial financing.

Low volume/high costs. Because of the low volume of existing markets, dealers may face high per-unit costs and may be unwilling to provide service and maintenance.

Uncertain or unrealistic grid expansion plans. Unrealistic political promises for future electricity-grid expansion can reduce demand for solar home systems if households believe “the grid is coming.” But such promises may lack substance or financial backing. The lack of coordination between SHS market development and rural electrification programs and policies can impair markets.

Source: adapted from GEF project documents

Box A2: Barriers to Energy Efficiency in District Heating in Countries in Transition

Lack of incentives and undeveloped regulatory frameworks. In many cities in countries in transition, heat supply markets have yet to move to a market orientation. Heat is still often sold at fixed monthly tariffs rather than at prices based on actual metered consumption, which discourages conservation. Other regulatory frameworks may be either missing or deficient, for example those providing incentives for district heating companies to reduce losses in their networks.

Lack of capital. Because of poorly developed capital markets, there may be difficulties in obtaining financing for energy efficiency investments, which discourages the involvement of private and NGO actors. The characteristics of some capital markets, specifically high interest rates and short financing terms, may make them inappropriate for energy efficiency investments.

Lack of financial and managerial skills. Many of the legal, financial and managerial skills needed for project development, financing, and implementation are relatively unfamiliar to managers trained in a centrally planned economy, not only in the public sector but also among private and NGO actors.

Lack of information. Engineers, managers, financiers and consumers may lack information on energy-efficient technology characteristics, economic and financial costs and benefits, and amounts of potential energy savings.

Source: adapted from GEF project documents.

Box A3: Barriers to Energy-Efficient Refrigerators in China

Lack of awareness of the life-cycle economic benefits of high-efficiency refrigerators. Consumers remain highly sensitive to the first costs of their purchases, preferring models with low purchase prices and higher electricity costs because the idea that total life-cycle costs can be much lower for high-efficiency models is unclear.

Lack of reliable, comparative information available to consumers about specific models. Even if consumers want to purchase models with low life-cycle costs, they are unable to make comparisons among models because labels do not exist to provide such information in a consistent and easy-to-understand manner. Labels that have appeared recently on some models lack certification based on national energy efficiency criteria, and provide inadequate information. This has led to consumer confusion and growing government concern over proliferation of multiple criteria.

Manufacturer uncertainty about market demand for high-efficiency models. Manufacturers have had access to few, if any, market research studies about the potential demand for high-efficiency models in the Chinese market. Only recently, with rising electricity prices, more disposable income among a growing segment of Chinese society, and a greater emphasis on competitiveness in industry, has consumer attention turned to high-efficiency products.

Manufacturer uncertainty about cost-effectiveness of high-efficiency models. Manufacturers are uncertain about both the costs of developing and producing high-efficiency models and the price premium that high-efficiency models might command. Therefore, manufacturers are reluctant to commit resources to developing and producing high-efficiency models.

Lack of expertise in energy-efficient refrigerator design. The majority of Chinese manufacturers lack engineering and design expertise to develop new energy-efficient refrigerator models or improve the efficiency of existing models, for three reasons. First, manufacturers have not cultivated these skills. Second, most domestic manufacturers have relied heavily on imported or licensed technology and therefore are reluctant or unable to develop new energy-efficient designs. Finally, many domestic manufacturers have in the past relied on a limited and unchanging product line for their sales and therefore have extremely limited experience in product design and redesign. For these reasons, many manufacturers are uncertain of their ability to move in new technology directions without targeted training.

Higher-efficiency compressors are not available domestically. The high-efficiency compressors needed to produce high-efficiency refrigerators are not available domestically; the high cost of imported high-efficiency compressors is a strong disincentive for domestic refrigerator manufacturers to utilize them.

Dealer reluctance to stock or promote high-efficiency models. Uncertainty about consumer demand, the need to educate their sales force, and fear of reduced sales because of higher refrigerator prices all make dealers reluctant to stock high-efficiency models. Survey results have also indicated that sales staff are uneducated about the benefits of energy efficiency and unable to provide consumers with reliable information.

Lack of an appliance recycling program. The lack of an appliance recycling program means that unnecessary refrigeration is occurring. As China's refrigerator market matures, an increasing proportion of purchases involve the replacement of an old refrigerator. Unlike most developed countries, where older appliances are scrapped or recycled, market research indicates that 50% of new buyers in China keep their old refrigerators. These older refrigerators still in use may offset much of the efficiency gain from the purchase of new refrigerators.

*Lax efficiency standards. C*hina's current efficiency standards, promulgated in the 1980s, were established in view of the needs of hundreds of small refrigerator producers. They are currently outdated, and provide no incentives for companies to increase the energy efficiency of their models. Experience in countries that have adopted mandatory efficiency standards has proven standards effective in removing the most inefficient models from the market and creating expectations of periodic increases in minimum energy performance standards.

Source: project proposal submitted to GEF Council by UNDP, 3/98

Annex B: The GEF Project Portfolio[22]

B.1. Solar Home Systems and Rural Energy Services

Twenty-one projects promote solar home systems and rural energy services (Table B1). Despite differences in design details, these projects share many approaches, so much can be said about them as a group. GEF experience with solar home systems (SHS) projects has evolved steadily since the first project, the India Alternate Energy project, was approved in 1991. Installations as a direct result of these projects could total more than 700,000 systems, which would significantly expand the installed base in developing countries, now estimated at between 300,000 and 500,000 (Foley 1995; Kammen 1999; unpublished material). Projects employ several approaches, described below (Martinot et al. 2000a).

Pilot Private-Sector Delivery Models. Projects have employed two basic private-sector-oriented models for delivery of SHS: "dealer sales" and "energy service companies." A dealer-sales model means that a dealer purchases systems or components from manufacturers and sells them directly to households, usually as installed systems. The household then owns and is responsible for servicing the system. Dealers offer warranties, provide maintenance and repair services, and may provide flexible payment or credit mechanisms to make systems more affordable. An energy-service-company (ESCO) model means that an ESCO owns the SHS, charges a monthly fee to the household, and is responsible for service. The ESCO may be a monopoly concession regulated by government to serve specific geographic regions, or it may operate in an open market. Combinations of these two forms of ESCO start with monopoly concessions and progressively open up markets to competition after a some number of years (the Cape Verde project is an example).

Dealer sales. Dealer sales models are being used in Zimbabwe, India, Indonesia, Sri Lanka and China. Dealer eligibility varies among projects. In the India project, any dealer could participate through financial intermediaries; the Indonesia project, in order to better ensure dealer success, competitively selects dealers based upon existing business competence and market infrastructure in related rural sales/service markets. In the China project, any entrepreneur who passes the project's eligibility criteria can participate.

Energy service companies. In Argentina, the ESCO concession model is being used because Argentina already has substantial experience with concession systems. For each of 10 provinces, the government awards a monopoly concession based upon a competitive selection process. Five other projects, in Benin, Togo, Cape Verde, Ghana, and Peru, also use the ESCO concession model. In Benin and Togo, like Argentina, monopoly concessions will be granted for 15 years in targeted regions to the winners of a competitive selection. In Ghana, the public rural electric utility acts as the ESCO. In Peru, concessions are established in four separate regions based upon a legal model that the project is developing based on Peru's existing Electrification Law. But concessions in the Peru project do not have monopoly status after the project; rather, each region will have an installed customer base to generate sufficient local demand for spare parts, replacements, and maintenance services so that each region will be a worthwhile market for further private-sector investment. Business financing for ESCOs comes from a number of sources, including governments, multilateral banks, and commercial financiers.

Combination approaches. The Sri Lanka project has built-in flexibility to accommodate ESCOs as well as dealers. Both types of firms can obtain credit from the financial intermediaries established under the project. Additional flexibility means the dealer or ESCO doesn't have to be a private company but can be a non-governmental or community organization. Another project, PVMTI, is a purely private-sector approach that allows for both dealers and ESCOs, as well as other models. The project establishes a fund that finances commercial business plans of companies intending to operate in PV markets in India, Kenya, or Morocco. These business plans are being selected through a competitive solicitation process. Flexible business financing for commercial PV companies is also the approach used in the Solar Development Group project (IFC global project).

The Mauritania project provides low-interest financing directly to local enterprises for the installation and maintenance of small decentralized wind electric equipment. The project also establishes a mechanism for longer-term financing of rural electrification, using options such as a specialized wind equipment finance company, a standard credit mechanism for project developers, and Islamic lease finance.

Government procurement. For some GEF projects, government procurement is tied to private-sector or community delivery. For example, in Uganda, where a few PV dealers have operated in a limited PV market, the project identifies pilot sites and technical specifications, identifies credible commercial PV dealers, and awards installation contracts to these dealers. In Lao PDR, the national electric utility will install 20 solar battery charging stations for a pilot demonstration of the technology as part of a larger rural electrification project. The project will also train staff in a number of village electricity associations to plan and manage off-grid renewable energy projects, thus increasing the prospects for community delivery of PV systems. In Mexico, a project will procure and install a variety of demonstration equipment for water pumping and refrigeration.

Pilot Credit Mechanisms and Make Systems Affordable. Affordability and financing are important barriers to overcome. Market studies associated with GEF projects have revealed that the majority of rural households that have incomes less than $250/month and are not connected to rural electricity grids pay $3 to $15 per month for energy (kerosene, battery charging and disposable batteries). These surveys have revealed that households are willing to pay for energy for the end-uses they value the most—including lighting, television and radio. Because GEF projects target these lower-income households, solar home systems must overcome the barrier created by their high initial cost relative to conventional alternatives. In other words, projects must find a way for households to continue to pay amounts equivalent to or less than those expended for conventional energy. Several approaches have been used to improve affordability:

- offer long-term credit so monthly payments are not higher than current energy expenditures, either through third-party commercial credit, dealer credit, or microfinancing;
- provide "first-cost subsidies" to reduce initial consumer payments;
- offer energy services on a fee-for-service basis (energy-service business);
- sell smaller-size systems initially and provide trade-in or resale mechanisms for consumers to "trade up" to more expensive systems;
- change trade policies to reduce import duties on PV system components.

Third-party commercial credit. Zimbabwe was the first PV project to pilot third-party, long-term credit. The Agricultural Finance Corporation successfully provided below-market-rate credit to households to purchase solar home systems through a revolving loan fund. Third-party long-term credit was also tried in India but proved infeasible for rural households (see Annex C.1). The Uganda project also attempts to establish third party financing; SHS customers apply directly to commercial banks for credit under a pre-established mechanism. In the Sri Lanka project, larger customers like NGOs and cooperatives can borrow directly from commercial financiers.

Dealer credit. In Indonesia, credit is extended by commercial financiers to SHS dealers; SHS dealers in turn lend to their customers. Dealers extend credit to households in the form of term loans (expected terms are about four years) and bear the collection risk for repayments. In turn, dealers have access to credit from commercial banks at prevailing market interest rates on-lent from the World Bank. The commercial banks bear the responsibility for appraising dealer requests for credit, and for the commercial risk on the credit extended to a dealer. Like in India, an apparent problem in Indonesia is proving to be that financiers consider dealers uncreditworthy, and dealers consider their customers uncreditworthy. In Sri Lanka, dealers can also borrow from commercial financiers so they can offer credit to their customers.

Microcredit. Microcredit is another financing approach in which households receive small loans from community-based microcredit lenders. The Sri Lanka project incorporates microcredit; microcredit organizations borrow from the commercial financiers participating in the project. Another idea advanced by the project is for microcredit organizations to directly receive World Bank financing on-lent by the government although World Bank eligibility criteria for financial intermediaries might need to be relaxed to accomplish this.

Cash sales. A cash sales model without credit is employed in a few projects. In China (Renewable Energy Development), extending credit to rural households was not considered feasible given the almost complete absence of experience with consumer credit in general in China, so a cash-sales model was used. Although case sales were not originally in the project design, Sri Lanka, midway through project execution, is considering them as a way to reduce transaction costs and financing risks, perhaps by allowing more-affordable systems of capacity smaller than 30 Wp to be eligible for GEF grants under the project. Offering smaller systems sizes and cash sales is an approach incorporated into several projects and is being proposed for the Indonesia project because of reduced incomes from the recent economic downturn in that country. In Zimbabwe, many of the sales were cash.

Pay First-Cost-Subsidies and Lower Import Duties. First-cost subsidies are incorporated into projects in Zimbabwe, China (Renewable Energy Development), Indonesia, Argentina, Benin, Togo, Cape Verde, Peru, and Sri Lanka. These subsidies are intended to reduce household monthly payments for a SHS to make them as close as possible to current monthly payments for energy (i.e., kerosene and batteries). First-cost subsidies are generally related to the difference between the life-cycle costs of the SHS and the costs of kerosene, candles, and other fuel sources displaced by the SHS. First-cost subsidies are justified by cost reductions expected over the life of the projects, which should eliminate the future need for subsidies to make purely commercial markets sustainable. Cost reductions are expected as a result of increasing market volume and competition, refinement of procurement methods and bulk purchasing, economies of scale in sales and service networks, standardization of components and installation processes, and improved quality and acceptance of technology with the introduction of technical standards and certification.

Fix cash grants. Some projects offer fixed cash grants for each system installed once certification of the installation is available. In the Zimbabwe and China Renewable Energy Development projects, a $100 cash grant is paid directly to the SHS dealer. In Sri Lanka, a $100 cash grant is paid to the commercial financier. In Indonesia, grants are $75 in Java and $125 elsewhere, paid directly to dealers.

Declining cash grants. Declining cash grants on a sliding scale over the life of the project are built into more recent projects to “push” the market early on and then allow a transition to a fully commercial market. The idea of declining grants is that, as a project gets closer to completion, existing businesses will be able to offer cheaper systems to customers, and thus smaller grants are needed to maintain the same levels of affordability. For example, in Argentina, ESCO concessions are given a variable cash grant from the GEF for each system installed during the first five years of the project. The cash grants decline for installations made in later years of the project, gradually reaching zero by the end of the project. Grants also depend on system size. In Benin, Togo, Peru and Cape Verde, declining grants similar to Argentina’s are used. For example, in Peru, grants start at $200 in the first year but decline to $70 for installations in the last year of the project.

Reduced import duties. In addition to first-cost subsidies, reduced import duties on PV components can make solar home systems more affordable for rural households. Governments reduced import duties in conjunction with GEF projects in Zimbabwe, Uganda, and Sri Lanka (duties were 40% before the project in Zimbabwe). With this approach, however, continued reduction of import duties after the project is a key element of market sustainability.

Build Capacities of Public Agencies and Private-Sector Firms. There is a need to develop the commercial skills of delivery firms, whether they are acting as dealers or ESCOs. Delivery firms may be entirely new business ventures with little business and/or PV experience. Existing companies operating in rural areas, for example dealers selling TVs and radios, may also become SHS delivery firms if they want to expand their business activities and increase demand for their other businesses; these firms still need to learn about how to market and service solar home systems.

Dealer capacities. Grants strengthen the business capabilities of competitively selected SHS dealers in several projects. In Indonesia, because cash flow was recognized as the key constraint on the emerging enterprise of selling solar home systems on credit, training efforts for dealers are specifically targeted at how to develop an attractive business plan and approach a banker for business financing. In Sri Lanka, grants are available to dealers to cover up to 90% of the external consultant costs (not dealers' own direct costs) of preparing a specific investment proposal or business plan for approval by a commercial financier. In the China Renewable Energy Development project, grants enable dealers to improve system quality, warranties and after-sales service, and to strengthen technical, financial, and managerial capabilities. In Mexico, similar training targets technicians and private-sector vendors.

Energy service company capacities. Projects build the capacities of ESCOs and provide them with business services. In Cape Verde, ESCOs are assisted with business planning, technical training for staff and managers, delivery systems and infrastructure setup, market development and research, consumer promotion, establishment and negotiation of regulatory norms, and development of technical standards. In Argentina, provincial governments assist concessions by preparing detailed market studies; conducting dissemination workshops for concessionaires, customers, and NGOs; and studying how to improve the availability of DC appliances compatible with SHS in rural areas. In Benin and Togo, the rural electric utility conducts marketing activities to support ESCOs; the utility polls communities on their interest in and willingness to pay for solar home systems, collects information on village demographics, and installs solar-resource monitoring stations.

Regulatory agency capacity. For projects using the ESCO concession model, technical assistance to national regulatory agencies is also included for: concession bidding and contracting, training of agency staff, and monitoring and regulation of concessions. Examples of regulatory agencies are provincial governments in Argentina; the national energy agency (INERG) in Cape Verde; and the Agence d'Electrification Rurale (AER) in Benin and Togo. In Argentina, sustainability is enhanced by strengthening provincial regulatory functions and institutions and offering appropriate incentives and returns for the concessionaires.

Market building activities. In some projects, capacity building and technical assistance is directed at initial conceptual, institutional, and market building activities. The Bolivia project formulates and evaluates institutional and legal models for implementing rural renewable-energy-based electricity companies (e.g., NGOs, public-private enterprises) using Bolivia's Popular Participation Law. The project also provides technical assistance to evaluate rules and procedures that hinder commercial financing of renewable energy, and to strengthen financial institutions interested in renewable rural electrification. The China Capacity Building project conducts workshops focusing on market penetration, foreign investment, power-purchase agreements, and information needs; establishes a major renewable energy center/clearinghouse;

trains policy makers, renewable energy professionals, and buinessmen in market-based renewable energy development and best practices; and builds capacity to assess renewable energy resources.

Enact Codes and Standards and Put in Place Certification and Testing Institutions. Codes, standards and certification are important elements of reducing commercial risks and purchase risks and making markets sustainable. Most projects develop and establish PV component and systems standards to ensure quality, safety, and long-term reliability, some at the national level (like in Malawi and in the Benin and Togo projects where the rural electrification agencies issue and enforce a "PV code of practice" and technical standards). Projects also ensure that directly installed systems meet these standards. Some projects, such as in Indonesia, provide assistance to get equipment certified by international laboratories for dealers with approved financing.

Certification and testing agencies. Domestic certification and testing agencies are important. The Indonesia project provides technical assistance for strengthening capabilities of the Agency for the Assessment and Application of Technology for solar PV testing and certification. In Uganda, in addition to establishing equipment standards and codes of practice, the project will strengthen the Uganda Bureau of Standards and create a balance-of-system test facility. The China Renewable Energy Development project provides equipment and training to create a national PV Testing and Certification Center.

