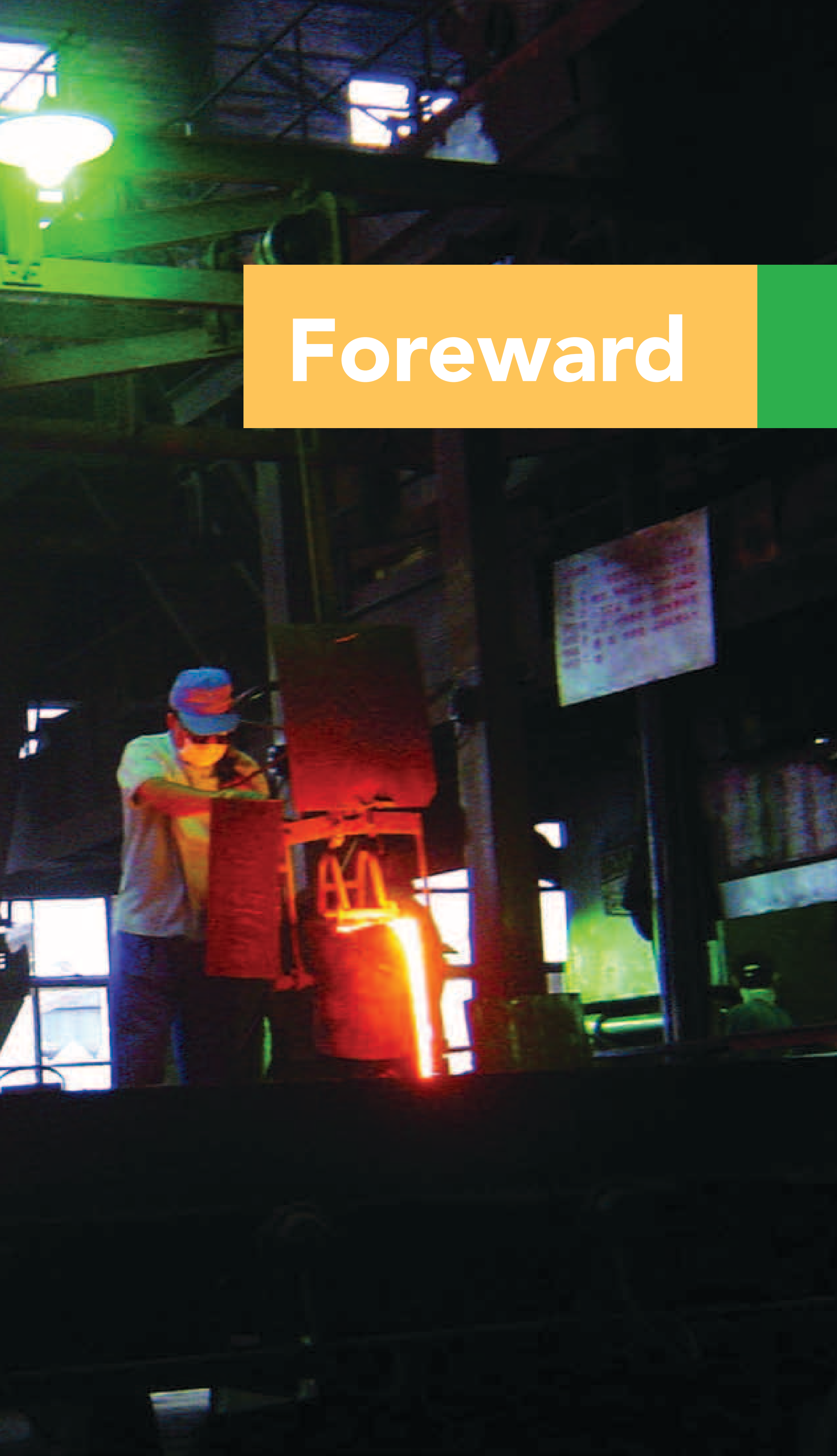
GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES:

CASE STUDIES FROM GEF CLIMATE CHANGE PORTFOLIO



Foreward

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Since its inception in 1991, the Global Environment Facility (GEF) has been facilitating technology transfer to help developing countries address the global climate change challenge. The GEF has evolved into the largest public-sector funding source for the transfer of environmentally sound technologies (ESTs), and has supported technology transfer activities in almost 100 developing countries. Our current project portfolio, upon completion, is expected to eliminate more than 2.7 billion tonnes of CO_2 emissions. Along the way, a wealth of knowledge on technology transfer has been generated, which merit being harnessed and shared with a wide audience.

With this background, we are stepping up our dissemination initiative to build a better articulated and more in-depth understanding of the technology transfer process and the role of the GEF. The dissemination initiative enables us to share our experiences on the ESTs that have already been successfully demonstrated with GEF support to a wider range of countries and stakeholders—with a view to facilitating further adoption of these technologies.

This publication is part of a series of products and activities for dissemination, developed under the *Poznan Strategic Program on Technology Transfer*. The Poznan Program was established in 2008 under the guidance of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) to scale up the level of investments in technology transfer in order to help developing countries address their needs for ESTs, and to enhance technology transfer activities under the Convention.

We are excited to share case studies of some of the key technologies and mechanisms that the GEF has supported to date, encompassing the areas of renewable energy, energy efficiency, sustainable transport, and innovative financing. The case studies on fuel cell buses, concentrating solar power (CSP), and wind energy are some of the seminal examples of the GEF support spurring innovation in developing countries. The brick making example highlights how energy efficiency could be improved drastically in an industry that is ubiquitous in so many developing countries, and be up-scaled through South-South technology transfer. The innovative financing example showcases the merits of financial instruments in promoting investments for technology transfer.

We hope that the following pages will help readers gain a better understanding of our efforts in transferring ESTs, and will inspire further EST adoption around the globe.

Biomass is biological material, including wood, crops, as well as wastes such as agricultural and forest residues, that can be used to generate electricity or produce heat.

Evolution of GEF Policies and Approach to Technology Transfer

Introduction

Technology transfer plays an increasingly critical role in the global response to the challenges of climate change. The transfer of environmentally sound technologies (ESTs) is embodied in the very fabric of the United Nations Framework Convention on Climate Change (UNFCCC).[1]

Since the First Session of the UNFCCC Conference of Parties (COP), the Global Environment Facility (GEF) has served as an operating entity of the financial mechanism of the Convention. It has responded to guidance by the COP on policies and program priorities, many addressing the financing of ESTs. To improve its effectiveness and scope in response to changing needs, COP guidance, and funding levels, the GEF has regularly examined and modified its strategic approach to critical technology transfer activities.

GEF Pilot Phase (1991–1994) to GEF-1 (1994–1998)

During the GEF's pilot phase from 1991 to 1994, funded projects primarily aimed to demonstrate diverse technologies that would be useful in stabilizing the concentrations of greenhouse gases (GHGs) in the atmosphere. After the restructuring of GEF in 1994, the GEF Council approved a broad operational strategy and a specific climate change strategy to support "sustainable measures that minimize climate change damage by reducing the risk, or the adverse effects, of climate change." The strategy also stated that the "GEF will finance agreed [upon] and eligible enabling mitigation and adaptation activities in eligible recipient countries" (GEF 1995).

Further, the operational strategy identified three long-term operational programs to support climate change mitigation and another program for cost-effective short-term response measures Short-Term Response Measures (STRMs).[2] The long-term programs facilitated technology transfer through support for less cost-effective interventions and by distinguishing among technologies on the basis of their maturity and commercial availability. All of the programmatic long-term approaches and short-term projects promoted mitigation through the use of commercialized or nearly commercialized technologies that were not yet widely disseminated in developing countries or in countries with economies in transition.

GEF-2 (1998–2002) to GEF-3 (2002–2007)

Subsequent GEF operational programs addressed technology transfer through a focus on energy efficiency and renewable energy technologies that were mature, available in international markets, and profitable, yet faced human, institutional, technological, policy, or financial barriers to dissemination. These projects were termed "barrier removal" projects, as they sought to remove such barriers to accelerate adoption of new technologies and practices.

Another operational program focused on reducing the long-term costs of low GHGs emitting electricity generating technologies. The technologies included in this program (e.g., concentrating solar power (CSP) plants, biomass-integrated combined-cycle generation, stationary fuel cells, and microturbines) were not yet commercially available at the time and were very expensive relative to the baseline or conventional alternatives. In these cases, significant incremental costs remained—the technology costs themselves formed the barrier to greater dissemination and transfer.

BOX 1: TECHNOLOGY TRANSFER DEFINITION

While there are many definitions of technology transfer, the GEF has adopted the concept of technology transfer as defined by the Intergovernmental Panel on Climate Change (IPCC) and embodied in the UNFCCC technology transfer framework. Technology transfer is defined as:

> … a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organization (NGOs) and research/education institutions…
>
> …the broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It covers technology transfer processes between developed countries, developing countries and countries with economies in transition, amongst developed countries, amongst developing countries, and amongst countries with economies in transition. It comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies.

This definition includes a wide range of activities and extends to a broad array of institutions. The COP established the Expert Group on Technology Transfer (EGTT) under the Subsidiary Body for Scientific and Technological Advice (SBSTA), which defined the following five-part framework for meaningful and effective actions to enhance the implementation of technology transfer: technology needs and needs assessments; technology information; enabling environment; capacity building; and mechanisms for technology transfer.

[1] Article 4.5 of the Convention states: "The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention.

[2] Short-term projects are considered extremely cost-effective, with a unit abatement cost of less than $10/tonne of carbon avoided, or roughly $2.7/tonne of CO_2 equivalent avoided.

A sustainable transport program approved by the GEF Council in 2000 contained a combination of approaches, including one focusing on cost-effective yet underutilized technologies and practices, and another on technologies that were not yet fully developed.

In 2004, with the benefit of several years of implementation and monitoring experience, the GEF's operational strategy for removing barriers to renewable energy and energy efficiency technologies was judged successful—but in need of codification. Accordingly, five key potential barriers to more efficient, market-driven dissemination of technologies in developing countries were identified as follows:

- **Policy frameworks:** Governments must play an essential role in setting policies favorable to the adoption of ESTs;
- **Technology:** Options should be robust and operational. The more mature a technology, the easier it is to transfer;
- **Awareness and information:** National stakeholders, especially market participants, must be aware of the technology and have information on its costs, uses, and markets;
- **Business and delivery models:** Market-based approaches are preferred; businesses and institutions must be in place that can deliver to and service those markets; and
- **Availability of financing:** Financing must be available for technology dissemination, though it is insufficient in itself to ensure uptake of ESTs.

GEF-4 (2007–2010) and Poznan Strategic Program on Technology Transfer

As part of the GEF-4 replenishment process, the climate change strategy for mitigation was revised to focus primarily on six strategic objectives, each with important technology transfer elements:

1. Energy efficiency in buildings and appliances
2. Industrial energy efficiency
3. Market-based approaches for renewable energy
4. Sustainable energy production from biomass
5. Sustainable innovative systems for urban transport
6. Management of land use, Land Use, Land-Use Change, and Forestry (LULUCF) as a means to protect carbon stocks and reduce GHG emissions.