Assistance for testing and quality improvement. Most projects provide capacity building to ensure that quality systems are installed. This assistance is important not only to protect consumers but also the reputation of an industry striving for large-scale commercialization. In Sri Lanka, assistance is provided to dealers for testing and quality improvements and a consumer protection agency is being established. The China Renewable Energy Development project also provides capacity building for quality assurance and consumer protection. In Benin and Togo, the rural electrification agency is developing the capability to spot check installed systems and conduct regular consumer surveys. The Uganda project, in conjunction with the national bureau of standards, will monitor system installation to ensure conformity to contract specification and installation codes of practice. Similarly, in Peru, installation technicians will be trained to understand the new PV standards and will be certified proficient at following PV installation guidelines.

Table B1: Solar Home Systems and Rural Energy Services Projects

Project	Objective	Intended Results
Zimbabwe Photovoltaics for Household and Community Use (1991) UNDP $7 m. GEF $7 m. total	Supply basic electric service to rural populations lacking access to grid extension; demonstrate alternatives to planned electric utility grid extensions.	1. Install 10,000 SHS financed through the project. 2. Establish revolving-fund mechanisms for financing SHS and pilot commercial, utility, and local-community-organization delivery mechanisms for SHS. 3. Strengthen the business and technical capabilities of domestic solar PV firms and the PV industry as a whole. 4. Conduct public awareness and education campaigns.
India Alternate Energy / Renewable Resources (1991) World Bank $26 m. GEF $186 m. total	Promote commercialization of wind power and solar PV technologies in India. In particular, pioneer financing and market delivery mechanisms based on private-sector intermediaries.	1. Finance private developers to install wind farms and mini-hydro projects through the India Renewable Energy Development Agency (IREDA). Target: 85 MW total. 2. Strengthen the functions and capabilities of the India Renewable Energy Development Agency (IREDA) to develop, market, and finance renewable energy projects. 3. Establish a solar PV credit line and marketing program. 4. Conduct studies for improving policy environment for small-scale independent power producers (IPPs).
Mauritania Decentralized Wind Electric Power for Social and Economic Development (1992) UNDP $2.3 m. GEF $2.3 m. total	Establish a widely used mechanism for the diffusion and support of small-scale decentralized wind turbines	1. Install 55 demonstration wind-electric powered systems. 2. Conduct market research, including the publication of a survey and analysis of the need for decentralized small-scale electricity. 3. Develop a wind-energy database and atlas in collaboration with the Mauritanian Department of Energy. 4. Promote consumer awareness through the local news media and a series of publications and presentations on the opportunities and experiences with small wind electric systems. 5. Develop financing and institutional mechanisms for further development of small wind electric systems.
Indonesia Solar Home Systems (1995) World Bank $24 m. GEF $118 m. total	Promote commercialization of solar photovoltaic home systems in Indonesia through local private-sector entrepreneurs (dealers); strengthen Indonesia's institutional capacity to support and sustain decentralized rural electrification using SHS.	1. Train a competitively selected group of SHS entrepreneurs in business and technical skills 2. Establish credit mechanisms for on-lending WB financing through commercial financiers to local SHS entrepreneurs. 3. Sell and install 200,000 SHS through local entrepreneurs, financed through the project. 4. Educate and provide information to rural households about SHS 5. Establish government agency capability to test and certify SHS and to monitor installed system performance in the field.

Project	**Objective**	**Intended Results**
Uganda Photovoltaic Pilot Project for Rural Electrification (1995) UNDP $1.8 m. GEF $3.6 m. total	Lay a firm foundation for the sustainable dissemination and use of solar PV systems in rural areas that cannot be accessed by the national electric grid.	1. Install 840 SHS and 4 community-based PV systems through contracts with commercial firms and financed through third-parties. 2. Pilot third-party financing mechanisms for PV (i.e., revolving fund) through commercial banks, NGOs and cooperatives; train financial institution staff to appraise and administer loans for PV. 3. Strengthen the capacity of private-sector firms to design, install, service, and eventually manufacture PV systems; and of public agencies to promote, monitor, and evaluate PV system installations. 4. Conduct consumer education campaigns. 5. Establish an industry association, equipment standards and codes.
Sri Lanka Energy Services Delivery (1996) World Bank $6 m. GEF $55 m. total	Promote the sustainable provision, by the private sector, NGOs, and cooperatives, of grid and off-grid energy services in Sri Lanka using renewable energy technologies; strengthen the environment for DSM implementation.	1. Finance private sector project developers, cooperatives, and NGOs to construct renewable energy subprojects (subproject target: 16 MW of wind farms, SHS, and village hydro). 2. Establish a Standard Small Power Purchase Agreement, non-negotiable power purchase tariff for wind farms and village hydro. 3. Strengthen capabilities of project developers, public agencies, NGOs, and cooperatives to develop, finance, and install projects. 4. Create a code of practice for energy efficiency in commercial buildings and strengthen the capabilities of public agencies and private firms to incorporate into building designs and operations. 5. Conduct consumer awareness and marketing programs.
PV Market Transform-ation Initiative (PVMTI) (1996) World Bank/IFC $30 m. GEF $120m. total	Stimulate PV business activities in India, Kenya, and Morocco and demonstrate that quasi-commercial financing can accelerate sustainable commercialization and financial viability in the developing world.	1. Finance commercial business ventures to install SHS according to individual business plans competitively selected by the project. 2. Finance business plans with commercial subloans at below-market terms or with partial guarantees or equity instruments. 3. Pilot an External Management Team as to administer financing to a large number of small subprojects and to support SHS businesses. 4. Provide technical assistance to businesses on planning, financing, operations, and technology (by the External Management Team).
Ghana Renewable Energy-Based Electricity for Rural, Social and Economic Development (1996) UNDP $2.5 m. GEF $3.1 m. total	Facilitate the widespread use of low-carbon, renewable-energy-based electricity-supply technologies to meet electricity needs in the more than 3,000 presently unelectrified communities; provide a model for large-scale use of such technologies.	1. Provides SHS to 800 households in nine villages and provide hybrid PV/diesel systems to 800 households in three other villages on a fee-for-service basis (by a quasi-public rural electric utility). 2. Conduct market and community surveys of energy use and solar resource assessments; form village committees to assist with education and awareness and assist with payments. 3. Train the electric utility, local operators, and NGOs on PV technology and establish a local operation and maintenance center. 4. Establish equipment technical standards. 5. Design standard contracts for private-sector based ESCOs; train private-sectors firms on PV technology and business skills.

Project	Objective	Intended Results
Lao PDR S. Provinces Renewable Energy Pilot (1997) World Bank $0.7 m. GEF $2.1 m. total	Increase access to electricity in remote, rural areas of Laos and demonstrate that renewable energy technologies (micro-hydro mini-grids and solar battery charging) are viable off-grid electrification options to displace diesel power generation.	1. Install 20 solar battery charging stations as a pilot demonstration of the solar technology (by the national electric utility). 2. Train staff within the national electric utility and within a number of village electricity associations to plan and manage off-grid renewable energy projects. 3. Draft a national rural electrification plan that incorporates off-grid renewable energy technologies.
China Capacity Building for the Rapid Commercial-ization of Renewable Energy (1997) UNDP $9 m. GEF $28 m. total	Promote the widespread adoption of renewable energy sources in China by strengthening the capacity of Chinese government agencies to implement identified policies and by removing barriers to solar and wind hybrid systems, wind farms, biogas, bagasse, and solar hot water	1. Conduct workshops focusing on market penetration, foreign investment, power purchase agreements, and information needs. 2. Establish a major renewable energy center/clearinghouse for information, training, and facilitation programs. 3. Train policy makers, renewable energy professionals and buinessmen in market-based renewable energy development and best practices; build capacity to assess renewable energy resources 4. Develop standards, codes of practice, and certification procedures. 5. Install 200 pilot SHS and several biogas digestion plants
Bolivia: A Program for Rural Electri-fication with Renewable Energy Using the Popular Participation Law (1997) UNDP $4.5 m. GEF $8.5 m. total	Promote the widespread adoption of renewable energy in Bolivia by piloting an off-grid electrification program in one set of villages that can be replicated in other areas of the country.	1. Formulate and evaluate institutional models for implementing renewable-based rural electricity companies (i.e., NGO, public-private enterprises); formulate standard contracts 2. Provide technical assistance to evaluate rules and procedures hindering commercial finance of renewable energy, to strengthen financial institutions interested in renewable rural electrification. 3. Train local electricity companies in technical, business, and operational aspects of renewable energy. 4. Install pilot installations of PV and wind technologies in 25 selected communities using a small revolving fund. 5. Develop PV equipment standards and certification procedures (by National Institution of Standards and Certification Procedures).
Argentina Renewable Energy in Rural Markets (1997) World Bank $10 m. GEF $120 m. total	Provide rural off-grid energy services in Argentina sustainably through the private sector using renewable energy systems.	1. Bid and award standard concession contracts to ESCOs for providing electricity services to rural markets (by provincial governments). 2. Install 108,000 SHS in households and public agencies (by ESCO concessions). 3. Strengthen capability of provincial governments to regulate and contract with concessions. 4. Conduct consumer awareness and information campaigns. 5. Establish technical standards and certification systems for equipment and installers (by provincial governments).

Project	Objective	Intended Results
Small and Medium Scale Enterprise Program (replenishment in 1997) IFC	Stimulate involvement of small and medium scale enterprises in GEF-eligible activities; on-lend GEF grant funds to intermediaries, which finance GEF-eligible small and medium scale enterprise projects.	Vietnam ($750,000): Solar Electric Light Company sells and installs 12,000 SHS systems during the first two years; some may be financed through a Vietnamese agricultural (third-party) bank. Bangladesh ($750,000): Grameen Shakti sells 1,800 SHS to households; some may be financed by microcredit for existing members of the Grameen Bank. Dominican Republic ($75,000): SOLUZ sells and installs 5,000 SHS systems for cash based on a replicable, sustainable dealer/sales/service business model.
Peru Photovoltaic-based Rural Electrification (1998) UNDP $4 m. GEF $9 m. total	Remove barriers to successful implementation of rural renewable energy projects using photovoltaic technology and create incentives for increased public and private sector investment in renewable energy	1. Establish PV concessions under the existing Electrification Law; concessions install 12,500 SHS in four regions 2. Finance concessions through participating commercial financiers and develop frameworks for future financing of renewable energy. 3. Develop and adopt PV systems standards. 4. Conduct training and educational programs for university students, installation technicians, and PV system users. 5. Develop solar energy technology and resource databases.
Cape Verde Energy & Water Sector Reform and Development (1998) World Bank $5 m. GEF $65 m. total	Promote a sustainable market for PV in Cape Verde; promote the use of wind power in the electric power system; increase operational and end-use efficiency in the power and water sectors.	1. Install 7.8 MW of wind farms financed through the project, representing 25% grid penetration for the 31 MW grid (by an electric power utility undergoing privatization). 2. Install 4,000 SHS in rural households financed through the project (by private-sector PV concessions). 3. Create the capabilities in public agencies to promote SHS and to contract and regulate PV concessions.
China Renewable Energy Development (1998) World Bank $35 m. GEF $445 m. total	Develop commercial markets for wind farms and PV systems in China	1. Install 190 MW of wind farms financed through the project (by public provincial electric utilities). 2. Install 200,000 SHS in rural households financed through the project (by private-sector PV entrepreneurs). 3. Conduct a program to encourage technology innovation by manufacturers of wind turbine and PV system components (based on industry proposals for cost-shared technology innovation grants). 4. Establish a PV test center and national PV system standards. 5. Conduct consumer awareness and education campaigns.
Solar Development Group (1998) World Bank/IFC $10 m. GEF $50 m. total	Accelerate growth of PV systems in the rural, off-grid market of a number of GEF-eligible countries by providing financing and business advisory services to PV companies	1. Provide debt and equity financing to PV-related businesses, including local assemblers/system integrators, distributors, retailers, ESCOs, NGOs, and commercial financiers (by investment fund). 2. Provide technical assistance and business services to PV-related businesses. 3. Conduct broad awareness, marketing, training, standards-setting, and capacity building activities.

Project	Objective	Intended Results
Benin Off-grid Electrification / Traditional Energy (1998) World Bank $1 m. GEF $6 m. total	Create an enabling environment conducive to investment in PV technology, promote private-sector market penetration of PV in rural areas, and create rural delivery mechanisms through a participatory process.	1. Establish private-sector SHS concessions; these concessions install 5000 SHS financed through the project. 2. Strengthen the capacity of the public rural electrification agency to contract, regulate, and monitor rural energy concessions. 3. Conduct training and information programs to accredit PV technicians. 4. Conduct consumer awareness and marketing programs. 5. Develop codes of practice and standards.
Togo Off-grid Electrification / Traditional Energy (1998) World Bank $1 m. GEF $6 m. total	Create an enabling environment conducive to investment in PV technology, promote private-sector market penetration of PV in rural areas, and create rural delivery mechanisms through a participatory process.	1. Establish private-sector SHS concessions; these concessions install 5,000 SHS financed through the project 2. Strengthen the capacity of the public rural electrification agency to contract, regulate, and monitor rural energy concessions 3. Conduct training and information programs to accredit PV technicians. 4. Conduct consumer awareness and marketing programs. 5. Develop codes of practice and standards
Mexico Renewable Energy for Agriculture (1999) World Bank $8.7 m. GEF $26 m. total	Promote the use of renewable energy for productive purposes in Mexico's agricultural sector.	1. Conduct information and media campaigns to increase awareness of renewable energy among farmers and associated private-sector companies and government agencies. 2. Install demonstration equipment: 840 solar water pumping systems in 28 states, 33 wind water pumping systems in 11 states, and 16 solar refrigerated milk storage tanks in 8 states; disseminate the experience from these installations among neighboring farmers. 3. Train technicians, extension workers, and private-sector vendors on renewable energy system design, operation, maintenance, and business management. 4. Conduct market assessments and technology assessments to encourage private-sector equipment and service providers to enter the market; test vendor financing of farm-based renewable energy.
Malawi Barrier Removal to Malawi Renewable Energy Programme (1999) UNDP $3.4 m. GEF $10.7 m. total	Promote a market for the purchase and use of PV technologies in rural and peri-urban areas of Malawi.	1. Contribute to the design of enabling renewable energy policies; develop financing mechanisms for PV systems and businesses. 2. Demonstrate and promote PV applications (targets: 4,000 home lighting systems, 600 public building lighting systems, 190 fans, and 2,000 commercial refrigerators and lighting. 3. Increase awareness of energy issues in Malawi citizens' groups. 4. Build institutional and technical capacity among financiers, the PV industry, government agencies, NGOs, and utilities to delivery renewable energy services. 5. Develop and institute standards and codes of practice for PV technologies and their installation and maintenance.

B.2. Grid-Connected Renewable Energy

Twelve projects incorporate grid-connected renewable energy technologies for generating electric power from wind, biomass, bagasse, mini-hydro, and geothermal resources (Table B2). Projects take the following approaches:

Demonstrate Technologies and their Commercial and Economic Potential. Projects construct pilot or demonstration installations to show technical, economic, environmental, and commercial feasibility, thus stimulating and sustaining interest in renewable energy technologies among a variety of stakeholders, including local and national government agencies, financial institutions, state-owned or private enterprises (including utility companies), private entrepreneurs, and consumers.

Wind turbines. In the India Alternate Energy project, private sector developers install 85 megawatts of wind turbine and mini-hydro capacity, financed through the India Renewable Energy Development Agency (IREDA). The Mauritania project selects, procures, installs, tests and evaluates 55 wind-electric-power systems of different sizes and configurations for water pumping, battery charging, refrigeration, ice making, lighting, and other uses. In Costa Rica, the state utility company constructs a demonstration 20-megawatt wind farm. The Sri Lanka Energy Services Delivery project constructs a pilot 3-megawatt wind farm. In the China Renewable Energy Development project, public-sector wind farm companies (structured as subsidiaries of the State Power Company and provincial/municipal power companies) construct 190 megawatts of wind farms at five sites in four separate provinces.

Mini-hydro, biomass, and geothermal. The India Hilly Hydel project constructs 20 small hydro units to serve as models for replication throughout the hilly regions of India. In the Sri Lanka Energy Services Delivery project, private-sector project developers, NGOs, and/or cooperatives construct an anticipated 16 megawatts of village-scale hydro, grid-connected mini-hydro systems, and biomass power. In Indonesia, private-sector project developers construct up to 90 megawatts of wind, biomass and mini-hydro. The Philippines project constructs 440 MW of geothermal capacity.

Build Capacities of Project Developers, Plant Operators, and Regulatory Agencies. Technical, financial, environmental, managerial, and project appraisal skills are essential to the market sustainability of renewable energy technologies. Projects provide education, training, market studies, resource assessments, and contracting skills and models. For example, the India Alternate Energy project increases the capacity of IREDA to finance and promote renewable energy technologies, particularly among private-sector project developers. In Mauritania, foreign wind turbine equipment suppliers train technicians from local Mauritanian enterprises to assemble, manufacture, install, operate, and maintain the wind turbines, in return for gaining access to the local market. And the Indonesian project assists private-sector project with environmental reviews, project management, and pre-feasibility and feasibility studies (for further examples see also Box 1 in Section B).

Develop Regulatory and Legal Frameworks that Encourage Independent Power Producers and Establish Transparent, Non-Negotiable Tariff Structures. Development of regulatory and legal frameworks can encourage project developers, typically from the private sector, to finance and install new renewable energy generation sources and sell power to an electric utility or directly to consumers. Regulations governing independent power producers, power purchasing agreements, and/or published, transparently determined power purchase tariffs can all remove barriers. The establishment of codes of practice, industry standards, and equipment certification procedures will also encourage more private- sector initiatives. For example, the Cape Verde Energy Sector Reform project strengthens the regulatory framework of the State Electricity Board in terms of service quality standards, tariff approval, environmental protection, and technical and performance norms.