Photovoltaic panel installation in Bozcaada Island, Turkey as part of the *Poznan Strategic Program on Technology Transfer* pilot project, implemented by the United Nations Industrial Development Organization (UNIDO).

GEF experiences leading up to GEF-4 had generated the following observations about technology transfer to inform subsequent programming:

- Technology is transferred primarily through markets, and barriers to the efficient operation of those markets must be removed systematically;
- Technology transfer is not a single event or activity but a long-term engagement, during which partnerships and cooperation, often requiring time to develop and mature, are mandatory for the successful development, transfer, and dissemination of technologies; and
- Technology transfer requires a comprehensive approach, incorporating capacity building at all relevant levels.

These observations provided important insights for the *Poznan Strategic Program on Technology Transfer,* which was developed in response to the 13th COP to the UNFCCC (Decision 4/CP.13), which requested the GEF to elaborate a strategic program for scaling up investment in technology transfer to help developing countries address their needs for ESTs. The 14th COP welcomed the GEF's program in its Decision 2/CP.14. The Poznan Strategic Program on Technology Transfer established the following three windows within the GEF in support of technology transfer:

1. Conduct Technology Needs Assessments (TNAs)
2. Pilot priority technology projects linked to TNAs
3. Disseminate GEF experience and successfully demonstrated ESTs

During GEF-4, the Poznan Strategic Program was provided $50 million, including $35 million from the GEF Trust Fund, and $15 million from the GEF Special Climate Change Fund (SCCF).

GEF-5 (2010–2014)

Under GEF-5, funding pledge for the climate change mitigation program has expanded to approximately $1.4 billion, and the climate change strategy increases the priority of technology transfer in all elements of the portfolio.

Development of the climate change focal area strategy for GEF-5 drew on past experience and was guided by three principles: (1) responsiveness to Convention guidance; (2) consideration of national circumstances of recipient countries; and (3) cost-effectiveness in achieving global environmental benefits. GEF-5 endeavors to make a transformative impact in helping GEF-recipient countries move to a low-carbon development path through market transformation of and investment in environmentally sound, climate-friendly technologies.

The climate change portfolio in GEF-5 will continue to support the technology transfer framework outlined by the COP through the six key objectives:

Objective 1:
Promote the demonstration, deployment, and transfer of innovative, low-carbon technologies

Objective 2:
Promote market transformation for energy efficiency in the industrial and buildings sectors

Objective 3:
Promote investment in renewable energy technologies

Objective 4:
Promote energy-efficient, low-carbon transport and urban systems

Objective 5:
Promote conservation and enhancement of carbon stocks through sustainable management of land use, Land-Use Change, and Forestry

Objective 6:
Support enabling activities and capacity building

The first objective focuses on innovative technologies at the stage of market demonstration or commercialization where technology push is still critical. The second to fifth objectives focus on technologies that are commercially available in the country but face barriers and require market pull to achieve widespread adoption and diffusion. The last objective supports enabling activities and capacity building under the UNFCCC that can be critical to successful technology transfer.

In summary, it is clear that GEF climate change investments have promoted technology transfer at all stages of the technology development cycle, from demonstration of innovative, emerging low-carbon technologies to diffusion of commercially proven, ESTs and practices. GEF-5 investments will continue this comprehensive approach.

Featured EST Case Studies

GEF technology transfer investments have generated not only significant emissions reductions, but a body of knowledge and lessons learned that are informing today's technology transfer activities. This publication features some of the key EST supported by the GEF to date, encompassing the areas of renewable energy, energy efficiency, sustainable transport, and innovative financing. The case studies include the following:

1. Concentrating Solar Power (CSP)
2. Energy efficient kilns for brick making
3. Wind power
4. Fuel Cell Bus (FCB)
5. Innovative financing for energy efficiency

The case studies provide background information, project description, technology description, as well as results and outcomes. The common features of successful EST transfer projects are identified to inform future projects in the last section of the publication.

CFE's (Comison Federal de Electricidad) La Venta II Wind Farm in Oaxaca, Mexico.

Parabolic troughs consist of a reflector that follows the sun along a single axis and concentrates light onto a tube filled with a working fluid, which is chosen for its thermal management properties. The fluid is heated to 150–400°C and flows to a heat exchanger where it is used to make steam and drive a power generation cycle.

Concentrating Solar Power in Egypt

Introduction

CSP technologies use technologies use renewable solar resources to generate electricity. In locations with plentiful sunshine, generally clear skies, and access to high voltage transmission lines, CSP, with their capacity for heat storage, can provide reliable electricity that can be dispatched when needed.

These technologies are proven and commercially available in advanced economies such as the United States and Spain. GEF CSP projects have played an important role in demonstrating the viability of CSP technologies in developing countries and supporting better understanding of costs, benefits, and risks—key elements for successful technology transfer.

In 1996, the GEF's Scientific and Technical Advisory Panel (STAP) recommended CSP projects due to the technology's readiness, potential for continuing cost reductions, and possibilities for large-scale and cost effective baseload power applications in countries with high levels of solar radiation and growing demand for electricity. Since then, the GEF has supported CSP projects in four countries:

- Integrated Solar Combined Cycle System Project in Al Kuraymat, Egypt, with the World Bank
- Hybrid Solar Power Plant in Agua Prieta, Mexico, with the World Bank
- Integrated Solar Combined Cycle System Project in Ain Beni Matar, Morocco, with the World Bank
- Concentrating Solar Power for Electricity Generation in Namibia, with the United Nations Development Programme (UNDP).