Power purchase agreements and tariffs. The Indonesia project establishes a small-power-purchase tariff under the State Electricity Board (small power is defined as 30 MW or smaller in Java and 15 MW or smaller elsewhere). Under the tariff, the power purchase price is non-negotiable and set at the State Electricity Board's avoided cost of producing electricity. Similarly, the Sri Lanka Energy Services Delivery project establishes a standard small-power-purchase agreement and non-negotiable power purchase tariffs for wind farms and village hydro under the State Electricity Board. Twelve power purchase agreements are expected during the project, including at least one with a private-sector project developer. The China Renewable Energy Development project pilots power purchase and other commercial and legal agreements to pave the way for private-sector participation in future wind power projects even though the 190 MW are installed by public-sector wind farm companies.

Create Financing Mechanisms for Project Developers. Several projects develop new financing mechanisms. Some examples:

India. In the India Alternate Energy project, IREDA provides low-interest loans to wind farm developers. Loans are expected to progressively approach commercial market rates as the technology gains wider acceptance and were considered more transparent and more effective at reducing product costs than direct subsidies. The India Hilly Hydel project establishes a revolving fund, also administered by IREDA, to provide low-interest financing to private entrepreneurs for small hydel projects. Like in the India Alternate Energy project, these loans are expected to progressively approach commercial market rates as the technology gains wider acceptance. The India Hilly Hydel project also creates a national strategy and master plan with detailed investment proposals for additional small hydel projects.

China. The China Renewable Energy Development project develops a strategy to encourage private-sector financing of wind farms. The project prepares pre-investment feasibility studies for several wind farm sites for potential private investment through commercial banks, including technical, legal, and contractual documentation.

Indonesia. The Indonesian project provides long-term financing to private power developers through state-owned or private commercial financiers. Grants help cover information, transaction and pre-investment costs.

Global. The Renewable Energy and Energy Efficiency Fund provides financing to project developers for grid-connected, medium-sized ($5 to $30 million) renewable energy projects for all GEF-eligible countries.

Table B2: Grid-Connected Renewable Energy Projects

Project	Objective	Intended Results
India Alternate Energy / Renewable Resources (1991) World Bank $26 m. GEF $186 m. total	Promote commercialization of wind power and solar PV technologies in India. In particular, pioneer financing and market delivery mechanisms based on private-sector intermediaries.	1. Install wind farms and mini-hydro projects financed through the India Renewable Energy Development Agency (by private power developers). Target: 85 MW total. 2. Strengthen the functions and capabilities of the India Renewable Energy Development Agency to develop, market, and finance renewable energy projects. 3. Establish a solar PV credit line and marketing program. 4. Conduct studies for improving policy environment for small-scale independent power producers (IPPs).
Mauritius Sugar Bio-Energy Technology (1991) World Bank $3.3 m. GEF $55 m. total	Expand electricity generation from bagasse; promote the efficient use of biomass fuels from the sugar industry for energy production; and strengthen the management and co-ordination of the Bagasse Energy Development Program	1. Construct a baseload power plant to provide continuous power to the utility, using bagasse during the crop season and coal in the off season. 2. Promote investments in sugar mill efficiency to generate surplus bagasse fuels. 3. Strengthen the capabilities of the Mauritius Sugar Authority and the Central Electricity Board to promote and regulate independent power producers, to implement a national bagasse energy program, and to develop and finance projects. 4. Conduct studies on ways to decrease the transport costs for bagasse and to optimize the use of sugar cane for power generation.
Philippines Leyte-Luzon Geothermal (1991) World Bank $30 m. GEF $1334 m. total	Develop the market for geothermal energy to meet the energy demand of the Leyte-Luzon region; promote increasing private-sector participation in power generation.	1. Expand the present capacity of the Leyte-Luzon geothermal plant from 200 to 640MW and construct associated power transmission lines to serve the geothermal plant. 2. Train staff of the National Power Corporation to conduct social and environmental impact assessments. 3. Support the implementation of a government energy-sector plan, including regulatory development, private-sector participation, power and oil pricing, environmental management, energy conservation, and operational efficiency.
India Optimizing Development of Small Hydel Resources in Hilly Areas (1991) UNDP $7.5 m. GEF $15 m. total	Optimize development of small hydel resources in the Himalayan and sub-Himalayan regions.	1. Install 20 commercially viable hydel demonstration projects to provide electricity to inaccessible areas. 2. Create a national strategy and master plan for the hydel subsector with detailed investment proposals for 3 MW of hydel plants for the entire region. 3. Establish management and ownership models that will foster local stakeholder responsibility for the hydel projects. 4. Train the Ministry for Non-Conventional Energy Sources, state agencies, equipment manufacturers, industry associations, and NGOs in planning, design, construction, operation, maintenance, management, and revenue collection for small hydel projects.

Project	**Objective**	**Intended Results**
Costa Rica Tejona Wind Power (1992) World Bank $3.3 m. GEF $31 m. total	Demonstrate and help to commercialize utility-scale wind energy technology in Costa Rica	1. Install a 20MW wind power plant in the Guanacaste province of Costa Rica.
Indonesia Renewable Energy Small Power Project (1995) World Bank $4 m. GEF $141 m. total	Facilitate private-sector investment in small renewable energy projects; strengthen Indonesia's capacity to sustain renewable energy development.	1. Finance private developers to install, own and operate renewable energy power generation subprojects and sell electricity to the state electricity company. 2. Create and publish a small-power-purchaser tariff. 3. Create a database on known sites for hydro and geothermal resources and disseminate to private-sector project developers. 4. Assist private-sector project developers with environmental reviews, project management, and feasibility studies.
Sri Lanka Energy Services Delivery (1996) World Bank $6 m. GEF $55 m. total	Promote the sustainable provision by the private sector, NGOs and cooperatives of grid and off-grid energy services in Sri Lanka using renewable energy technologies; strengthen the environment for DSM implementation.	1. Finance private-sector project developers, cooperatives, and NGOs to install renewable energy subprojects (target: 16 MW of wind farms, SHS, and village hydro). 2. Establish a Standard Small Power Purchase Agreement, non-negotiable power purchase tariff for wind farms and village hydro. 3. Develop and publish a technical guide on existing grid interconnection specifications and mandate technical standards and certification procedures for equipment. 4. Strengthen capabilities of project developers, public agencies, NGOs, and cooperatives to promote, develop, finance and install renewable energy projects. 5. Create a code of practice for energy efficiency in commercial buildings and strengthen the capabilities of public agencies and private firms to incorporate into building designs and operations. 6. Conduct consumer awareness and marketing programs. 7. Install a demonstration 3- MW wind farm.

Project	Objective	Intended Results
Sri Lanka Renewable Energy and Energy Efficiency Capacity Building (1996) UNDP $1.5 m GEF $1.5 m. total	Encourage investments in wind, small hydro and biomass energy projects; improve access to and confidence in renewable energy technologies in Sri Lanka; improve awareness of and familiarity with renewable energy.	1. Measure the wind resource potential, develop a methodology for evaluation of mini hydro potential of river systems, and conduct a study to identify land available for commercial fuelwood plantations. 2. Establish performance and quality specifications and guidelines for PV and mini hydro equipment. 3. Strengthen capabilities of the private sector by providing energy efficiency training through the development of updated resource materials for national training centers. 4. Incorporate renewable energy and energy efficiency into the curriculum of educational institutions. 5. Encourage cooperation among domestic and foreign renewable energy equipment manufacturers to improve the quality and range of equipment available locally.
Renewable Energy and Energy Efficiency Fund (1996) World Bank/IFC $30 m. GEF $130 m. total	Mobilize new financial resources for investments in energy efficiency and renewable energy projects by the private sector in non-OECD countries; attain a competitive risk-adjusted rate of return on these projects.	1. Establish a fund capitalized with minimum of $130 million. 2. Establish a balanced portfolio of energy efficiency and renewable energy subprojects financed from the fund.
China Capacity Building for the Rapid Commercial-ization of Renewable Energy (1997) UNDP $9 m. GEF $28 m. total	Promote the widespread adoption of renewable energy sources in China by strengthening the capacity of Chinese government agencies to implement identified policies and by removing barriers to solar and wind hybrid systems, wind farms, biogas, bagasse, and solar hot water.	1. Conduct workshops focusing on market penetration, foreign investment, power purchase agreements, and information needs. 2. Establish a major renewable energy center/clearinghouse for information, training, and facilitation programs. 3. Train policy makers, renewable energy professionals and business people in market-based renewable energy development and best practices; build capacity to assess renewable energy resources. 4. Develop standards and codes of practice in collaboration with national, regional, and local industry associations. Develop certification procedures and select institutions to serve as certification centers. 5. Install 200 pilot SHS and several biogas digestion plants
Cape Verde Energy & Water Sector Reform and Development (1998) World Bank $5 m. GEF $67 m. total	Promote a sustainable market for PV in Cape Verde; promote the use of wind power in the electric power system; increase operational and end-use efficiency in the power and water sectors.	1. Install 7.8 MW of wind farms financed through the project, representing 25% grid penetration for the 31 MW grid (by an electric power utility undergoing privatization). 2. Install 4,000 SHS in rural households financed through the project (by private-sector PV concessions). 3. Create the capabilities in public agencies to promote SHS and to contract and regulate PV concessions.

Project	Objective	Intended Results
China Renewable Energy Development (1998) World Bank $35 m. GEF $445 m. total	Develop commercial markets for wind farms and PV systems in China.	1. Install 190 MW of wind farms (by public provincial electric utilities). 2. Sell or lease 200,000 SHS to rural households (by private-sector PV entrepreneurs). 3. Train the staff of provincial power companies to measure wind resources, conduct feasibility studies, and construct wind-farm subprojects. 4. Train the State Power Company and wind farm companies on the technical, legal, financial, and contractual requirements for obtaining private investment. 5. Assess renewable energy resource potential for follow-up investments and disseminate information on wind resources, site characteristics, and equipment performance. 6. Award grants on a competitive basis to local and joint venture manufacturers of wind turbine and PV system components to enable them to lower technology costs and improve performance. 7. Establish a PV test center and national PV system standards. 8. Conduct consumer awareness and education campaigns.

B.3. Solar Hot-Water Supply

Two solar hot-water projects in Tunisia and Morocco take four main approaches (Table B3):

Reduce Installed Costs and Make Systems Affordable. Projects directly install a sufficient volume of solar hot-water systems to produce economies of scale for manufacturers and create viable business opportunities for local production, service, and maintenance organizations. The Tunisia project provides more than $20 million of financing for solar collectors, which could amount to 50,000 m^2 installed if the average collector cost was $400/$m^2$. The Morocco project plans 80,000 m^2 of collectors installed. In addition, the Morocco project demonstrates rehabilitation of existing solar hot-water heaters, which could be an affordable alternative to many new installations. The Morocco project also designs and lobbies for practical mechanisms that would allow permanent reductions in VAT and import duties on solar water heaters. Finally, a variety of financing mechanisms are developed and piloted to reduce first-costs to consumers and thus make systems more affordable.

Raise Awareness and Build Capacity Among Consumers and Policy Makers. Both projects training government agencies and private firms to promote, evaluate and install solar hot-water systems. Awareness campaigns are spread over a large number of sectors. In Tunisia, beneficiaries include a variety of private-sector and public-sector establishments, such as hotels, schools, mosques, sports centers, and apartment buildings. Morocco similarly targets a wide variety of public and private users. Awareness campaigns are targeted at policy makers in connection with establishing policy frameworks, and at opinion leaders in the architect/engineering communities to influence architectural/engineering practices. In Morocco these activities are coordinated through a national solar water heaters marketing plan. Demonstration projects are also set in public facilities and other visible places in rural areas where large groups of potential future end-users can be introduced to solar hot-water heaters. The Morocco project also provides business plan training for SHW firms.

Promote a More Favorable Policy Framework. The Morocco project takes Moroccan public sector representatives on study tours to meet their counterparts in other Mediterranean countries and holds national workshops to develop public-private partnerships. Through these tours and workshops, the project aims to analyze policy contexts favorable to solar water heaters in other Mediterranean countries and draw lessons that can be adapted to Morocco. The project also aims to review the country's overall policy and regulatory framework and recommend macro-economic policy changes. Potential changes include reductions in VAT and import duties, regulations for electric utilities, changes in energy prices, and development of public-sector procurement guidelines and equipment standards and codes.

Improve Product Quality. The Morocco project develops norms, standards, testing procedures and trained test personnel, certification and labeling, and associated enforcement mechanisms. The project introduces assemblers and manufacturers to improved standards and specifications to facilitate compliance, trains architects and engineers to apply the standards and procedures, and develops codes of practice for constructors, installers, and plumbers along with training to facilitate compliance.

Table B3: Solar Hot Water Supply Projects

Project	Objective	Intended Results
Tunisia Solar Water Heating (1993) World Bank $4 m. GEF $21 m. total	Promote the use of solar hot-water heating in commercial, residential, and public (schools, hospitals) buildings and enhance the economic viability of investments in solar hot-water heating.	1. Install about 150 subprojects for solar hot-water heaters in hotels, schools, and apartment buildings, financed 35% by the project and 65% from third-party or self-financing (beneficiaries conduct installations). 2. Train private firms and the project executing agency (Agence pour la Maitrise de l'Energie) to promote, evaluate, and install solar hot-water systems.
Morocco Market Development for Solar Water Heaters (1999) UNDP $3.0 m. GEF $5.4 m. total	Remove barriers preventing sustainable market development for solar water heaters in Morocco.	1. Analyze policy contexts favorable to solar water heaters in other Mediterranean countries and draw lessons that can be adapted to Morocco. 2. Review policy and regulatory framework and recommend macro-economic policy changes, including reduced VAT and import duties. 3. Raise awareness of solar water heaters among public and private decision makers and architects and engineers. Provide information on best practices and equipment available internationally. 4. Install new equipment (total 80,000 m^2) and rehabilitate existing equipment (target: 50 units) to demonstrate the potential for rehabilitation 5. Develop a national marketing plan, including media campaigns and information dissemination. 6. Create new financing mechanisms for SWH businesses. 7. Conduct training workshops on preparing business plans for bankable solar water heating projects. 8. Develop norms, standards, testing procedures, certification and labeling, and associated enforcement mechanisms.

B.4. Precommercial Renewable Energy Technologies (OP7)

A number of renewable energy technology applications are still not commercial; further research, development, and demonstration are needed to bring long-term costs for these technologies down sufficiently to create commercial markets for them. To reduce long-term costs, four projects install demonstration hardware and provide training and dissemination mechanisms (Table B4). Projects rely heavily on the demonstration effects from these installations and on the technology development effects from designing, bidding, constructing, and operating a single plant. Planned project clusters using similar technology across diverse geographic regions, for example in the case of solar-thermal power plants, are expected to demonstrate technical performance over a wide range of climate and market conditions. In these projects, long-term cost reductions are achieved through two main approaches:

Select Technologies for Attractive Niche Markets with Good Cost-Reduction Potential

Central-station photovoltaic. Since the 1980s, central-station photovoltaic (PV) power plants have been developed in a relatively small number of installations globally. Although it is still several times more expensive on an installed-kW basis than conventional power plants, solar cell costs are declining and this technology is promising because it entails no fuel costs and offers other application-specific benefits. The first project was approved for the Philippines in 1999. This central-station PV power plant is used to even out the load curve for hydropower, avoiding the need to install thermal power generation (mainly diesel and oil-fired gas turbines) for this purpose. The PV is installed on the distribution system of a district electric power utility, which avoids transmission capital costs. The nature of the avoided generation (peaking) and avoided transmission costs enhances the cost-competitiveness of the PV technology in this application.

Solar thermal. Solar thermal technologies also are significantly more expensive than conventional technologies on an installed-kW basis. Nevertheless, costs have been falling sharply, from $5,000 per kW for plants in the 1980s to recent projections of $2,000 per kW. In the India and Morocco projects, demonstration hybrid-solar-thermal/fossil-fuel electric power stations are installed. These power stations consists of solar-trough-collector arrays integrated with a combined-cycle natural-gas thermal power plant (with total capacity in the range of 150 MW). In Morocco, the type of solar-thermal technology to be used is left open in the project design; the final specifications will be selected by the project after competitive bidding, to ensure minimum costs and maximum plant efficiency. The open specification will also help to ensure that the resulting design is more likely to be replicated by the private sector in the future. Several other countries have expressed interest in solar thermal technologies, including Egypt, Tunisia, Israel, Jordan, Spain, Italy, Greece, and other African countries with high solar insolation.

Biomass integrated gasification/gas turbine. Biomass integrated gasification/gas turbine (BIG/GT) technology is a promising way to utilize biomass wastes (i.e., sugar cane bagasse or wood chips) to generate grid-connected electricity in favorable regions with good fuel sources. In Brazil, studies have shown that this technology compares favorably with hydropower resources in terms of cost and overall energy potential. However, using gasified biomass with relatively low calorific value to generate power through gas turbines has not yet been demonstrated commercially. Following extensive research and studies on BIG/GT technology in the 1980s were funded by the Brazilian government, international private-sector firms, and international assistance; as a result of this research, three GEF projects in Brazil have been approved to demonstrate commercial viability. The first project conducted pre-feasibility and project design activities (i.e., technology development, basic engineering, and institutional and commercial arrangements for project implementation). The second project studies the feasibility of new fuel sources and modes of obtaining bagasse/biomass fuel supplies for BIG/GT plants in Brazil; green sugar cane bagasse and trash are potential fuel sources. The third project is for the bidding, construction, and operation of a 30-megawatt pilot plant.

Catalyze Demonstration Effects

Central-station photovoltaic. The Philippines project, by demonstrating PV technology in a competitive niche market, hopes to expand the use of PV in such applications by several orders of magnitude. The main idea is to generate greater volume in worldwide PV demand. The assumption is that greater volumes in global demand will accelerate declines in global long-term costs for PV. Demonstration results will be disseminated through presentations and site tours.

Solar thermal. In India, a variety of demonstration effects are expected. Demonstration of the plant's operational viability in India is expected to result in follow-up investments by the private sector both in the manufacture of the solar field components and in larger solar stations within India. Insights gained into local design and operating factors such as meteorological and grid conditions and use of available back-up fuels, are expected to lead to replication tailored to local conditions. The project is also expected to revive (from a slump since the late 1980s) and sustain the interest of the international business and scientific community in improving solar thermal plant design and operation. Demonstration effects are strengthened by involving a range of stakeholders, such as local industries, the Rajasthan State Electricity Board, the Rajasthan Energy Development Agency, the Ministry of Non-Traditional Energy Sources and Indian technical institutes. Operational results are disseminated to these stakeholders as well as other members of the Indian and international solar energy industry.

Biomass integrated gasification/gas turbine. In the Brazil Biomass Integrated Gasification project, the technology demonstration is intended to spur further research, development, and commercialization of the technology worldwide. The indirect impacts of the project can be measured by adoption of this technology worldwide as costs are reduced and perceptions of its commercial feasibility change. The third Brazil project will disseminate information on the BIG/GT technology and lessons learned from the demonstration stage to practitioners elsewhere in Brazil and in other countries.

Table B4: Precommercial Renewable Energy Technologies (OP7)

Project	Objective	Intended Results
Brazil Biomass Integrated Gasification /Gas Turbine—Project I (1992) UNDP $8 m. GEF $8 m. total	Establish a globally replicable prototype unit on a commercial scale for the cogeneration of electricity based on the gasification of wood chips or sugar cane bagasse.	1. Develop and test a gas turbine for burning gas of low-heat-value of the type produced by biomass air-blown gasification. 2. Develop and test a fuel-plant engineering process suitable for biomass gasification and gas cleaning. 3. Complete the basic engineering design for the gasification plant and specify the main plant equipment and construction activities. 4. Select a site for building a pilot plant and conduct environmental assessment studies. 5. Develop a plan for the next phase of the project (bidding, construction, and operation); conduct economic studies and elaborate contract models for fuel supply and energy sales.
India Solar Thermal Electric (1996) World Bank $49 m. GEF $245 m. total (major funds from German agency KfW)	Demonstrate the operational viability of parabolic trough solar thermal power generation in India and promote commercial development of solar thermal technology and cost reduction.	1. Construct a 150-MW-range hybrid power plant using solar-thermal-trough-arrays integrated with a combined-cycle natural-gas thermal power plant. 2. Promote solar thermal technologies among potential investors. 3. Train and develop plant staff and a local consult base. 4. Collect and measure solar insolation data and map solar resources.
Brazil Biomass Power Generation: Sugar Cane Bagasse and Trash—Project II (1996) UNDP $3.8 m. GEF $6.5 m. total	Determine available volumes, quality and cost of bagasse/trash biomass for potential use in BIG/GT systems, to facilitate planned and future investments that target wide-scale replication and cost reduction.	1. Conduct studies on trash availability and quality and on herbicide reduction through use of trash substitution. 2. Develop new equipment for green cane harvest and handling and conduct an assessment of the environmental impacts of the proposed green cane system on agro-ecosystems. 3. Conduct gasification tests of green cane and trash. 4. Analyze BIG/GT-sugar mill integration. 5. Develop an information dissemination strategy; produce informational materials; conduct media campaigns; conduct workshops for public and private-sector sugar cane producers.
Brazil Biomass Power Commercial Demonstration —Project III (1997) World Bank $40 m. GEF $122 m. total	Demonstrate the commercial viability of using wood as a feedstock for power generation using the Biomass Integrated Gasification/Gas Turbine (BIG/GT) concept.	1. Construct a 30-MW demonstration Biomass Integrated Gasification/Gas Turbine plant. 2. Develop new environmental, operational, administrative, and procurement procedures associated with BIG/GT technology. 3. Conduct an assessment study of the environmental aspects of widespread replication of the BIG/GT technology in Northeast Brazil. 4. Plan a commercial dissemination phase for the project.

Project	Objective	Intended Results
Morocco Solar Based Thermal Power Plant (1999) World Bank $43 m. GEF $114 m. total	Demonstrate the economic feasibility of solar-thermal-based power generation worldwide by establishing and disseminating project experience.	1. Construct a 150-MW-range hybrid power plant using solar-thermal-trough arrays integrated with a combined-cycle natural-gas-fueled power plant.
Philippines CEPALCO Distributed Generation PV Power Plant (1999) World Bank/IFC $4 m. GEF $8 m. total	Demonstrate the technical, operational and economic feasibility of utilizing PV based solar energy for supplementing and firming up the productive capacity of existing hydropower projects, initially in the Philippines, but also as a model that can be replicated elsewhere in the developing world.	1. Construct a 1-MWp PV generating plant to operate in conjunction with an existing 7-MW hydroelectric plant with dynamic load control, effectively providing “firm” generating capacity.

B.5. Energy-Efficient Product Manufacturing and Markets

Seven projects foster a "market transformation" approach to energy-efficient product supply and demand, which simultaneously provides both "market push" and "market pull" for a particular technology (Table B5). Market research, market testing, technology promotion, consumer education, product labeling, technical assistance, and technology transfer can, in combination, boost market demand for more efficient products while increasing the willingness of suppliers to produce them. A market transformation approach overcomes the "chicken-and-egg" problem: producers are unwilling to produce a product because no established market for it exists, and consumers do not demand the product because it is not produced or sold or they are unaware of it. Projects utilize a variety of approaches to remove barriers to markets for more energy-efficient products:

Provide Technical Assistance and Technology Transfer to Manufacturers to Upgrade Their Product Designs. The China Industrial Boilers project provides technology transfer and technical assistance to nine competitively selected boiler manufacturers to allow them to develop high-efficiency boiler models. As part of the technology transfer, the project acquires advanced equipment from abroad to upgrade these firms' designs to new boiler models. The project also provides technical assistance to the nine boiler manufacturers to develop, produce, market, and finance the new models and to strengthen customer service programs. Similarly, the China Efficient Refrigerators project provides technical assistance and training for compressor and refrigerator manufacturers to produce more efficient designs. In this case, targeting compressor manufacturers is especially important, because virtually all Chinese refrigerators use Chinese-produced compressors, and compressor designs have remained less efficient than they could be. The project creates specific incentives for these manufacturers to modify their product designs and to convert production lines. In both projects, the actual costs of conversion are financed from commercial or government sources arranged as part of the project.

Reduce Retail Prices of Technology through Subsidies, Bulk Procurement, or Manufacturer Contributions. Projects to promote CFL markets employ three mechanisms to reduce retail prices. First, the Poland, Mexico and Jamaica projects provide per-unit subsidies for CFLs on the order of several dollars. Second, the Thailand Electricity Efficiency, Mexico and Jamaica projects also substantially lower retail prices by relying on the economies of bulk purchases from manufacturers. Third, the Poland project, in a unique approach, obtained subsidy contributions from lighting manufacturers. Manufacturers competed to provide the largest guaranteed sales at the lowest project subsidy cost, providing subsidies themselves on a contractual basis that specified wholesale and retail prices. This subsidy program allowed large retail price reductions with smaller project subsidies because of the manufacturer contributions, as well as the multiplier effects of VAT tax and retail markups. This approach to manufacturer contributions, having been deemed very successful in Poland, is being replicated in the Efficient Lighting Initiative project in seven countries.

Pilot New Distribution Mechanisms through Retailers, Dealers, or Electric Utilities. In Mexico and Jamaica, the electric utilities distribute CFLs through utility offices. In the Thailand Electricity Efficiency project, lamp distribution through a chain of "7-11" convenience store is a new distribution mechanism in that market. In Poland, distribution through existing retailers was enhanced through the use of a special "green" product logo. The Efficient Lighting Initiative project in seven countries develops new financing mechanisms, such as energy service companies, which could serve as new distribution vehicles.

Educate Consumers/Users about the Characteristics, Costs, and Benefits of the Energy-Efficient Technology. All projects conduct consumer education and outreach programs. In some projects, like in Mexico, this is done primarily through utility offices to reach the utility's customer base. Most projects use media advertisements—television, newspaper, and radio. The Poland project utilized a special "green" logo to promote CFLs sales and also conducted an energy/environmental education program in primary and secondary public schools. The China Industrial Boilers project provides technical assistance and training for industrial enterprises to understand, procure, and operate the higher-efficiency boilers, and for design and research institutes and government agencies to disseminate the technologies to other boiler manufacturers. In addition to consumer education and outreach, the China Efficient Refrigerators project enacts a national refrigerator labeling program to educate consumers at the point-of-sale. The project also provides dealer incentive programs to encourage dealers to actively stock and sell more efficient refrigerators. Finally, the project conducts a consumer buyback/recycling program for old refrigerators, to provide incentives and opportunities for consumers to trade their less efficient models for more efficient ones.

Conduct Utility-Based Demand-Side Management (DSM) Programs. Utility-based DSM projects in Mexico, Thailand Electricity Efficiency, and Jamaica are vehicles through which energy-efficient product markets are promoted. In Mexico, the project particularly targeted low-income consumers because the utility was paying large subsidies for electricity purchased by these consumers. In the Thailand Electricity Efficiency project, the national electric utility (EGAT) was keen to avoid subsidy programs and instead relies on voluntary agreements, market mechanisms, and intensive publicity and public education campaigns. In Jamaica, the utility extends credit to consumers for purchasing energy efficient equipment; consumers have the option of financing the equipment with 12 monthly payments through their electricity bills. The Efficient Lighting Initiative project helps utilities develop DSM programs for lighting in seven countries. In the industrial sector, the Thailand Electricity Efficiency project offers rebates to purchasers of new, more efficient motors and offers free audits to encourage replacement of existing inefficient motors. The project also develops efficiency standards and testing capabilities and conducts efficiency certification for selected equipment types by establishing test procedures and minimum efficiency requirements. In the Thailand Chillers project, EGAT replaces chillers with high-efficiency models and pilots an energy service company mechanism that could be replicated by the private sector after the project is completed.

Table B5: Energy-Efficient Product Manufacturing and Markets

Project	Objective	Intended Results
Mexico High Efficiency Lighting Pilot (1991) World Bank $10 m. GEF $23 m. total	Pilot a utility DSM program to sell CFLs to residential consumers.	1. Finance the national utility (CFE) to purchase 1.7 million CFLs and sell them directly to consumers through its offices.
Thailand Promotion of Electricity Energy Efficiency (1991) World Bank $9.5 m. GEF $190 m. total	Conduct a five-year utility DSM program by the national electric utility responsible for power generation (EGAT); pilot different market intervention strategies that demonstrate on a large scale the potential for electricity efficiency.	1. Create a Demand-Side Management Office within EGAT. 2. Conduct voluntary agreements with Thai lighting manufacturers and importers to improve the efficiency of their lighting products. 3. Purchase in bulk a planned 1.5 million CFLs and sell them through a distribution network of 7-11 convenience stores. 4. Promote low-loss magnetic ballasts through bulk procurement. 5. Develop and promulgate new commercial building codes and conduct demonstration commercial building retrofits. 6. Develop labeling and standards for household appliances and industrial motors. 7. Conduct consumer education and awareness campaigns. 8. Provide end-user and manufacturer incentives for producing and purchasing more efficient equipment.
Jamaica Demand Side Management Demonstration (1993) World Bank $3.8 m. GEF $12.5 m. total	Test and demonstrate the marketing, technical, financial, and economic feasibility of implementing cost-effective DSM measures, particularly in the residential sector.	1. Create a DSM program unit within the Jamaica Public Service Co (JPSCo) utility. 2. Provide free CFLs to 100 homes to test and establish technical criteria regarding equipment performance, customer response, and installation problems. 3. Sell 100,000 CFLs to 30,000 households at discounted prices, as part of energy savings packages that may include other equipment like low-flow showerheads and outdoor lighting controls. 4. Conduct public education and information campaigns through utility mailings, offices, and the media 5. Conduct energy audits in 20 large-scale and 10 small-scale buildings (new and existing) in the commercial sector, focusing on lighting, air conditioning, refrigeration, and water heating. 6. Assess the solar water heater market in Jamaica and strengthen the market by providing information and installation and maintenance assistance, and by monitoring existing installations.

Project	**Objective**	**Intended Results**
Poland Efficient Lighting Project (1994) IFC/World Bank $5 m. GEF $5 m. total	Stimulate the national market for energy-efficient lighting in Poland and accelerate the market by five years.	1. Sell 1.2 million CFLs directly under the project through commercial retailers, utilizing both direct product subsidies and indirect manufacturer-contributed wholesale price decreases. 2. Conduct a pilot peak-load-shaving DSM program by selling discounted CFLs to residents in specific districts where peak electric capacity was constrained (done by three municipal governments and local electric utilities). 3. Sell discounted CFL luminaires through a wholesale buy-down program. 4. Conduct a public education program, including a special logo to promote CFLs, television and press advertising, and an energy/environmental education program in primary and secondary public schools.
China Efficient Industrial Boilers (1996) World Bank $33 m. GEF $101 m. total	Develop affordable, energy-efficient, and cleaner industrial boiler designs; mass produce and market these high-efficiency boiler designs; and disseminate more energy-efficient and cleaner boiler technologies throughout China.	1. Provide technology transfer and technical assistance to nine competitively selected boiler manufacturers to allow them to develop high-efficiency boiler models. 2. Acquire advanced equipment from abroad to upgrade production with new boiler models. 3. Provide technical assistance to nine boiler manufacturers to develop, produce, market, and finance plans for the new boiler models and to strengthen customer service programs. 4. Provide technical assistance and training for industrial enterprises to understand, procure, and operate the higher-efficiency boilers, and for design and research institutes and government agencies to disseminate the technologies to other boiler manufacturers.
China Barrier Removal for the Widespread Commercialization of Energy-Efficient CFC-Free Refrigerators in China (1998) UNDP $9.9 m. GEF $41 m. total	Remove barriers to the widespread commercialization of energy-efficient refrigerators in China.	1. Provide technical assistance and training for compressor and refrigerator manufacturers. 2. Create incentives for energy-efficient product design or modification and conversion of factory production lines. 3. Enact national efficiency standards. 4. Enact a national refrigerator labeling program. 5. Conduct consumer education and outreach. 6. Conduct dealer and manufacturer incentive programs. 7. Conduct a consumer buyback/recycling program for old refrigerators.

Project	**Objective**	**Intended Results**
Efficient Lighting Initiative (1998) IFC/World Bank $15 m. GEF $50 m. total	Promote market expansion for energy-efficient lighting in Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines, and South Africa.	1. Sell on the order of 3 million CFLs directly under the project through commercial retailers, utilizing both direct product subsidies and indirect manufacturer-contributed wholesale price decreases.[23] 2. Provide financial advisory services and develop local, sustainable financing mechanisms to overcome first-cost barriers (i.e., leasing, energy service companies, partial guarantees). 3. Conduct consumer education and marketing campaigns to increase consumer awareness of life-cycle costs, energy efficiency, and climate change issues. 4. Collaborate with local utilities to develop DSM programs. 5. Support establishment of industry associations.
Thailand Building Chiller Replacement Program (1998) World Bank $2.5 m. GEF $90.5 m. total	Remove barriers to widespread replacement of low-energy efficiency chillers with new, high-efficiency, non-CFC chillers in Thailand.	1. Replace 440 chillers with new high-efficiency chillers. 2. Pilot an energy service company model in which the national utility (EGAT) replaces chillers and charges customers on a fee-for-service basis. 3. Establish a zero-interest revolving loan fund for end-user investments in chillers. 4. Disseminate information on high-efficiency chillers in Thailand.

B.6. Energy Efficiency Investments in Industry

Fourteen projects directly target energy efficiency in the industrial sector (Table B6). These projects take the following approaches:

Pilot Innovative Financing Mechanisms. Projects pilot a number of innovative financing mechanism designed to reduce financing barriers to energy efficiency improvements. Examples include:

China. The China TVE Phase II project establishes a Working Capital Fund (WCF) to provide loans for energy conservation projects. The fund is initially seeded with funds from the GEF, the Ministry of Agriculture, and the Agricultural Bank of China. The fund provides, initially, 20% of the necessary project financing, the remainder comes from the project developer and the Agricultural Bank of China.

Hungary. The Hungary project provides partial credit guarantees to domestic commercial financiers to reduce the credit risk of debt or lease-financing to ESCOs, project developers, or equipment manufacturers and suppliers. In addition to partial credit guarantees, the project provides incremental financing when the participating commercial financier reaches its own assessed lending ceiling. Commercial financiers are responsible for selecting individual projects and conducting due diligence. Financing is medium to long term so that investments can be self-financing from the energy savings realized. Once commercial viability of energy efficiency investments has been demonstrated, the fund is expected to be replicated by commercial financiers; the level of participation risk and the amount of partial guarantees will diminish as the project develops until commercial financiers are able to operate without it.

India. In the India project, IREDA finances the direct production, purchase and installation of energy efficiency equipment for a range of end-use technologies including electric motors, refrigeration, industrial cogeneration, boilers, steam drives, and lighting. Project costs vary from $25,000 to $250,000.

Kenya. The Kenya project makes SMEs aware of financing that is already available and affordable to them as the private financial sector in Kenya is already well established. The project publishes a *Guide for Kenyan and Foreign Investors Participating in the Implementation of Energy Efficiency and Energy Conservation projects* to provide information on taxes, regulations and sources and types of financing available and under what terms. The project also conducts financial engineering courses to train SME managers on how to develop investment projects acceptable to commercial financiers.

Global. The Renewable Energy and Energy Efficiency Fund provides capital for energy efficiency projects with rates of return or uncertain risk-profiles that would discourage full commercial backing. The fund will invest in medium-sized projects (US $5-30 million) that meet GEF criteria.

Promote or Create Energy Service Companies. In many countries there are important opportunities for energy service companies (ESCOs) to profit from energy efficiency by advising and supporting end-users to implement energy efficiency measures and by engaging in energy performance contracting.

Create new ESCOs. The China Energy Conservation and Brazil projects directly create and finance demonstration or pilot ESCOs. The China project creates three ESCOs to demonstrate energy performance contracting for the first time in China. These ESCOs are responsible for identifying industrial clients, financing the investments, and bearing the financial and technological risk. Under the performance contract, ownership reverts to the host enterprise once the ESCO's costs and a reasonable profit are recouped from avoided energy costs, equipment. Similarly, the Brazil project creates demonstration ESCOs to implement performance contracts and also creates a credit facility from commercial or development banks to encourage third-party financing of ESCO projects.