The GEF investment in these projects totals about $144 million and they involve approximately $314 million in cofinancing. These projects were an important component of the GEF's portfolio of renewable energy projects and when completed will deliver substantial carbon free electric capacity in the host countries.

The technology transfer aspects of the GEF's CSP projects have each followed a deliberative path as developers, suppliers, power companies, lenders, and government agencies have learned about the costs, benefits, and risks of CSP technology. The projects also addressed key technology, market, and policy barriers to greater CSP use. The projects are supporting hybrid or integrated systems approaches which combine solar technologies with conventional fossil fuel power generation, although the technology for the Namibia CSP project has not yet been selected.

Technology Description

CSP plants produce electricity by using the sun's energy to heat a working fluid to make steam that then drive engines or turbines for electric power generation. CSP currently uses four different types of solar technologies for making heat: parabolic troughs (as at Al Kuraymat), Stirling engine dishes, linear Fresnel reflectors, and power towers. Each of these approaches can produce high temperature thermal energy.

Parabolic troughs consist of a reflector that follows the sun along a single axis and concentrates light onto a tube filled with a working fluid, which is chosen for its thermal management properties. The fluid is heated to 150–400°C and flows to a heat exchanger where it is used to make steam and drive a power generation cycle.

The integrated solar combined cycle—blending CSP with conventional power generation technologies—is one of the most cost effective CSP designs and is conducive to technology transfer. This approach offers the ability to dispatch power even when the sun is not available and without need of thermal storage, thus enabling operation as baseload power generation.

Integrated solar combined cycle power plants using parabolic troughs have reached commercial readiness and can produce electricity at costs of $0.20/KW-hour or less, depending on the size and location of the project, and the availability of financial incentives.

According to the United States National Renewable Energy Laboratory (NREL), there are 48 CSP power plant projects worldwide at various stages of construction that use parabolic trough technologies.[3] Most of these involve Steam Rankine Cycle systems; only a few involve integrated solar combined cycle systems, which have not been demonstrated to the same extent as other CSP plants (World Bank 2006). This lack of experience poses risks for potential users in selecting among design options for both the solar and fossil energy contributions, and for the role of thermal storage in the operation, cost, and overall energy efficiency of the projects. There are also questions about business models for project development and the relative merits of having a "turnkey" supplier for the whole project versus separate suppliers for the solar and fossil energy systems, subsystems, and components.

[3] A list of these projects can be found at http://www.nrel.gov/csp/solarpaces/parabolic_trough.cfm.

Project Description

Initial planning and feasibility studies for the application of CSP in Egypt began more than 10 years ago and led to the eventual selection of the Al Kuraymat site for the following reasons:

- Proximity to a major load center (about 90 km south of Cairo)
- High level of solar radiation and a flat terrain
- Nearby availability of water and natural gas
- Access to the electric transmission system at 550, 200, and 66 kilovolts.

The Al Kuraymat project is being carried out by the New and Renewable Energy Authority (NREA) in Egypt and includes cofinancing from the Japan Bank for International Cooperation.

The project includes two parts: a combined cycle island (natural gas turbines) and a solar island. Contractors were competitively selected through a request for proposal. The contract for the combined cycle island went to Iberdrola Ingeniería y Construcción; the solar island contract went to ORASCOM Construction Industries. Construction began in 2008 and the plant is expected to be commissioned in 2010. The project has an overall capacity of about 126 MW, with a solar contribution of about 20 MW. In this project the solar energy partially substitutes for fossil fuels, and thus reduces GHG emissions.[4]

The solar island at Al Kuraymat consists of a parabolic trough solar field with a total area of about 130,800m2 that is expected to deliver thermal energy at a temperature of about 390°c.

The solar island at Al Kuraymat consists of a parabolic trough solar field with a total area of about 130,800m^2 that is expected to deliver thermal energy at a temperature of about 390^{o}c. The combined cycle island consists of a 74 MW gas turbine, a 59 MW electric heat recovery steam generator, and a solar heat exchanger. The Al Kuraymat project does not use thermal storage and has separate suppliers for the solar and fossil portions of the project.

The objectives of the project are to:

- Demonstrate the cost effective generation of at least 20 MW of concentrating solar power generation from the integrated solar combined cycle plant and realize associated reductions in GHG emissions;
- Demonstrate the successful integration of a concentrating solar power plant in the Egyptian electric grid and the delivery of the power to Egyptian load centers;
- Demonstrate successful project management and engineering process for replication in other locations in Egypt and elsewhere; and
- Develop CSP expertise and position Egypt as a solar energy developer for technology transfer projects internationally (GEF 2009c).

Results and Outcomes

The expected benefits of the Al Kuraymat project over a conventional natural gas combined cycle system include increased renewable electricity production of about 80-85 GW-hours per year and reduced carbon emissions of about 149,975 tonnes over the life of the project (GEF 2009c).

The technology transfer challenge for integrated solar combined cycle systems depends on a variety of factors, including suitable locations with access to water and natural gas, favorable government policies, proper project finance, and cost effective access to electric transmission for delivering the power to market. The Al Kuraymat project developer, NREA, has indicated long term plans for the deployment of integrated solar combined cycle systems elsewhere in Egypt and in other countries and regions. Those plans call for developing about 750 MW of CSP capacity by 2020 in locations worldwide based on experiences from Al Kuraymat.[5] However, for these plans to be realized, new locations need to be identified, and projects need to be designed, sited, and financed properly and supported locally with appropriate policies, regulations, and incentives. Access to the electric grid and the availability of long term power purchase agreements will be important ingredients for projects successfully moving forward.