Finance and promote existing ESCOs. Other projects do not attempt to establish ESCOs directly but rather provide financing for private-sector ESCOs that submit viable financing proposals. In the India project, IREDA finances private-sector ESCOs to implement performance contracts in the range of $0.25 to $1 million with large industrial and commercial users such as the steel, chemical and distillery industries. The Hungary project also provides explicit financing for ESCOs. The Malaysia project illustrates a national effort to further promote the ESCO concept in a country where ESCOs are already well established. The project will address the lack of awareness and information on ESCOs by instituting a national workshop to promote the ESCO concept and a cooperative workshop to develop the legal and institutional framework for the delivery of ESCO services as well as developing tools for use by energy engineers in ESCOs and a marketing strategy for ESCOs. The project also conducts surveys to determine the existing ESCO density in Malaysia, and monitors and evaluates existing ESCO programs. The Brazil project designs and implements a financing facility for energy efficiency activities by ESCOs and promote performance contracting among industrial firms, public institutions, financiers, and engineering service companies.

Lay the groundwork for future ESCOs. Other projects lay the institutional and capacity building groundwork for future ESCOs once markets for energy efficiency technologies and services mature. Projects first create government or quasi-government agencies and develop their capabilities in delivering energy efficiency services. Then these agencies are expected to evolve or split into private-sector ESCOs. The Lebanon project creates the Lebanese Center for Energy Conservation and Planning, initially structured as an independent entity within the Ministry of Hydroelectric Resources. Initially, only a portion of the costs of the center will be recovered from its clients. However, over time and as a market is established, full cost recovery from clients is expected and ultimately the activities that generate revenue will be privatized into an energy service company. Similarly, the Palestinian/Egyptian project establishes two pilot energy consumer service centers to reach industrial, commercial, and other private-sector energy consumers and to gather and disseminate information about energy consumption and conservation. These centers will help to create private-sector ESCOs and eventually are expected to become privately owned and managed ESCOs themselves. In the Thailand project, the national electric utility (EGAT) anticipates turning over some its DSM activities to ESCOs once the market for these investments is proven (a second Thailand project for chillers involving EGAT, described in Annex B.5, also expects to be replicated by private-sector energy service companies).

Create or Strengthen Dedicated Energy-Efficiency Centers. Projects in China, Egypt, India, Lebanon, Malaysia, Palestine Authority, Peru, and Syria create or strengthen a number of different types of dedicated centers or intermediary organizations to support energy efficiency improvements in industry.

China. The China TVE Phase II project establishes a Production Technology and Product Marketing Consortium (PTPMC) to assist town and village enterprises (TVEs) with feasibility studies, staff training, energy management, quality control measures, construction, commissioning and operation of subprojects. The China TVE Phase I project strengthens the capabilities of three existing TVE regional energy conservation centers by providing them with basic computing and library facilities and technical assistance for developing training programs. The China Energy Conservation project establishes an Energy Conservation Information Dissemination Center to provide industry with information on energy efficiency improvements and best practices.

India. The India project increases the capacity of IREDA to finance and market energy efficiency investments, particularly the concept of performance-based energy efficiency contracting using ESCOs. IREDA's clients include industry, equipment manufacturers and vendors, state electricity boards, and private electric utilities. IREDA assists these clients with financing, investment planning, business plan development, project development, and procurement.

Peru. The Peru project strengthens the institutional and technical capabilities of CENERGIA, a non-profit entity with strong links to the public and private sectors, to provide advice and support to its clients in the public and private industrial sectors on potential energy efficiency and conservation savings. CENERGIA experiences and knowledge will be shared with public and private educational institutions and with energy conservation professionals from other Latin American countries.

Syria. The Syria project establishes an Energy Services Center with expertise in energy auditing, heat engineering, power system planning, ventilation, refrigeration, air conditioning, motor systems, marketing, and financial and economic analysis. The center assists public and private entities with task such as energy audits, building codes, and access to credit in the longer term.

Build Capacity of Industrial Enterprises to Understand, Select, Finance, and Install Energy-Efficient Process Technologies. A few projects directly develop the capabilities of personnel within industrial enterprises. Capabilities developed include project appraisal skills, financial and commercial marketing skills, and energy auditing and energy management skills. The Kenya project trains energy auditors and establishes a national network of auditors to increase their capacity to identify and evaluate energy efficiency opportunities. The project trains personnel from small and medium scale enterprises, through a series of seminars and workshops, to prepare and implement energy-saving measures. The project also trains a unit within the Kenyan Association of Manufacturers on energy management and international best practices. The Egypt/Palestine project assists the private sector to develop energy planning, project feasibility analysis, and conceptual design skills. The project also provides energy auditing and conservation and engineering services to industries and commercial firms. And the Malaysia project establishes an energy audit program in which audit team members from various industrial subsectors receive training in all aspects of energy management and auditing, conduct audits, and train other auditors.

Demonstrate the Technical, Economic and Commercial Viability of Energy Efficiency and Energy Conservation Measures. Projects in Brazil, China, India, Kenya, Malaysia, Peru, and Syria directly finance energy efficiency subprojects that demonstrate the commercial and technological viability of energy efficiency and conservation in selected subsectors. Projects also conduct information and awareness campaigns to disseminate demonstration subproject experiences, including both financial and technical data and results. The China TVE Phase I project conducts one technology demonstration project in each of eight provinces and four industrial subsectors (brick-making, coking, metal casting, and cement making). The Malaysia project conducts demonstration projects in the cement, ceramics, food, glass, iron/steel, pulp, paper, and rubber industries, co-financed with the private sector. The Syria project rehabilitates selected facilities in one electric utility; as the project builds awareness of energy efficiency technologies among managers and policy makers and disseminates experience to other utilities, it is expected to be replicated. The Brazil project conducts and evaluates a series of demonstration projects for commercial customers, large industrial customers, and public facilities. The project also establishes a "best practices" program based upon collected experiences from the demonstration projects, which will disseminate to the financial community project information such as rates of return and profitability.

Table B6: Energy-Efficiency Investments in Industry

Project	Objective	Intended Results
Peru Technical Assistance to Center of Energy Conservation (1991) UNDP $0.9 m. GEF $0.9 m. total	Enable the Peruvian non-profit entity CENERGIA to become a regional energy efficiency and energy conservation training and service center to public and private industrial clients.	1. Train CENERGIA's technicians in energy conservation techniques and in evaluation and control of industrial and vehicular emissions. 2. Provide CENERGIA with materials and equipment to implement energy conservation and emissions testing techniques. 3. Survey environmental pollution in the most energy-intensive industries and survey diesel vehicle emissions. 4. Establish a national program to minimize and regulate industrial emissions. 5. Conduct six demonstrations of energy efficiency and conservation measures in industrial enterprises identified by CENERGIA audits.
Chile Reduction of GHGs (1992) UNDP $1.7 m. GEF $1.7 m. total	Demonstrate the commercial viability of making energy efficiency improvements in industry.	1. Create two ESCOs (done by mining companies). 2. Conduct three demonstrations of energy efficiency improvements for industrial motors. 3. Establish a revolving fund to finance the incremental costs of energy efficiency investments. 4. Conduct a feasibility study for a biomass plant.
China Energy Conservation and Pollution Control in Township and Village Enterprise Industries (TVE) Phase 1 (1995) UNDP $1 m. GEF $20 m. total	Demonstrate the value of energy efficiency improvements in China's Town and Village Enterprises (TVEs), specifically in the brick-making, coking, metal casting and cement sectors.	1. Conduct surveys at 76 existing TVEs with high energy consumption and pollution levels; identify 8 pilot sites and conduct demonstrations of energy efficiency technologies. 2. Develop training materials and programs for three existing TVE Energy Conservation Centers to train TVE managers and technicians in energy conservation project appraisal and industrial management. 3. Train energy auditing trainers and project management trainers in at least 10 TVE service organizations. 4. Conduct pre-investment feasibility studies to build a portfolio of potential energy conservation projects.
Renewable Energy and Energy Efficiency Fund (1996) IFC/World Bank $30 m. GEF $130 m. total	Mobilize new financial resources for investments in energy efficiency and renewable energy projects by the private sector in non-OECD countries; attain a competitive risk-adjusted rate of return on these projects.	1. Establish a fund capitalized with a minimum of $130 million. 2. Establish a balanced portfolio of energy efficiency and renewable energy projects financed from the fund.

Project	**Objective**	**Intended Results**
Syria Supply-side Efficiency and Energy Conservation Planning (1996) UNDP $4.1 m. GEF $4.1 m. total	Improve the efficiency of electric power generation and increase the capacity of domestic entities to evaluate and implement energy-conservation activities.	1. Rehabilitate an existing power plant to demonstrate improvements in thermal efficiency. 2. Train power plant operators in plant management and maintenance practices for greater efficiency. 3. Establish a Syrian Energy Services Center and train its personnel to perform audits and retrofits and eventually provide credit lines to customers. 4. Conduct seminars for Ministry of Environment decision makers to raise awareness of energy efficiency technologies and practices. 5. Establish a National Energy Efficiency Program and integrated resource planning at the Ministry of Environment
Hungary Energy Efficiency Co-Financing Program (1996) IFC/World Bank $5 m. GEF $25 m. total	Demonstrate the viability of co-financing to leverage domestic private capital for energy efficiency investments.	1. Establish a co-financing program with domestic commercial financiers to leverage $25 million over five years in medium to long term finance. 2. Establish a partial credit guarantee mechanism for participating commercial financiers to reduce credit risks. 3. Promote the marketing of energy efficiency financial services offered by commercial financiers.
China Energy Conservation (1997) World Bank $22 m. GEF $202 m. total	Increase energy efficiency savings sustainably through the establishment of ESCOs and promote awareness of the viability of energy efficiency investments.	1. Establish three pilot ESCOs to demonstrate energy performance contracting in China (called "Energy Management Companies"). 2. Finance the three pilot ESCOs to conduct energy efficiency projects in industry. 3. Create a national Energy Conservation Information Dissemination Center and distribute materials and information to industry about energy conservation opportunities and technologies. 4. Create an Energy Management Company Development Unit to disseminate information about performance contracting and encourage further formation of ESCOs in China. 5. Disseminate energy efficiency information through government, industry and professional networks in the form of newsletters, site visits, workshops and published professional articles.

Project	Objective	Intended Results
Brazil Energy Efficiency (1997) World Bank $20 m. GEF $200 m. total	Create a market-based energy efficiency industry by removing market barriers, enhancing institutional delivery mechanisms, and encouraging the development of ESCOs.	1. Conduct pilot and demonstration energy efficiency projects for emerging technologies; PROCEL documents and disseminates the experience and "best practices" derived from these projects. 2. Design and implement a financing facility for energy efficiency activities by ESCOs and promote performance contracting among industrial firms, public institutions, financiers, and engineering service companies. 3. Enhance testing, certification, and labeling of energy efficiency of equipment. 4. Establish a revolving fund for public sector and electric power utilities to finance energy efficiency investments.
Egypt and Palestinian Authority Energy Efficiency Improvements (1997) UNDP $6.4 m. GEF $8.1 m. total	Strengthen the capability of the Palestinian Authority to manage energy systems and improve energy efficiency; enable a market for energy efficiency investments in Egypt.	1. Establish an energy conservation program and an Energy Conservation Center within the Palestinian Energy Agency. 2. Establish two pilot energy consumer service centers that are expected to be converted to ESCOs in the future. 3. Provide energy auditing, conservation, and engineering services to industries and commercial establishments. 4. Identify, evaluate, and prepare projects for loss reduction in the electric power transmission and distribution system. 5. Draft codes and standards for energy efficiency in buildings and appliances. 6. Conduct educational, awareness, and outreach campaigns among the public and private sectors.
Kenya Removal of Barriers to Energy Conservation and Energy Efficiency in Small and Medium-Scale Enterprises (1998) UNDP $3.2 m. GEF $8.4 m. total	Develop SME capacity to identify appropriate energy efficiency measures, to implement demonstration energy efficiency projects, and to pioneer financial delivery mechanisms for these projects.	1. Conduct demonstration energy efficiency investments within designated industrial subsectors. 2. Train small- and medium-scale enterprises and commercial financiers to appraise and implement energy efficiency projects and to pioneer new financial mechanisms. 3. Train small- and medium-scale enterprise staff and local energy auditors in energy efficiency.

Project	**Objective**	**Intended Results**
India Energy Efficiency (1998) World Bank $5 m. GEF $37 m. total	Promote and finance the delivery of energy efficiency services and equipment, implementation of DSM schemes, and the development of ESCOs.	1. Increase the institutional capacity of IREDA to directly finance the production, purchase, and installation of energy efficiency equipment and to encourage the creation of ESCOs. 2. Establish credit lines for end-users, equipment manufacturers and ESCOs to undertake energy efficiency investments. IREDA appraises, finances, and supervises energy efficiency projects. 3. Support private-sector ESCOs to provide turnkey energy efficiency services including energy audits, feasibility studies and performance contracting. 4. Conduct a national survey to collect, collate, and synthesize information related to energy efficiency business development and investments.
Malaysia Industrial Energy Efficiency Improvement Project (1998) UNDP $7.3 m. GEF $19.3 m. total	Implement capacity-building and demonstration incentive schemes to address inadequate information and perceived risks of energy efficiency technologies among energy producers.	1. Establish industry energy performance benchmarks and energy ratings for energy efficiency industrial equipment and machinery. 2. Train personnel from various subsectors in energy auditing and energy management. 3. Provide incentives to local manufacturers to produce more-efficient equipment (motors, heat exchangers, pumps, fans, boilers). 4. Hold national workshops to promote the ESCO concept. Monitor and evaluate the performance of existing ESCOs. 5. Conduct energy efficiency projects on a 50/50 cost-sharing basis with project developers.
Lebanon Barrier Remova1 for Cross Sectoral Energy Efficiency (1999) UNDP $3.4 m. GEF $5.4 m. total	Improve demand-side energy efficiency through the creation of a multi-purpose Lebanese Center for Energy Conservation and Planning.	1. Establish the Lebanese Center for Energy Conservation and Planning as an autonomous public corporation. 2. Conduct 300-400 audits of industrial plants to identify potential energy savings and conduct feasibility studies outlining energy efficiency measures suggested by the audits. 3. Devise financing mechanisms that create incentives for investments in energy efficiency and conservation. 4. Conduct an assessment of demand-side energy efficiency potential by end-use technology, by sector, and by energy source. 5. Conduct an information and awareness campaign to promote energy efficiency and specific cost-effective options for various sectors and end-use technologies. 6. Draft energy conservation codes and standards for industrial equipment. 7. Make policy recommendations for legislative action on pricing, tariffs, taxation, incentives, and equipment standards.

Project	**Objective**	**Intended Results**
China Energy Conservation and GHG Emission Reduction in Chinese Township and Village Enterprises (TVE) Phase 2 (1999) UNDP $8 m. GEF $19.6 m. total	Demonstrate the value of energy efficiency improvements in China's Town and Village Enterprises (TVEs), specifically in the brick-making, coking, metal casting, and cement sectors.	1. Establish a Production Technology and Product Marketing Consortium that will provide project support and advice, such as feasibility studies of energy conservation, to TVEs. 2. Establish a Working Capital Fund to provide access to commercial financing (initially to finance 20% of project costs, with the remainder financed by the project developer and Agricultural Bank of China).

B.7. Energy-Efficient Building Codes and Construction

Four projects demonstrate the potential for energy savings in existing buildings and for setting energy efficiency codes and standards for newly constructed buildings (Table B7). These projects share some of the following approaches:

Conduct Energy Audits and Collect and Disseminate Data on Building Characteristics. Two projects collect and disseminate data on building characteristics as a way to overcome information barriers, especially those related to opportunities and costs of energy efficiency improvements. The West Africa (Cote d'Ivoire and Senegal) project collects and analyzes energy data from public and commercial buildings (e.g., hotels and banks). The project surveys building owners and obtains information on building specifications, structural materials, fittings, energy-related equipment, and the costs of material and equipment. The Jamaica project collects information on commercial buildings through a series of energy audits in commercial buildings (20 audits of large buildings and 10 audits of smaller buildings), focusing on lighting, air conditioning, refrigeration, and water heating.

Establish Building Codes and Standards and Establish New Agencies or Institutional Mechanisms to Enforce the Standards and/or Certify Equipment. Building codes and standards and implementation/enforcement mechanisms are prominent parts of three projects:

Thailand. The Thailand project institutes a mandatory energy code for commercial buildings to compel building owners who would not otherwise participate in the project's DSM programs. In addition to minimum mandatory standards, the project provides financial incentives for building owners who exceed the established standards. Implementation of the building code is undertaken by a working group established by the government with representatives from the architectural and engineering communities as well as manufacturing firms.

West Africa (Cote d'Ivoire and Senegal). The West Africa project helps finalize an existing energy efficiency code for air-conditioned buildings and helps implement the code; the project consults with affected parties, tests the application of the code to several building projects, trains construction operators to understand and apply the code, and introduces the code into building permit procedures. In addition to the energy efficiency code, the project drafts a thermal comfort code for buildings without air conditioning and assists with its implementation.

Tunisia. The Tunisia project helps validate energy efficiency standards for all new buildings in the commercial and residential sectors. The project selects a representative sample of 10 buildings from the service sector (including a hospital, a shopping mall, and an office building) and 36 residential projects (equivalent to 840 house lots). The public and private sectors are invited to bid to implement energy efficiency measures in these buildings, with awards going to bids that best comply with the standards.

Demonstrate Technical Energy Efficiency Measures. The Jamaica project conducts several demonstration subprojects in buildings. In the commercial sector, 20 audits are conducted on a representative sample of buildings over 1,000 m^2 (typically office buildings). The audits focus on the potential for energy savings from energy-efficient lamps, ballasts, refrigeration, and air-conditioning and ventilation systems. Ten smaller buildings are also audited and retrofitted. Also in the commercial sector, the project conducts studies that analyze the technical, financial, and economic feasibility of cogeneration as an alternative to energy conservation, particularly in hotels. In the residential sector, the project conducts a study on the technical potential for solar water heating and lighting and conducts small demonstration projects. In the West Africa (Côte d'Ivoire and Senegal) project, one representative building from each country will be audited and retrofitted, with an emphasis on air conditioning and lighting. In the Tunisia project, builders submit designs and compete to receive financial awards that cover the incremental architectural and construction costs for complying with the standards.