The Al Kuraymat project is providing valuable information on costs, risks, technical performance, and the necessary ingredients for successful business cases for integrated solar combined cycle systems. This information is essential for government agencies, suppliers, developers, financiers, and power companies to implement new projects, assuming appropriate locations and grid access can be found. The Al Kuraymat project is confirming several key hypotheses about integrated solar combined cycle technologies for successful technology transfer:

[4] See http://www.menarec.org/resources/Kuraymat-E-+Nov.2007-CU.pdf
[5] For further information, see http://www.menarec.org/resources/Kuraymat-E-+Nov.2007-CU.pdf

- That they are relatively mature and that no further breakthroughs in science and engineering are needed for cost reductions to continue;

- That they can provide power even when the sun is unavailable and thus do not require energy storage, or special grid integration strategies, both of which can add cost and complexity to a project;

- That they can be operated as baseload power plants in large arrays for bulk power markets or in smaller units for distributed energy applications; and

- There are many potential sites in developing countries and regions around the world that provide favorable conditions such as high levels of solar radiation, relatively flat terrain, and access to water and natural gas supplies.

In pursuing technology transfer opportunities several key lessons should be addressed to ensure best practices are replicated properly. For example:

- It is important for the project's business model to be clear from the outset to avoid delay. Specifically, if the projects are not government-led and involve primarily private financing, then national and local government participation and support must be included from the outset of the projects.

- The competitive bidding process for design and construction contractors should be designed to ensure that there will be quality offers from reputable firms and also allow for flexible exit strategies should milestones not be met.

- It is very helpful for projects to be located in countries with supportive national policies such as purchase requirements for renewable power generation, renewable portfolio standards, investment tax and production credits, or other forms of incentives to enhance financial attractiveness of the project.

- It is important to involve local or national power companies to lower the technical risk, boost financial attractiveness, ensure grid access and integration and for there to be a long term power purchase agreement in place.

Going forward, the GEF will continue to be interested in supporting cost effective projects that build on the lessons learned from Al Kuraymat and the other CSP projects. GEF assistance will be particularly important in those countries that are experiencing growth in electricity demand and are interested in adding new power supply technologies that have lower GHG emissions than conventional fossil energy plants.

Brick making is a common sight in rural areas in Asia as the raw materials are readily available and the demand for building materials continues to grow. After mixing with water, the clay is shaped into bricks, dried and fired.

Energy Efficient Kilns— Brick Making in Bangladesh

Introduction

The GEF has become one of the world's largest public sector funders of energy efficiency, having invested $1.1 billion in approximately 200 projects in 90 countries. These investments have attracted an additional $7.1 billion in cofinancing. The GEF has focused its investments on projects that tackle technology, policy, and market barriers, including more favorable policies and regulations such as appliance labeling and standards, market conditioning such as financial instruments, and technology transfer such as demonstration of appliances and equipment. Table 1 summarizes the history of GEF investments in energy efficiency and a project portfolio that has increased steadily over each GEF replenishment phase. Energy efficiency projects are expected to be a significant part of the GEF-5 replenishment phase (2010–2014).

TABLE 1 LEVEL OF GEF FINANCING IN ENERGY EFFICIENCY

Phase	Number of Projects	GEF Financing ($million)	Cofinancing ($million)
GEF Pilot (1991–1994)	11	67.6	347.4
GEF 1 (1994–1998)	19	164.4	626.1
GEF 2 (1998–2002)	35	207.1	1,407.0
GEF 3 (2002–2006)	37	273.1	1,509.2
GEF 4 (2006–2010)	101	473.4	3,201.8
Total	203	1,185.8	7,091.5

The GEF's investments in energy efficiency projects include both urban and rural areas. As a result, the GEF has been able to address urbanization pressures by investing in local projects which provide both energy savings and incomes for rural populations. One important target for rural energy efficiency improvements is brick making. The economies of many developing countries have growing building construction sectors so the demand for bricks and other building materials is on the rise. Traditional brick making industries have trouble keeping pace with the demand. For example, some of the key technical performance issues for rural brick makers include:

- Product quality. Improving thermal and moisture properties so that products can satisfy building codes and standards that are being improved worldwide for energy efficiency, fire, flood, and earthquake protection; and

- Energy and costs. Traditional brick making consumes at least 3 to 5 times more energy than advanced industrial brick making—improving energy efficiency is critical to cost-competitiveness.

To address these needs, the GEF has spearheaded a global effort to improve the energy efficiency of kilns for brick making and has invested in projects in China, India, Vietnam, and Bangladesh. These projects have been mutually supportive—sharing lessons learned on technologies, capacity building, and commercialization strategies. The project in Bangladesh is the most recent example of this successful "South-South" effort in technology transfer.

Project Description

The period of performance of the GEF project in Bangladesh is 2009–2014. The GEF is investing $3 million and is leveraging $11.1 million in cofinancing. In partnership with UNDP, the project aims to remove barriers to the widespread adoption of energy efficient kilns and energy efficient practices by the brick making industry, lower consumption of fossil and biomass fuels in Bangladesh, and reduce GHG emissions and local air pollution. The project will use the results of the pilot phase, during which a demonstration energy efficient kiln will be installed, and apply these to implement another 15 demonstrations over a 5-year period.

The project is supporting an integrated set of components: (1) re-confirmation of all technology options; (2) establishing demonstration projects; (3) technical and managerial capacity development; (4) communications and awareness; (5) financing support; (6) policy and institutional support; and (7) project management support.