Conduct Utility-Based DSM Programs. The Thailand and Jamaica projects are discussed in Annex B.5 in relation to efficient lighting improvements and products. Both programs also address energy efficiency of buildings. The Thailand project provides free lighting audits and rebates to encourage building owners in the commercial and public sectors to retrofit/replace inefficient lighting systems. The project also develops and promulgates building codes to enforce minimum efficiency standards. The project proposes modifications to existing codes and encourages their enforcement by providing financial incentives for energy efficiency measures that exceed the existing standards.

Table B7. Energy-Efficient Building Codes and Construction Projects

Project	Objective	Intended Results
Thailand Promotion of Electricity Energy Efficiency (1991) World Bank $9.5 m. GEF $190 m. total	Conduct a five-year utility DSM program by the national electric utility responsible for power generation (EGAT); pilot different market intervention strategies that demonstrate on a large scale the potential for electricity efficiency.	1. Create a Demand-Side Management Office within EGAT. 2. Conduct voluntary agreements with Thai lighting manufacturers and importers to improve the efficiency of their lighting products. 3. Purchase in bulk a planned 1.5 million CFLs and sell them through a distribution network of 7-11 convenience stores. 4. Promote low-loss magnetic ballasts through bulk procurement. 5. Develop and promulgate new commercial building codes and conduct demonstration commercial building retrofits. 6. Develop labeling and standards for household appliances and industrial motors. 7. Conduct consumer education and awareness campaigns. 8. Provide end-user and manufacturer incentives for producing and purchasing more efficient equipment.
West Africa (Côte d'Ivoire and Senegal) Control of GHG Through Energy Efficient Building Technology (1992) UNDP $3.6 m. GEF $3.7 m. total	Demonstrate the economic and environmental benefits of the large-scale application of energy efficiency measures in new and existing buildings and in the equipment and materials used for these buildings.	1. Collect data on energy efficiencies of representative types of buildings (from public and private sectors) and distribute data through a national network of government agencies and NGOs. 2. Incorporate energy management techniques into building operations management in selected buildings (i.e., air renewal rates, temperature specifications, and equipment operation times). 3. Develop, implement, and assess the impact of energy efficiency codes for air-conditioned buildings and thermal comfort codes for non-air-conditioned buildings. 4. Develop a portfolio of buildings for future investment projects. 5. Conduct design studies for new buildings to show how new energy efficiency and thermal comfort codes can be met. 6. Train state environmental personnel to measure the impact of the building code in terms of greenhouse gas reduction, ozone depletion, and the immediate local environment.

Project	Objective	Intended Results
Jamaica Demand Side Management Demonstration (1993) World Bank $3.8 m. GEF $12.5 m. total	Test and demonstrate the marketing, technical, financial, and economic feasibility of implementing cost-effective DSM measures, particularly in the residential sector.	1. Create a DSM program unit within the Jamaica Public Service Co (JPSCo) utility. 2. Provide free CFLs to 100 homes to test and establish technical criteria regarding equipment performance, customer response, and installation problems. 3. Sell 100,000 CFLs to 30,000 households at discounted prices, as part of energy savings packages that may include other equipment, such aslow-flow showerheads and outdoor lighting controls. 4. Conduct public education and information campaigns through utility mailings, offices, and the media. 5. Conduct energy audits in 20 large-scale and 10 small-scale buildings (new and existing) in the commercial sector, focusing on lighting, air conditioning, refrigeration, and water heating. 6. Assess and strengthen the solar water heater market in Jamaica by providing information and installation and maintenance assistance, and by monitoring existing installations.
Tunisia Experimental Validation of Building Codes and Removal of Barriers to their Adoption (1998) UNDP $4.4 m. GEF $8.1 m. total	Remove barriers to the adoption and enforcement of regulatory measures that introduce the highest attainable energy-efficient building standards for all new buildings in the commercial service and residential sectors.	1. Retrofit 10 demonstration service-sector buildings and 840 residential housing units using previously identified building standards; validate the standards. 2. Conduct awareness campaigns to promote public support for the adoption of the highest building standards.

B.8. District-Heating Energy Efficiency and Biomass/Geothermal Heat Production

Five projects in countries in transition (Bulgaria, Lithuania, Romania, Russia, and Slovenia) improve energy efficiency in municipal district-heating networks and associated buildings, undertake municipal energy-saving projects, and demonstrate and promote heat production in district-heating systems from biomass and geothermal energy (Table B8). These projects take the following approaches:

Create New Financing Mechanisms, Particularly Involving the Private Sector. The Romania project demonstrates the overall feasibility of energy efficiency projects to stimulate long-term financing on a sustainable basis. The project reviews potential domestic and international sources of financing and consults with government and other stakeholders to identify viable financing mechanisms. The project plans to establish a grant-loan financing scheme to leverage loans and other resources for energy efficiency investments; it is expected that this mechanism would eventually finance a portfolio of energy efficiency projects and build financial, managerial and technical experience among the public, private, and NGO sectors. The Bulgaria project develops business infrastructure and market conditions for energy efficiency investments. The project publishes documentation accessible to potential investors on taxation, fees, budget regulations, liability, and labor practices, and establishes a clearinghouse to bring together municipal entrepreneurs with national and international sources of funding. The project also facilitates joint-venture energy service companies between Bulgarian and foreign investors and undertakes subprojects to demonstrate financial rates of return.

Build Capacities among Municipal Governments, District-Heating Companies, and Households to Understand, Finance, and Implement Projects

Russia. The Russia project trains personnel from the municipal government of Vladimir, local universities, the municipal gas company, and the municipal district-heating company to conduct financial and economic analysis of the feasibility of energy efficiency projects. The experience gained from the training will be disseminated to several other Russian cities.

Bulgaria. Likewise, the Bulgaria project trains municipal employees, local architects and engineers, and industry and institutional managers to design, implement and evaluate energy efficiency projects. The Bulgaria project also builds a network of Energy and Environment Offices (EEOs) in 20 municipalities to share information and experience from energy efficiency programs.

Romania. The Romania project trains a broad spectrum of actors: government agencies, “recipient-side” stakeholders of energy efficiency technologies, and personnel from the private and NGO sectors. In particular, the project builds the capacity of the Agency for Energy Conservation, a central government agency with regional offices, to identify and develop energy efficiency projects and present them to potential financiers. Assistance to this agency includes training and improved access to information (printed and electronic) and fostering of links with financial institutions and other entities interested in energy efficiency. On the recipient side, small, medium and large enterprises, municipal and government authorities and utility companies participate in thematic training/awareness events about energy efficiency.

Create New Regulatory Frameworks that Provide Incentives for Improving Energy Efficiency and Conserving Energy Among Households and Heat Suppliers

Russia. The Russia project develops a prototype system of metered heat consumption in residential buildings, including an entirely new set of institutions for heat meter reading and billing using heat meters installed (under a separate project) in buildings. In addition, the project targets housing policies that presently do not allow tenant associations to be formed to make investment decisions about the buildings in which they reside but do not usually own. The project also studies the unresolved regulatory, institutional, and technical questions surrounding installation of autonomous, decentralized heat production units at the building level, which would mean customers disconnecting from centralized heating networks.

Bulgaria. Similarly in Bulgaria, although there is already some metered heat consumption in the city of Gabrovo, the project introduces a comprehensive system of metering and billing to pave the way for eventual privatization of district-heating companies. The project recommends a new legal framework to support energy efficiency investments; the city of Gabrovo, based on experience from the project, will write a report on "Model Policies and Legislation for Municipalities Seeking Energy Efficiency Investments." The report will outline legislative and regulatory measures, taxation and fee structures, and utility infrastructure requirements needed for energy efficiency investments, and will be disseminated to other municipalities.

Disseminate Information on the Characteristics, Costs, and Benefits of Energy-Efficiency Technologies to Households and Heat Suppliers. All three projects disseminate information to a variety of stakeholders. In Russia, information gaps are disincentives to the private sector to invest in autonomous heat production; the project will install demonstrations of autonomous boilers and disseminate information on their feasibility. In addition, the project conducts a public information campaign to increase households' awareness of consumption-based heat metering, and a handbook is being published outlining the city of Vladimir's experience in implementing consumption-based heat billing. Information from Bulgaria's technology demonstration subprojects is disseminated to a variety of potential investors and financiers. In Romania, workshops, public awareness campaigns and other participatory actions are conducted for the public, NGOs, and the private sector.

Demonstrate Equipment Performance and Commercial Viability. The Russia project installs demonstration autonomous heating boilers in two or three selected buildings to demonstrate installation costs, metering issues, operation and maintenance, and safety and security. The Lithuania project installs a demonstration geothermal plant that provides 150 GWh of heat annually to a municipal district heating network, the first geothermal heating plant in the region. Although the calculated economic rate of return of the protype is relatively low by commercial standards, subsequent plants may cost less once local engineering and other technical skills are developed under the project. The Slovenia project disseminates information from demonstration biomass district-heating/cogeneration installations being done by other agencies and constructs additional demonstration installations as well.

Table B8: District-Heating Energy Efficiency and Biomass/Geothermal Heat-Production Projects

Project	Objective	Intended Results
Lithuania Klaipeda Geothermal Demonstration (1995) World Bank $6.9 m. GEF $18 m. total	Demonstrate the feasibility and value of using low temperature geothermal water as a renewable indigenous energy source in district heating systems at the regional and national levels.	1. Construct a demonstration geothermal plant that produces 150 GWh/yr of heat for a municipal district-heating system. 2. Provide technical assistance for the design of the geothermal loop between the plant and the district heating system. 3. Train plant managers and operations staff in the operation of a plant.
Romania Capacity Building for GHG Reduction Through Energy Efficiency Improvements (1995) UNDP $2.3 m. GEF $5 m. total	Remove technological, institutional and financial barriers to sustainable energy efficiency investments in Romania.	1. Train municipal authorities, state agencies, and small/medium enterprises to analyze, prioritize, develop, and appraise "bankable" energy efficiency projects. 2. Train private sector companies and NGOs to understand and invest in energy efficiency improvements, through workshops and public awareness campaigns. 3. Consult with local banks and other potential financiers, explore possibilities for co-financing energy efficiency projects, and establish a new financing schemes for energy efficiency projects. 4. Develop a legal, regulatory, and institutional framework and/or financing mechanism to ensure sustainable energy efficiency investments.
Russia Capacity-Building to Reduce Key Barriers to Energy Efficiency in Russian Residential Buildings and Heat Supply (1996) UNDP $3.0 m. GEF $4.3 m. total	Create incentives and opportunities for energy efficiency improvements and energy conservation in residential buildings and municipal heat supply systems, and demonstrate the feasibility of using autonomous heating boilers in residential apartment buildings.	1. Create a prototype regulatory and institutional model for consumption-based heat and hot-water metering and billing. 2. Conduct a study of the technical, economic, and institutional feasibility of investments in autonomous heat supplies in residential and public buildings. 3. Install autonomous heating boilers in two or three selected buildings to demonstrate installation costs, metering issues, operation and maintenance, and safety and security. 4. Increase the skills and capabilities of the city of Vladimir to conduct project financial and economic analyses and to undertake project feasibility studies for public and private financing sources.
Bulgaria Energy Efficiency Strategies to Mitigate GHG Emissions (1996) UNDP $2.6 m. GEF $8.6 m. total	Build national capacity to implement energy efficiency and conservation programs in Bulgaria and demonstrate the viability of renovating district-heating systems to make them more energy efficient.	1. Establish a network of municipal governments to disseminate information on energy efficiency. 2. Create an Energy and Environment Office in 20 municipal governments to develop and implement energy efficiency programs. 3. Train and educate municipal government personnel to design and implement energy efficiency programs, including specific training in energy auditing and energy management. 4. Conduct a feasibility study on renovation of the city of Gabrovo's district heating system and introduce a consumption-based heat metering and billing system.

Project	Objective	Intended Results
Slovenia Removing Barriers to the Increased Use of Biomass as an Energy Source (1999) $4.4 m. GEF $12.3 m. total	Promote the market for biomass technologies for district heating and cogeneration in Slovenia.	1. Prepare and disseminate experience and information on biomass demonstration projects being conducted by other agencies in Slovenia; conduct hearings, seminars, and study tours. 2. Prepare guidelines for training local communities, industry, and consultants to evaluate and prepare “bankable” biomass projects. 3. Train local professional groups to install, maintain, and operate biomass district heating and other biomass energy installations. 4. Formulate a cross-sector national biomass energy program / action plan; develop a model for long-term biomass supply agreements. 5. Prepare, finance, and implement three to five biomass district heating and/or cogeneration projects.

B.9. Fuel Switching and Production/Recovery

Eighteen fuel switching and production/recovery projects demonstrate technologies for switching from combustion of existing high-carbon fuels (primarily coal) to low-carbon fuels (such as gas), as well as producing methane fuels from coal beds or municipal and agricultural wastes that would otherwise contribute to greenhouse gases (Table B9).

Because most of these projects, strictly speaking, fall outside of the three GEF long-term operational programs for energy efficiency or renewable energy, they are designated as *short-term response measures* (STRM).[24] One of three principal criteria for STRM projects is a low carbon abatement cost—less than $10 per ton of carbon emissions directly reduced. Nevertheless, many of the projects in this category also demonstrate technologies and build capacities, which can result in replication and indirect benefits. Projects in this category follow two primary approaches:

Demonstrate Technical, Economic, and Commercial Feasibility of Low-Carbon-Fuel Plants or Fuel Production/Recovery Techniques. Coal-bed methane collection and utilization technologies are demonstrated in China (to coal-mine owners and interested commercial enterprises) and India. Also in India (Biomethanation), public and private companies demonstrate the technical and commercial viability of recovering methane from agricultural, municipal, and industrial wastes. Energy production using methane produced from landfill and/or industrial wastes is also demonstrated in China, Jordan, Latvia and Tanzania. Combined-cycle combined-heat-and power plants and waste heat recovery are demonstrated in the Czech and Slovak Republics. A district-heating combined-cycle power plant fueled by both natural gas and waste straw is demonstrated in Hungary. Conversion of heating boilers from coal to natural gas fuels is demonstrated in Poland.

Develop National Strategies, Plans, and Institutions for Promoting Fuel Switching and/or Production/Recovery Technologies. The China Coal-Bed Methane project establishes a new joint venture, the China Coal-Bed Methane Company, to continue to commercialize coal-bed methane recovery in China and to facilitate future partnerships and investments between Chinese and overseas developers. The China Sichuan Gas project restructures the China National Petroleum Corporation and the Sichuan Petroleum Administration into joint-stock companies with commercial accounting systems and establishes an independent regulatory agency to set, monitor, and enforce safety standards on gas production in Sichuan. The Poland project establishes a program within the Polish Bank for Environmental Protection to finance the conversion of a number of small- and medium-sized boilers from coal fuel to natural gas cogeneration. The India Biomethanation project establishes a National Bioenergy Board to coordinate research and operational activities in biomethanation, to raise national awareness of the benefits of recovering and using biogas, and to oversee the implementation of a national bioenergy strategy. The China Methane Recovery project develops a national action plan for landfill gas recovery.

Table B9: Fuel Switching and Production/Recovery Projects

Project	Objective	Intended Results
China Development of Coal-Bed Methane Resources (1991) UNDP $10 m. GEF $10 m. total	Demonstrate technologies and techniques to reduce atmospheric methane emissions and to cost-effectively recover methane for use as an energy source.	1. Install demonstration methane recovery technologies at three sites and specifically demonstrate vertical well-drilling techniques and an integrated recovery system using in-seam horizontal drain holes. 2. Create a database and financial/economic assessments of coal-bed methane resources in five Chinese coal-mining administrations. 3. Conduct study trips abroad for policy-makers to learn about the technologies and sponsor an international conference to increase understanding among coal mine engineers and policy makers. 4. Train technicians from coal geology companies, research institutes, and coal-mining administrations in vertical-well drilling techniques.
Poland Coal-to-Gas (1991) World Bank $25 m. GEF $48 m. total	Demonstrate the cost-effective substitution of gas for coal and technological innovation to improve energy efficiency throughout the heat supply chain.	1. Construct two coal-to-gas conversion projects to utilizing both condensing-boiler and gas-turbine cogeneration technologies. 2. Establish a program to select and finance additional boiler conversion projects through the Bank for Environmental Protection. 3. Train staff of Polish Bank for Environmental Protection in project engineering, appraisal, and supervision. 4. Assist boiler owners in identifying, proposing and implementing boiler conversion projects. 5. Install energy efficiency equipment in 670-800 residential homes.
China Sichuan Gas Transmission and Distribution Rehabilitation (1992) World Bank $10 m. GEF $123m. total	Optimize the safety, operational efficiency, and environmental management of Sichuan's gas production and the T&D system.	1. Restructure the China National Petroleum Corporation and the Sichuan Petroleum Administration (SPA) into joint-stock companies and introduce commercial accounting systems. 2. Drill a 100-well field in Sichuan to expand gas production. 3. Rehabilitate and upgrade 90 gas wells and the gas T&D system in Sichuan to reduce methane losses. 4. Train SPA personnel to more effectively manage, operate, and maintain the T&D system. 5. Establish an independent Office of the Regulator to set, monitor, and enforce safety standards on gas production in Sichuan.
Russian Federation Greenhouse Gas Reduction (1992) World Bank $3.7 m. GEF $131 m. total	Identify and appraise projects to decrease GHG emissions through increased efficiency in natural gas production, transmission, distribution and utilization.	1. Identify and evaluate sources of GHG emissions in the production and processing of natural gas, the transmission system, and the distribution network. 2. Propose methods for GHG emissions reduction and estimate future emissions levels at selected sites. Evaluate and prioritize a series of investment subprojects. 3. Conduct energy audits, surveys, and interviews in four cities to identify and estimate actual and future levels of GHG emissions from the industrial, municipal, residential and commercial sectors.

Project	**Objective**	**Intended Results**
Mali Household Energy (1992) World Bank $2.5 m. GEF $11.1 m. total	Promote popular participation in household energy activities, rational use of household energy services, and improved household fuels use.	1. Sell improved kerosene and charcoal stoves that are subsidized by the project (done by private-sector dealers). 2. Mobilize popular participation in the management of natural forests and restructure the fuelwood trade.
Morocco Repowering (1992) World Bank $6 m. GEF $46 m. total	Demonstrate the commercial viability of modern repowering technology using gas turbines	1. Install a 60-MW gas turbine at an existing steam-power-plant. 2. Monitor and evaluate the technical, environmental, and financial performance of the hybrid plant and make this information available to other electric utilities.
Tanzania Electricity, Fuel and Fertilizer from Municipal and Industrial Wastes (1993) UNDP $2.5 m. GEF $4.0 m. total	Establish medium- and large-scale biomass production facilities in Tanzania and other African countries; create education and management base for sustainable development of biogas production facilities.	1. Construct a medium-scale demonstration biogas plant for treatment of organic municipal and industrial wastes in Dar- es-Salaam. 2. Demonstrate using biogas as fuel for automobiles. 3. Build the capacity of local educational, technical, and administrative instititutions in the biogas field to replicate the project.
India Development of High-Rate Bio-Methanation Processes to Reduce GHG (1994) UNDP $5.5 m. GEF $5.5 m. total	Promote biomethanation technologies and the utilization of biogas to abate methane emissions from industrial, municipal and agricultural waste.	1. Develop a national strategy for bioenergy generation from high-rate biomethanation and establish a National Bioenergy Board to coordinate bioenergy development 2. Conduct biomethanation subprojects. 3. Train government and national laboratory personnel in biomethanation technologies through foreign study tours and fellowship opportunities. 4. Disseminate information on biomethanation and biogas utilization through workshops, promotional literature, and media campaigns.
Jordan Reduction of Methane Emissions and Utilization of Municipal Wastes for Energy in Amman (1995) UNDP $2.5 m. GEF $5.4 m. total	Demonstrate the viability of utilizing municipal solid waste (MSW) as an energy source.	1. Conduct a study of the composition and quantities of MSW at the selected site and estimate its atmospheric emissions and environmental impacts. 2. Train plant technicians and engineers about bioenergy technology and how to operate medium- and large-scale biogas plants. 3. Construct a combined landfill gas plant and medium-scale biogas plant for treatment of organic and industrial waste at a selected site. 4. Develop a national strategy and master plan for bioenergy. 5. Develop a plan for collection and transport of organic waste resources to landfill and biogas plant. 6. Collect information on the potential for environmental benefits and financial savings at other landfill sites in Jordan.

Project	**Objective**	**Intended Results**
China Promoting Methane Recovery and Utilization for Mixed Municipal Waste (1996) UNDP $5.3 m. GEF $20.6 m. total	Demonstrate the capture and burning of landfill methane to generate electricity or for direct use as a fuel in the industrial, commercial, and domestic sectors.	1. Study the MSW composition, disposal practices, and the results of field trials of landfill gas technology at three pilot sites. 2. Conduct workshops to identify financiers and end-users and to help define the institutional arrangements for the use and sale of energy products from landfill gas at the three pilot sites. 3. Conduct subprojects demonstrating landfill gas collection and recovery technologies at the three pilot sites. 4. Develop a national action plan for the promotion and widespread adoption of landfill gas recovery and utilization technologies. 5. Establish a research, training and information center to educate, train and assist landfill operators, energy service companies, and municipalities to build and operate landfill energy plants and to conduct research to improve methane recovery technology.
Senegal Sustainable and Participatory Energy Management (1996) World Bank $4.7 m. GEF $19.9 m. total	Inter-fuel substitution options component: Promote substitution of kerosene and liquid petroleum gas for charcoal and disseminate efficient charcoal stoves.	1. Set up a charcoal reserve stock to stabilize the flow of charcoal to the principal urban centers and to reduce the risk of artificial supply shortages. 2. Reorganize and modernize the urban charcoal trade to establish long-term contract supply agreements between rural communities and selected urban traders; provide technical assistance and limited support for the diversification of existing urban charcoal traders. 3. Provide support for the continuation of inter-fuel substitution options (kerosene and LPG) and dissemination of improved stoves by the private sector and NGOs.
Latvia Solid Waste Management and Landfill Gas Recovery (1997) World Bank $5.1 m. GEF $25 m. total	Demonstrate financially self-sustaining, modern management of municipal solid waste and methane recovery and develop landfill gas as an energy source.	1. Remediate an existing waste disposal site to prevent leachate from reaching groundwater aquifers and contaminating the water supply. 2. Establish a sorting line at the landfill to separate out recyclable and toxic materials. 3. Construct a plant to collect landfill gas and generate electricity from the gas.
Czech Republic Kyjov Waste Heat Utilization (1997) World Bank $5.1 m. GEF $5.1 m. total	Demonstrate the commercial and technological viability of gas-fired combined-cycle cogeneration and the benefits of combining the production of industrial process heat with district heating.	1. Reconstruct an existing glass manufacturing plant with a combined-cycle turbine and harness waste heat for the local district heating system. 2. Create a regulatory pricing framework, based on avoided-cost principles, for district-heating company purchases of heat from local industries. 3. Establish a joint venture company as an implementation model for future projects.

Project	Objective	Intended Results
India Coal-Bed Methane Recovery and Commercial Utilization (1997) UNDP $9.1 m. GEF $19 m. total	Demonstrate the economic viability of harnessing coal-bed methane in the Indian coal mining sector.	1. Train personnel in the Central Mine Planning and Design Institute to identify, design, and implement programs to recover and utilize coal-bed methane. 2. Conduct four subprojects to demonstrate coal-bed methane recovery techniques using vertical surface wells drilled in advance of mining and horizontal drainage boreholes. 4. Recover methane from demonstration drilling to fuel the mine's gas-fueled vehicles, to supply a pipeline, and to bottle for sale. 5. Establish a clearinghouse for the dissemination of information and the coordination of meetings and seminars for potential foreign business partners on coal-bed methane recovery and uses.
Hungary Renewable Energy and Regional Development (1997) World Bank $5.8 m. GEF $60 m. total	Demonstrate the technical feasibility of large-scale utilization of waste-straw for district-heat production and combined-cycle electric power production.	1. Construct a 18-MWt straw-fired boiler, a 25-MWe gas turbine and a 7-MWe steam turbine to generate electricity and to provide hot-water to the district heating system. 2. Create a new market for regional farmers to supply waste straw to the power plant.
Slovak Republic Chemosvit Cogeneration Project (1999) World Bank $2.2 m. GEF $18.4 m. total	Demonstrate gas-fired combined cycle CHP technology; stimulate technological and institutional changes which would promote energy efficiency through developing combined-cycle heat and power CHP systems.	1. Construct a 14-MW CHP plant, pipelines, heat exchangers, steam reduction technology, and an energy management system for the plant. 2. Develop a replicable and cost-effective monitoring protocol for assessing the performance of the project.
Ukraine Coal-Bed Methane Recovery (1998) World Bank $6.2 m. GEF $17.4 m. total	Promote the commercial extraction of coal-bed methane and increase productivity and safety of coal mines.	1. Demonstrate methane recovery technology. 2. Create a commercial coal-bed methane recovery company.
Poland Geothermal and Environment Project (1999) World Bank $5.4 m. GEF $84.7 m. total	Exploit geothermal resources for district heating systems.	1. Drill geothermal wells and construct a 60- to 70-MW capacity baseload geothermal district-heating plant, supplementary gas-fired peaking capacity, and a new district-heating network.

Annex C: Emerging Impacts of Completed or Continuing Projects[25]

C.1 Solar Home Systems

The Zimbabwe Photovoltaics for Household and Community Use project was the only GEF solar home system project that was fully completed by early 1999 (see Annex B.1 for a complete list of all solar home systems projects). Four other projects, the Sri Lanka Energy Services Delivery project and three subprojects in Vietnam, Bangladesh and the Dominican Republic under the Small and Medium Scale Enterprise Program, are in the early stages of implementation and have reported preliminary results.

In Sri Lanka, more than 1000 solar home systems had been installed by 1999 by two commercial firms and one NGO. The commercial firms were focusing on cash sales while the NGO, a large and established national institution, was selling systems financed under its existing microcredit program (on-lending GEF project financing through the microcredit program). Two larger companies, one multinational and one domestic, were considering entering the solar home system business in Sri Lanka as part of the project, which would help meet the project's target of 30,000 installed systems by 2002. Preliminary implementation experience suggests that dealer-supplied credit may be problematic; smaller dealers, although able to manage the risks associated the marketing and technical aspects of product delivery and service, do not want to assume the risks of being credit suppliers as well. Thus the Sri Lanka project has begun to consider further promotion of microfinance mechanisms through established microfinance organizations.

Under the Small and Medium Scale Enterprise (SME) Program, a private company supported by the SME program in the Dominican Republic had sold or rented approximately 3,500 systems by 1999. Grameen Shakti in Bangladesh has successfully started providing credit to consumers and has sold more than 1000 solar home systems. And a private company has initially sold about 100 systems for cash in Vietnam.

In the India Alternate Energy project, there have been problems with extending credit to potential rural PV consumers. Evidence suggests that financial institutions perceive rural consumers as unwilling to repay loans and therefore these institutions have not extended credit. Also, the lack of infrastructure for after-sales support and service has emerged as an additional difficulty in rural markets. Most of the project's PV sales have been to commercial customers. Nevertheless, domestic production capacity for solar modules went from 3 MWp in 1991 to 8 MWp by 1996, and the number of companies involved in the PV industry went from 16 in 1991 to more than 70 in 1998 (although it is difficult to attribute these industry changes to the GEF project). Promotional efforts and numerous business meetings organized under the project have increased awareness of various PV applications among potential users.

The Zimbabwe project was designed to enhance and upgrade indigenous solar manufacturing and delivery infrastructure, to develop an expanded commercial market in rural areas for affordable domestic solar electric lighting by providing low-interest financing through existing institutions, and to establish new credit mechanisms at the grassroots level to benefit lower income groups in rural areas (both households and community-based institutions). Over the five-year project period, the project expected a direct impact of about 9,000 PV systems installed on low-interest financing terms provided by the project. The project also originally expected an indirect impact of up to another 9,000 systems sold without credit or subsidies during the five-year project period, as a result of market development fostered by the project. The project has had a number of impacts on the market for PV systems in Zimbabwe:

Number of producers and dealers in the market. Prior to the project there was one PV module and systems manufacturer, and three smaller firms performing installation and system integration. At the completion of the project, 60 firms were registered with the Solar Energy Industries Association although only 30 have since renewed and only six accounted for 80% of the market share for the project. No new module assembly companies have emerged as a direct result of the project because of a lack of funds for plants and machinery. Some project observers have worried about industry shake-outs after the project that may leave the industry in a weakened or chaotic state; certainly many firms are similarly worried about the future market and whether they will survive.

Changes in market prices. Import duties of 40% on imported components were waived during the project, which resulted in substantial cost reductions for installed PV systems. There was speculation that these duties will be put back in place now that the project is completed, which would have significant bearing on future market prices. The number of producers and dealers remaining in the market (see above) will also affect future market prices.

Technical knowledge. Technicians from five installer companies were trained during the project. Two colleges and one polytechnic institute will begin to provide courses on PV technology initially in the form of adult education courses. The University of Zimbabwe began to offer a M.Sc degree in Renewable Energy Systems in 1996. The project management unit and the Solar Industries Association have produced a solar magazine.

Standards enacted and in use. The Standards Association of Zimbabwe and the Solar Energy Industries Association created PV module standards that are being used to certify and warranty installed systems. Standards were still being drafted for batteries, lamps, and charge controllers.

Certification procedures and institutions exist and active. Certification procedures were instituted for suppliers during the project, but it is not clear whether these procedures were institutionalized after project completion. The project management unit enforced component and installation standards during the project, assisted by its own small testing laboratory. A code of conduct for the Solar Energy Industries Association has been included in the organization's constitution.

Operating financing mechanisms. The Agricultural Finance Corporation successfully provided low-interest credit to 4,200 PV consumers through a revolving fund mechanism. No data are available on the repayment rates and turnover for the revolving fund, and thus what additional resources will be required to sustain it. "It is obvious now that the prevailing interest rate of 15% is sub-economic and as such the fund will certainly deplete to zero if no corrective action is taken," the project's terminal evaluation reported. During the project an additional credit facility was established to help suppliers with cash flow and to enable suppliers to procure imported components (from the PMU) before they were paid for the systems. This credit was available based upon PMU certification of suppliers.

Perceptions of commercial credit viability. Prior to the project, ZIMBANK was making loans for solar PV but then stopped. The project demonstrated that loans for solar PV systems are viable under the terms given (Z$8,000 to Z$9,000 principal, 15% nominal interest rate that is actually a negative real interest rate, and three- to five-year term).

Degree and quality of information available and known by consumers. "There is now much greater awareness by government, NGOs, and the public about home PV systems than before the project," according to one evaluation report.

Presence and function of market intermediaries. During the project, the project management unit played a critical role in reducing barriers. Its "market intermediation" functions included provding long-term credit for purchasers, certification of suppliers, commercial credit for certified suppliers to assist with cash flow, technical standards for components and systems, and bulk procurement and import of components.

It is not clear how these functions will be sustained and to what degree they will still be necessary now that the project is completed. A Solar Industries Association was established prior to the project and continues to function.

Number of systems installed. As a *direct* market impact, 10,000 systems had been installed by 1997, 300 of which were provided by non-governmental organizations and the rest of which were provided by private sector dealers. An estimated 3,000 PV systems had been installed prior to the project, mostly in rural and semi-urban centers like health clinics, schools, community centers, and commercial farms, so the project has great increased the installed base. A market baseline, estimated before the project started, projected sales of 320 home systems per year, which would equal roughly 1,600 systems over the five-year project.

Sources of Data for Annex C.1: internal GEF documents; internal UNDP documents, interviews with project participants; Nagendran 1999; Martinot 1998a; Martinot et al. 2000a and 2000b.

C.2 Grid-Connected Wind and Biomass Power

Six projects for grid-connected wind, biomass, and geothermal power have been completed or are nearing completion: Costa Rica Wind Power, Mauritius Bioenergy, Philippines Geothermal, Mauritania Wind Electric, India Hilly Hydel, and India Alternate Energy (see Annex B.2 for project details).

India. The India Alternate Energy project was started in 1991 to promote commercialization of wind power and solar PV technologies in India. The project was designed to support existing government policies to promote wind power through special tax incentives. The project also was designed to pioneer financing and market delivery mechanisms based on private-sector intermediaries and incentive schemes and policies suitable for small independent power producers. Markets for these technologies were catalyzed through large-scale demonstration, increased consumer confidence, and enhanced willingness to pay. The project channeled financing through the India Renewable Energy Development Agency (IREDA) and strengthened IREDA's capabilities to promote and finance private-sector investments.

By 1998, more than 270 megawatts of wind power had been financed by IREDA and commissioned, including 41 megawatts commissioned with GEF and IDA financing and 10 megawatts commissioned with Danish funds. In parallel with these direct project impacts, a total of 968 megawatts (MW) of wind farms were installed and operating in India, of which 917 MW were commercial and privately operated. Highly favorable investment tax policies strongly influenced these commercial installations.[26] New suppliers entered the wind power market; before the project there were three major companies involved in the wind industry, but by 1998 as many as 26 companies were engaged in the wind turbine manufacturing industry, many with foreign partners. High-technology wind turbine designs up to 600-kW with variable speed operation were being produced by 14 companies. Domestic production of blades began and exports of blades and synchronous generators to Europe was under way. Wind turbine exports to other countries had also begun. The installed costs of wind turbines in India declined.

The GEF project indirectly helped catalyze these market changes by helping to raise awareness among investors and banking institutions of the viability of wind power technology and by helping to lobby for lower import tariffs for wind systems. Many financial institutions decided to offer financing for wind farms, and a wind-power loan portfolio among commercial banking institutions emerged (this was a key project goal). The number of Indian consultants capable of developing wind power investment projects increased dramatically, in part because of GEF-supported training and networking activities for consultants, technicians, and private firms (a roster of consultants was available from IREDA for reference by investors).

Also in India, the Hilly Hydel project has identified 20 sites to demonstrate the benefits of small hydro installations and increase awareness of the cost-effectiveness of hydro-electricity. Capacity-building activities so far have trained more than 50 officials abroad in small hydro power planning, design, construction, management, and maintenance. A local educational establishment now offers a postgraduate program on alternate hydro energy. Ten states have issued guidelines for engaging the private sector in the commercial installation of small hydro. Local ownership and management models are being tested at three of the demonstration sites.

Mauritius. The objectives of the Mauritius Sugar Bio-Energy project were to expand electricity generation from bagasse, to promote the efficient use of biomass fuels from the sugar industry for energy production, and to strengthen the management and coordination of the Bagasse Energy Development Program. To achieve these objectives, the project sought to build a baseload power plant that would provide continuous power to the utility, using bagasse during the crop season and coal in the off season. The plant was to be the first in a series of regional plants, and its output was to depend in part on investments in efficiency improvements of regional satellite sugar mills (financed under the project) to provide surplus bagasse for power generation. The project also included components for technical assistance and technology demonstrations to promote private/public sector cooperation in power plant ventures and evaluate ways to decrease the transport costs for bagasse and optimize the use of sugar cane for power generation.

One of the major intended project outputs, a bagasse power plant, was not constructed and the utility had to invest in an additional diesel-fueled plant to make up for the power supply shortfall. Instead, however, $6 million was dispersed under the project for efficiency investments in sugar mills to provide surplus bagasse for power generation. These investments had not been projected to occur in the baseline.

The project appears to have indirectly catalyzed dramatic changes in electricity generation in Mauritius. Electricity generation from bagasse increased from 70 GWh/yr in 1992 to 118 GWh/yr by 1996. Several sugar mills have completed or embarked upon bagasse power plant investments on their own, independent of the GEF project, including the original mill that had been targeted for the bagasse power plant under the project. The European Investment Bank has agreed to finance a bagasse/coal-fired power plant. There was no baseline projection of what bagasse power plant development would have been in the absence of the project; thus, it is unknown how strongly linked these developments are to the project. A project completion report states that "extensive dialogue between the public and private sector on design work, the least-cost power development plan, and power purchasing agreements have directly or indirectly led to the development of other power plants."