The project aims to transform the brick kiln industry by demonstrating the superior performance of the more energy-efficient Hybrid Hoffman Kiln (HHK) technology—the same technology demonstrated in China by a GEF-supported project. Removal of barriers and successful adoption of the HHK technology will lead to a decline in the emissions of not only GHGs but also other pollutants and at the same time markedly improve the profitability of the small and medium enterprises (SMEs) that comprise Bangladesh's brick making industry.

In 2005, a team from the Bangladesh University of Engineering and Technology (BUET) and the Bangladesh Brick Manufacturers and Owners Association visited with the Research and Design Institute of Wall and Roof Materials in Xian, China. The purpose of the trip was to evaluate Chinese brick making technologies and make site visits to operating brick fields. This mission determined that Chinese techniques and HHK designs could be adapted and deployed in Bangladesh. Bricks brought back from China were tested at BUET and were found to be of superior quality than those produced in Bangladesh from higher quality clay.

With GEF support. Liucun Hollow Brick Plant in Shaanxi Province, China, as shown here and in the next page, constructed this energy-efficient brick kiln. This technology has been diffused to many villages in Shaanxi, and is being adopted by brick plants in Bangladesh."

Technology Description

Total brick production in Bangladesh is estimated to be over 12 billion bricks annually with an estimated sales value of around $450 million, almost 1% of Bangladesh's gross domestic product. In the last decade, demand has risen steadily and annual growth rates have ranged from 8.1% to 8.9%. Brick making is the largest stationary source of local air pollution and GHG emissions because brick kilns inefficiently burn large quantities of coal and biomass. According to a BUET study, the brick making industry is the largest consumer of coal in the country, using about 2.2 million tons every year, along with about 1.2 million tons of biomass. Carbon emissions are estimated to be about 3 million tonnes annually. Brick Making in Bangladesh is locally described as a seasonal industry with old technologies, low labor productivity, non-existent capitalization, and with informal management.

SMEs dominate brick making in Bangladesh and there are few, if any, cooperative or large-scale operations. Most brickfields are on leased land and have no permanent facilities. This, along with the seasonal nature of production, contributes to the itinerant nature of the industry. The average brickfield employs about 120 skilled and unskilled workers. Apart from six to ten permanent employees, most are employed for only six months during the production season.

The basic ingredient of bricks is clay. After mixing with water, the clay is shaped into bricks, dried, and fired. The firing fuses the clay particles to form a ceramic bond. Depending on the type of clay, bonding happens at temperatures between 900 and 1,200°C. The bond gives bricks strength and resistance to erosion by water. The temperature at which bricks are fired is critical. If it is too low, the bond is poor, resulting in a weak product. If it is too high, the brick slumps or melts. As fuel is a major cost, using it efficiently is essential.

Bangladeshi researchers and industry representatives visited Chinese brickfields to evaluate Chinese brick making technologies.

Three types of brick making technologies dominate the traditional Bangladeshi brick making industry. Of these, the Fixed Chimney Kiln (FCK) is the most common, followed by the Bull's Trench Kiln (BTK), the Zigzag Kiln and the Gas Hoffman Kiln. A 2006 study by BUET for UNDP found that there were approximately 4,140 licensed kilns in the country with FCKs (actually modified BTKs, as discussed below) holding the largest market share at 76%.

Brick making in Bangladesh is a highly energy intensive and carbon emitting activity. Prior to 2004, about 95% of kilns in Bangladesh were based on the 150 year-old BTK technology. As the name implies, the kiln is essentially a trench in the ground with a crude structure built over it that serves as an enclosure in which the bricks are fired. Heat loss to the surrounding air through the kiln walls is excessive and the uncontrolled burning of coal in the kiln creates a high level of local emissions. In 2004, following a government order to raise smokestacks to approximately 36.6 meters, BTKs were modified to accommodate taller chimneys and underground piping necessary to divert the flue gas to the fixed chimney. This required extending the width of the base. The taller chimney creates a stronger draft, which improves combustion to some extent and enables flue gas to be released at a higher elevation, dispersing the pollution over a wider area. This "new" kiln was the FCK, which is essentially a BTK with a fixed chimney superimposed on it and slightly improved energy efficiency.

The HHK involves a permanent structure and is a hybrid version of the less-used Gas Hoffman Kiln (GHK). Structurally, it is built like the GHK except that the fuel used is coal. The inner kiln lining is made from refractory bricks and then plastered over by refractory cement. The firing chamber can be filled manually or automatically with green bricks, usually about five to six thousand bricks at a time, in line stacks of around one thousand each. The firing time for each line stack is about half an hour. The fuel, granulated coal, is fed into the firing zone in the kiln through stoke holes on the roof. Air required for the combustion process is forced from behind. As it reaches the line to be fired, the air is already preheated from the previous firing zone thus reducing firing time and energy usage. The temperature in the firing zone can reach as high as 1,800°c.

In addition to improved kiln efficiency, a technique commonly used in the HHK model in China is to inject coal into the green bricks. This technique enables better thermal bonding and reduces fuel usage, and hence carbon dioxide and other emissions. Clay is premixed with granulated coal and then extruded to produce the green bricks. This is a unique process and is fundamental to the energy efficiency achieved in brick making in China. Almost 80% of the total energy required is injected into the bricks and only about 20% is fed externally into the firing chamber. Over 95% of the fuel mixed into the brick undergoes combustion during firing. This technique, which has not been used in Bangladesh, will be implemented as part of the demonstration project.

Each HHK facility involves a kiln that is approximately 18 meters long, 15 meters wide and 4 meters high, 18 doors, and no chimney. It is built on four to five acres of land, requires 88 workers, and can produce about 15 million bricks annually.