The same project-completion evaluation report states that there has been "demonstration value" from the project and that the project led to establishment of a framework for independent-power-producer (IPP) development and an administrative focal point for private/public sector partnership in IPP development. The evaluation also states that "the project's major accomplishment was progress in helping to establish an institutional and regulatory framework for private power generation in Mauritius and the provision of technical studies and trials to support technologies for improved bagasse production and improved environmental monitoring."

Costa Rica. A significant private-sector wind-power industry has emerged from new dialogue and policy frameworks engendered by the GEF project even though the project has not yet installed wind turbines (the installation component of the project has been delayed). So far, a 20-megawatt wind farm has been installed by the private sector and began operating in 1997. This installation could be considered an indirect project impact. In addition, other countries in Central America are taking note of Costa Rica's experience. Technical questions still remain, as about one-third of the wind turbines in the 20-megawatt wind farm have been damaged by lightning and other climate conditions.

Sources of Data for Annex C.2: internal GEF documents; interviews with India project participants; internal World Bank documents; Martinot 1998a.

C.3 Energy Efficient Lighting

The GEF has funded four energy efficiency projects with lighting components (see Annex B.5 for project details): Mexico High Efficiency Lighting project, Poland Efficient Lighting project, Jamaica Demand Side Management Demonstration project, and Thailand Promotion of Electricity Efficiency project. These projects primarily promote compact fluorescent lamps (CFLs) for residential use, but the Thailand project has had significant impacts on the Thai market for ordinary fluorescent tube lamps as well. Impacts have occurred in all four projects. The Poland and Mexico projects have been fully completed, after successfully selling to households the targeted number of CFLs (3 million total for both countries) during project implementation.

In the Thailand utility DSM project, lamp distribution through a chain of "7-11" convenience stores, coupled with price reductions solely through bulk purchases by the electric utility (no direct price subsidies) appears to be working well. This approach has made CFLs more accessible to a larger base of consumers. With bulk purchases but no subsidies, the retail prices of CFLs (estimated at $9) are about 40% lower than normal retail prices. In 1996-97, the program sold 230,000 CFLs, but recent economic difficulties in Thailand will undoubtedly increase the first-cost barrier among a larger group of consumers and reduce program delivery.

The Mexico and Jamaica utility DSM projects also lowered retail CFL prices. In Mexico, consumers received a very favorable retail price estimated at about $5 to $8 (compared with a market price of up to $25 or more) as a result of a utility subsidy (estimated at about $7 to $10 per lamp) and economies from bulk purchases by the utility. The Mexican utility sold 1.7 million CFLs with no difficulty. In Jamaica, an estimated subsidy of $6 per lamp, combined with bulk purchases by the utility, led to an estimated retail price of around $6 per lamp (price data are sketchy, however).

The Poland subsidy program was unique in the way subsidies were channeled through the private-sector. The intention was to use manufacturers' knowledge of the marketplace to maximize CFL sales per dollar of available subsidy. In this case, a large retail price reduction (about $6) was possible with a smaller program subsidy (about $2) because of manufacturer subsidy contributions and the multiplier effects of VAT tax and retail markups. During 1995-1997, in two separate promotions, consumers bought 1.2 million CFLs through the project (half within the first month of each promotion); more than 40 different models were represented. This program was easy to manage, was considered cost-efficient, and allowed use of available distribution channels. Five manufacturers participated in the subsidy program although two manufacturers dominated it.[27] Both of these manufacturers were seriously pursuing the Polish market before the project began.

In Jamaica, a CFL sales program by the utility began slowly with mail solicitation only, but participation greatly accelerated once a direct-contact strategy, in which applicants could interact with a customer service office staff, was tried. Half of the consumers paid for the energy efficiency measures with credit provided by the utility, suggesting the high-first-cost barrier is significant.

Another successful approach was a voluntary agreement by manufacturers to produce more efficient lighting products in the Thailand program. Such an agreement was instrumental in transforming the entire Thai market for T-12 lamps into a market where only the more efficient T-8 lamps are sold. This market is estimated at 45 million lamps per year. Under the voluntary agreement, all manufacturers and importers of T-12 lamps agreed to produce or import T-8 lamps exclusively. In return, the Thai electric utility (EGAT) engaged in an extensive public education and information campaign during 1993-95. EGAT also conducted testing to ensure uniform performance of the new T-8 lamps. By 1995, all lamp manufacturers and importers had complied with the agreement, and almost all T-12 lamps had been eliminated from the market. Success was aided by a zero net cost to manufacturers (reduced T-8 production costs paid for the production conversion), and T-8 retail prices similar to those for the T-12 lamps. Success was also attributed to cultural factors; the utility stated that the public considered such voluntary agreements more desirable and fairer than price incentives like rebates or subsidies.

The educational and marketing effectiveness of these programs is more difficult to assess, and evaluations are generally limited to anecdotes. For example, in Poland survey results indicated that a majority of consumers felt that special labeling for environmentally friendly products was of "great or decisive importance" in their decision making (NECEL 1997). The school education program was commended by the Polish Ministry of National Education, which wrote a letter to the project management in June 1997 saying "it is apparent that as a result of the project large numbers of students and teachers have gained a useful insight into the use of energy and its impact on the environment." In the view of project management, the public education component was most successful with print media and educational efforts involving NGOs and local governments.

The Poland case provides the best data so far on the potential market transformation effects from a CFL program because of extensive pre-project and post-project market research that has been carried out in conjunction with the project. For example, retail prices of CFLs are lower by approximately 30% in real terms after the project. A global manufacturer of CFLs and foreign companies from Germany, China, and Japan have all entered the Polish market. The project led to a large change in consumer awareness about CFLs and the number of households with CFLs increased from 11.5% to 19.6% of all households. The percentage of retailers stocking CFLs climbed from 70.5% to 74.6% of retail lighting stores. A sustainable market is also aided by word-of-mouth from those with positive experiences; in one survey, 97% of consumers said they were "satisfied" or "very satisfied" with the CFLs, while in another, 43% said CFLs performed better than expected—and only 3% said they performed worse (NECEL 1997; EEI 1997). One set of obstacles to market transformation in a situation like Poland's is that high inflation, electricity tariff increases, and quarterly or semiannual utility billing can obscure the bill savings from CFLs because utility bills keep changing. This tends to diminish the verification of savings by the public over the longer term.

In the case of a utility-implemented program like in Mexico, continued replication of the program depends upon continued utility implementation and financing. When program participants were asked in a survey if they would buy CFLs in the future at market prices, however, only 30% answered no. Market transformation effects are difficult to assess in the Mexico case because of the lack of established baselines and surveys of non-participants. The CFLs installed under the program are likely to have a demonstration effect, but this may be insufficient to catalyze a broader market. Although there are no data available on the current private-sector CFL market and distribution networks in Mexico, the utility-distribution mechanism may tend to have a dampening effect on market development at the retail level. It appears that wealthy consumers are leaders in technology adoption, because of their ability to pay, knowledge, and/or higher electricity rates. Surveys of program participants have shown that 50% already knew about CFLs before the program, both through seeing them in supermarkets and hearing about them through friends. Between 9% and 19% of participants had already purchased CFLs before participating in the program. No survey data are available of non-participants to see how overall public awareness has changed.

Like Mexico, the Thailand CFL program is being implemented by a utility, but distribution is occurring through a convenience-store distribution network. The Thailand program is thus creating new private-sector distribution networks that can presumably lead to lasting market transformation once the utility program is finished. The Thailand program also differs from the Mexico program in that subsidies are not provided, so the functions of bulk purchasing and marketing could more readily be taken over by private-sector entities once the utility program is completed.

Besides the indirect market impacts of the programs discussed above, there are also follow-up activities initiated by these programs. Of course the sustainability of utility rebate programs depends upon continued utility financing, and such financing appears likely in several cases. In Mexico, the utility has gained extensive experience in implementing CFL projects and considers the project successful. With the revenue from the sales of CFLs already purchased under the program and with additional contributions, the utility was reportedly planning to purchase an additional 900,000 lamps, which would bring the project total to 2.5 million. It is also planning a nationwide CFL project to sell consumers four million CFLs by the year 2000 using the Ilumex model. In Poland, there are plans for a new program to push purchases of hard-wired luminaires by housing cooperatives, and a new "Green Lights" program is beginning with demonstration lighting replacements in a few schools.

Sources of Data for Annex C.3: internal GEF documents; internal World Bank documents; Sathaye et al. 1994; Friedmann et al. 1995; Granda 1997; NECEL 1997; EEI 1997; Harris 1997; Ratanopas 1997; Martinot and Borg 1998.

C.4 Fuel Switching and Production/Recovery

The GEF has approved 15 projects to demonstrate the commercial and technical viability of fuel-switching from coal to gas and of fuel production/recovery (see Annex B9 for project details). Although only one of these projects is formally completed, another three are substantially implemented and show documented impacts from implementation.

The China Coal-Bed Methane project is the first fuel production/recovery project to be completed. This project aimed to: (1) demonstrate technologies that reduce methane emissions and recover gas for use as a fuel; (2) assess the methane resources of coal mines and the potential for using methane gas as a domestic energy source; and (3) increase the awareness of top policy-makers of the benefits of coal-bed methane recovery and use. The project successfully demonstrated at three sites a number of techniques and technologies that Chinese coal mines can employ to reduce atmospheric methane emissions and recover methane as a fuel, and held training workshops at these sites to this end. The project published a detailed assessment of China's coal-bed methane resources and strengthened national capacity to conduct such assessments routinely. More than 500 people were trained, from senior government policy makers to senior managers and engineers of coal mining companies. Training was accomplished through study tours, domestic workshops, and overseas programs. The joint-venture China United Coal-Bed Methane Development Corporation was created and has been actively seeking new business opportunities to exploit coal-bed methane. Several additional exploration and development agreements with foreign partners have been negotiated. Policies and regulations for the coal-bed methane industry were in the process of being enacted.

The China Sichuan Gas project is designed to increase gas production and improve the efficiency, safety, and reliability of the Sichuan's Petroleum Administration (SPA) natural gas pipeline network by upgrading the network's environmental standards and by detecting and repairing leaks. By 1998, gas conservation under the project had led to an overall improvement in gas recovery from a range of 60-70% to a range of 70-80% and had increased gas reserves by 70 billion cubic meters (bcm). Total production of gas during the period 1995-1997 (22.1 bcm) was 5.9 bcm higher as a result of the project, and annual production of 7.5 bcm/year in 1997 was approaching the project's target of 8 bcm/year by 2000.

The India Biomethanation project aims to develop a National Master Plan for the generation and utilization of bioenergy and to create commercially viable and replicable packages of biomethanation technology. By 1998, 29 subprojects were approved for demonstrating a variety of possible biomethanation substrates including sewage, abattoir waste, and paper mill effluent. The project impacts so far are increased awareness and knowledge. Representatives from various technical institutes and government agencies have participated in overseas study tours to visit biomethanation plants, manufacturers, and experts in the field of waste-to-energy. A quarterly newsletter on bioenergy is being published. The project has also prepared a directory of entities and individuals working in the field of waste-to-energy and was sponsoring a number of conferences and workshops to share experiences with biomethanation.

The Poland Coal-to-Gas project promotes the conversion of small- and medium-sized boilers from coal to natural gas fuels and promotes energy-efficient practices in the architectural design and operation of new residential buildings. By 1998, 28 boiler conversion subprojects were under construction and eight residential energy efficiency subprojects were under way. Throughout its history, the project has raised awareness of the potential for coal-to-gas conversions in Poland. In particular, many of Poland's environmental investment funds, like the Bank for Environmental Protection, have begun to fund coal-to-gas conversions since the project began in 1991. In fact, a large coal-to-gas industry has emerged in Poland with many boiler conversions taking place using Polish government and private financing. Although these conversions are not directly connected to the GEF project, the GEF project has helped contribute to a greater awareness and priority within the government to address boiler conversions nationwide. The project has generated information, publicity, and promotion that has influenced the thinking of boiler owners and financiers. In addition, the EU Phare program has noted the GEF project in Poland and has begun to develop similar project concepts for coal-to-gas conversions in one or two other target countries in transition (i.e., Baltic States, Slovenia, Romania, or Bulgaria).

Sources of Data for Annex C.4: internal GEF documents; interviews with Poland project participants.

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Endnotes

[1] Many GEF documents, including project proposals and policy documents considered by the GEF Council, are available in electronic form at http://www.gefweb.org.

[2] The term "cost-effective" expresses the condition that the economic rate of return of an energy efficiency investment is greater than the prevailing cost of capital (see for example World Bank 1993).

[3] The classification of categories is oriented towards the technologies employed and the types of interventions necessary in specific institutional contexts. Some of these categories overlap with one another; for example, electricity consumption and fuel consumption in industry might be treated as one set of opportunities from a sectoral rather than technical viewpoint; electricity consumption in buildings and space-heat consumption in buildings might be treated as one set of opportunities or overlap if electric heating is used; and electricity consumption in industry and in buildings might overlap with electricity production, transmission, and distribution in the context of integrated resource planning and demand-side management frameworks and strategies.

[4] The UNFCCC is an international treaty that seeks to stabilize atmospheric greenhouse gas concentrations at levels that would prevent dangerous anthropogenic interference with global climate (UN 1992).

[5] During the pilot phase and continuing to the present, a set of *enabling activities* has also assisted countries to develop national communications under the climate change convention.

[6] These three operational programs are numbered 5, 6, and 7, respectively, in GEF operational work. Additional climate-change-related operational programs for transport and integrated ecosystem management (numbered 11 and 12 respectively) have recently been adopted but are not covered in this report. The other operational programs (1 to 4 and 8 to 10) relate to biodiversity and international waters.

[7] Project approaches and mechanisms described in this report are based on written project documentation, such as project proposals, GEF project documents, internal unpublished reports, published literature, and information supplied by implementing agencies in annual project implementation reviews. Actual or planned activities and results during implementation may differ from the existing documentation due to time lags or the inability of the authors to conduct detailed discussions with project executing agencies on individual projects. It is expected that subsequent evaluation activities by the GEF will expand and clarify this "knowledge base."

[8] Cluster definitions have not been formally adopted by the GEF; these clusters are the authors' definition.

[9] Annex B contains 84 distinct projects; 72 are classified as long-term projects and 12 are classified as short-term response measures.

[10] For example, a report by the Intergovernmental Panel on Climate Change (IPCC) on technology transfer has benefited from GEF portfolio experience (IPCC 2000).

[11] One prominent example is in China, where more than 700 biogas "service stations" operate as profit-and-loss companies that build digesters, sell materials, provide management and technical consulting, and train technical people (Qiu et al. 1990).

[12] Although many of the renewable energy projects could also be considered "market transformation" approaches, particularly those for consumer equipment like solar home systems and solar hot-water heating systems, the term "market transformation" is generally reserved in the literature for energy efficiency. Nevertheless, the same principles apply equally to both energy efficiency and renewable energy.

[13] "On-lending" means that a financier borrows from the World Bank (usually through the national government) and then approves sub-loans to individual borrowers using that financing. The financier bears the sub-loan risk, not the World Bank, although partial guarantees may also exist through the government.

[14] These figures include $21 million in GEF financing and $51 million in leveraged financing for the GEF/IFC Small and Medium Scale Enterprise Program, only a portion of which is applied to climate change subprojects.

[15] Besides references in project documents, data on NGO involvement is sometimes difficult to obtain, so the actual number is likely to be higher than 25 projects. See also UNDP (1997).

[16] An additional six climate change short-term response measures, out of 20 total approved, were completed by mid-1999.

[17] The project impact evaluations presented in this report do not reflect official views of the GEF, its implementing agencies, or the countries concerned, but are the authors' interpretations based on available information. Many aspects of project impact evaluations can be controversial, because different stakeholders may have contradictory views as to what has happened or what is important.

[18] For example, the IFC has recently completed a post-project evaluation of the Poland Efficient Lighting project, which is not incorporated into this paper; and the World Bank should shortly prepare a project completion report for the India Alternate Energy/Renewable Resources Development project. The first thematic review conducted by the GEF (Martinot et al. 2000b) was to be published in the summer of 2000, with additional thematic reviews underway in 2000-2001.

[19] For a discussion of measuring avoided greenhouse gas emissions from GEF projects, see World Bank 1994 and 1998; Vine and Sathaye 1997; and Kaufman 2000.

[20] See also Herman et al. 1997; Lee and Conger 1996; Prahl and Schlegel 1993; Reed and Hall 1997; Rogers 1995; Violette et al. 1995; Henriques 1993.

[21] In China, an ambitious program to replace coal- and wood-burning stoves with more efficient models resulted in more than 150 million households obtaining new stoves between 1985 and 1993 (Smith et al. 1993).

[22] Each project is listed in Tables B.1 to B.9 with the year of GEF Council approval of the GEF grant component of the project. Implementing agency approval dates and actual implementation start dates are generally several months to a year or more later than these dates. Project financing amounts given in Tables B.1 to B.9 are indicative and subject to revision. Project objectives and results given in Tables B.1 to B.9 may be based upon early project documentation and thus may not fully reflect current project designs or decisions made during implementation.

[23] The project documentation does not provide a specific figure for expected CFL sales. Approximately $10 million of GEF grants are expected to provide no more than $3.15 in subsidies per CFL sold.

[24] Six projects in the fuel switching and production/recovery project category were approved under the energy efficiency and renewable energy operational programs (Morocco under OP5; India Biomethanation, Jordan, Mali, Tanzania and China Coal-Bed Methane under OP6). Out of 20 climate change short-term response measures, 12 are shown in Table B9; the eight others not included are for research, carbon sequestration, and biomass resource management (six global projects, one in Benin and one in Sudan) and are beyond the scope of this paper.

[25] Project experience and impacts are very dynamic. The information in Annex C reflects basic project information as of mid-1999. Ongoing monitoring and evaluation efforts by the GEF, associated agencies, and independent evaluators will continue to supplement, update, and revise the information discussed in this report.

[26] Investment tax credits have been a powerful stimulus to market development, but some observers have questioned whether the wind farms, markets and joint ventures would remain sustainable if the credits were removed.

[27] At every step of the project, an open and competitive process was used and the GEF executing agency (IFC) went to considerable lengths to avoid any conflicts of interest in administering the program.