Results and Outcomes

Successful implementation of the 16 demonstration kilns in Bangladesh is expected to result in energy savings of about 15,415 terajoules of energy, which is the equivalent of about 525 kilotons of coal. This reduction in energy use will result in reductions of about 1.32 million tonnes of CO_2 emissions during the 15-year expected service life of the kilns.

The GEF project is expected to strengthen management and technical capacity of SMEs in Bangladesh to manage energy efficient kiln operations, and to provide for a pool of technical support consultants and services companies, as well as technical institutes and local equipment suppliers of affordable technologies. This will be accomplished through enhanced training programs, application of standardized and comprehensive training materials, mobilization of local manufacturing investment to produce higher energy efficiency equipment, and creation of new and stronger industry support groups. Considering that one HHK is roughly equivalent to 7.5 FCKs based on the annual brick production of each kiln type (15 million for HHKs versus 2 million for FCKs), the 16 demonstration HHKs would be the equivalent of 120 FCKs, which represents a 2.1% market share of the forecasted installations of 5,454 FCKs in Bangladesh by year 2014.

The key technology transferred, HHKs, offers a number of measurable benefits. Each HHK is more energy efficient through better kiln insulation that reduce heat losses, use of waste heat for drying green bricks, and the improved controls of air flows in the kiln. This results in several environmental advantages including reductions in smoke, soot, and other forms of air pollution, reduced land degradation by enabling use of river and lower quality clay, lower water use, reduced use of wood and other forms of biomass for fuel, and lower GHG emissions. Reductions in the use of energy and coal also

A brickyard in Bangladesh.

mean reductions in brick production costs. In addition, the improvements in mechanization in the energy efficient kilns also mean higher labor productivity, which enables business operators to afford higher wage levels. Mechanization also improves working conditions and improves worker safety through reductions in amount of manual labor where worker safety is at risk. Other labor benefits include more opportunities for year round employment, which contributes to family stability and improved standards of living. Another important result is the production of stronger and higher quality bricks, including improvements in strength and consistency in shape and size.

These advantages present opportunities for expansion of market share over time as experience is gained with the HHK technology. There are common problems with brick making across South and Southeast Asia for which HHK and other energy efficient kilns offer significant advantages. However, HHKs and other energy efficient models are relatively more expensive to construct and operate than traditional kilns. Like Bangladesh, India, Vietnam, and China, other countries in these regions need to address the energy and environmental problems from inefficient and polluting brick kilns. Continued technology transfer of efficient brick making technologies, such as HHK, is likely with continued lowering of market and non-market barriers, increased awareness of local brick makers, and recognition by local and national governments on the full range of societal benefits.

Oaxaca, Mexico.

Wind Power—Development and Deployment in Mexico

Introduction

Wind turbines are market-ready renewable power plants in many countries, and are among the fastest growing forms of electric generation in the world. In the last 25 years, wind power capacity has grown annually by about 40%, with more than 98% of this capacity located in industrialized countries. One reason for this growth has been steady improvements in technology leading to decreases in wind power costs. However, technical and institutional barriers remain with integrating wind, and its intermittent output, into traditional practices for electric grid system planning and operations. In parts of the world where wind power adoption has been relatively strong, it has been demonstrated that solutions to these barriers can be found, and that grid integration of wind power becomes easier and less costly as the level of experience with this renewable resource increases.

A key focus of the GEF's wind power investments is to help countries understand the planning and operational requirements of wind power, gain experience with installation and grid integration issues, and employ policy options that promote wind energy development. Policy options can include incentives for electric transmission lines to facilitate delivery of electricity from wind facilities, renewable energy portfolio standards, capital subsidies, tax incentives, tradable energy certificates, feed-in tariffs, and grid access guarantees.

The GEF has invested in 40 wind power projects in 38 countries by the end of 2009. After completion, these projects will result in the installation of almost 1 GW of wind power capacity (Figure 1). The GEF has invested $252 million and leveraged $1.9 billion of cofinancing for wind power projects.

Project Description

GEF investments in wind power in Mexico involve a number of projects including the construction of a 103 MW wind farm at La Venta III on the Isthmus of Tehuantepec in Oaxaca. This region possesses some of the best wind energy resources in Mexico. Average annual wind speeds range from 7 meters per second to 10 meters per second, measured 30 meters above the ground. Overall, Mexico is one of the most promising areas for wind energy development in Latin America and possesses an estimated 40 GW in untapped potential. Approximately 10% of this potential comes from the Isthmus of Tehuantepec, where the quality of the renewable resource is expected to result in capacity factors of at least 40% for wind power facilities. Such factors are 10 to 20% higher than typical values from other facilities.

Despite the significant potential for wind power development, progress has been slow in Mexico by global standards. This is due both to lack of adequate financial incentives for private development and investment, as well as issues with the existing policies and regulations affecting wind power. The GEF wind projects in Mexico have been successful in stimulating development and showing consistent progress starting with policies for capacity building and creation of a more favorable climate for development, continuing with innovative initiatives for local manufacturing of wind turbines, systems, and components, and resulting in the construction of wind power facilities. This progress provides lessons learned about best practices that can be replicated elsewhere in Mexico and other countries in the developing world.

GEF efforts began in 2004 to 2009 when Mexico's Electrical Research Institute and UNDP applied $4.7 million in GEF funds and $7.1 million cofinancing to accelerate the depreciation of investments in renewable energy; assess wind resources; initiate proposals on more favorable legal, regulatory, and institutional frameworks; and establish a green development fund. These initiatives were the result of the country's "Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power in Mexico."

Also launched following the Action Plan was the Regional Wind Technology Centre (Centro Regional de Tecnología Eólica) which was created to support wind turbine manufacturers, train local technicians, and facilitate cooperation between wind turbine manufacturers and other Mexican industries. The reduction of barriers and creation of incentives from the Action Plan led to the construction of the La Venta II wind project which became operational in 2007 with an installed capacity of 83.5 MW.

Also in 2007, a second GEF wind power project got underway. The World Bank used $24.4 million in GEF funding and leveraged $247.5 million from the Government of Mexico to support a tariff structure for a major new wind installation, La Venta III. Construction on La Venta III began in 2009 and will have an installed capacity of about 103 MW when completed. This project will generate local expertise in commercially-based, grid-connected renewable energy applications, enhance experience with independent power production, and build institutional capacity to value, acquire, and manage such resources on a replicable basis.

A third GEF wind power project is getting underway in 2010 to build on previous experiences and provide support for expanded wind power development in Mexico. This technology transfer project will support the production of wind power goods and services at the national level, and build human and technical capabilities for the manufacturing, testing and certification of wind turbines. This project will be implemented by the Inter-American Development Bank (IDB) and includes $5.5 million of GEF financing leveraged with $18.6 million in cofinancing. This project is expected to run until 2014.

FIGURE 1: GEF RENEWABLE ENERGY PROJECTS, INCLUDING WIND ENERGY, AROUND THE WORLD

Technology Description

La Venta III involves the first independent power production contract for wind power in Mexico. To deliver power from La Venta III to market, the Mexican Federal Electricity Commission (CFE) is constructing a 400 kilovolt, 300 kilometer electrical transmission line.

CFE issued a competitive request-for-proposals to supply the wind turbines for the La Venta III project. Iberdrola Renovables was awarded a 20-year power supply contract. La Venta III will use 121 wind turbines manufactured by Gamesa Eólica, each measuring about 44 meters high and 0.85 MW in nameplate capacity. The capacity factors for these turbines are expected to be about 42% on average over the 20-year contract.

The estimated installed costs for wind power projects on the Isthmus of Tehuantepec is estimated to be about $2,000 per KW and the levelized cost of electricity over a 20-year period is estimated to be about $0.065 per KW-hour.

Wind power is market ready for application in other locations in Mexico. The successful performance of the La Venta III project will reduce technical and financial risks for project developers and enable other independent power production projects for wind power to move forward in Mexico and in other countries around the world.

Results and Outcomes

The GEF wind power projects in Mexico have produced concrete results. The projects have followed a logical progression from support for building favorable policies and market environments to construction and operation of major facilities. While getting underway now, the independent power contract for La venta III with Iberdrola Renovables will soon provide 103 MW of wind power capacity, generate up to 370 GW-hours of electricity annually, and result in GHG reductions of about 247,000 tonnes of CO_2 annually, which equates to about five million tonnes CO_2 over the 20-year term length of the contract.

The GEF projects have contributed to building confidence in wind power in Mexico—resulting in other wind project development. For example, a total of five major wind power projects providing about 207 MW of capacity may be commissioned in 2010, including locations in Baja California and Tamaulipas. In addition, another five wind projects totaling about 500 MW are expected to begin construction in 2011. When complete, these projects along with the GEF and non-GEF projects at La Venta will bring Mexico's total wind power capacity to more than one GW. CFE is planning other electric transmission line construction projects to bring the wind power to market. There are other projects planned which could bring Mexico's total wind power capacity to about 2.5 GW by the end of 2012.

If these plans come to fruition, the GEF support will have made a significant contribution in the 25-fold increase in wind power in Mexico over the last 10 years. This level of technology transfer can be replicated in other countries if similar projects can be identified and financed. Key factors for replicating the Mexican success include availability of high quality wind resources, and the commitment of the local or national power company to the construction of high voltage power transmission lines to deliver electricity from where the wind power projects are located to the load centers where the power is needed.

It is expected that continuing experience with wind power systems will reduce barriers to grid integration and that manufacturing scale up will continue to result in reductions in installed costs of wind power plants and in the cost of electricity from those plants, depending on the quality of the wind resources and resulting capacity factors. Coupled with policies favorable to wind under consideration in many countries, wind projects are expected to become more financially attractive to the financial community and continue rapid growth.

A key focus of the GEF's wind power investments is to help countries understand the planning and operational requirements of wind power, gain experience with installation and grid integration issues, and employ policy options that promote wind energy development.

Fuel cell buses provided services in the 2008 Beijing Olympics as part of the GEF technology demonstration project.

Fuel Cell Buses in China

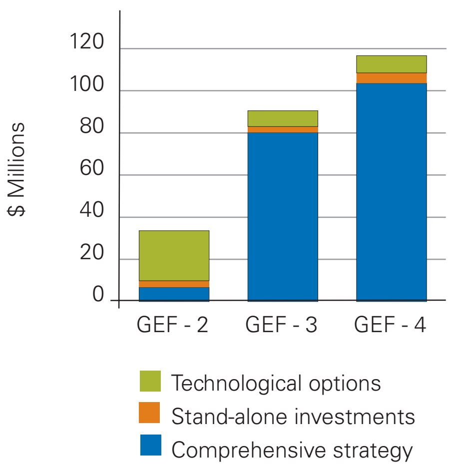
Introduction

Urbanization is an important global trend with significant implications for energy and GHG emissions. According to the IPCC Fourth Assessment Report, about 75% of people in the industrialized world and about 40% of the people in the developing world now live in cities. In addition, the cities themselves are growing larger with at least 19 having more than 10 million people (IPCC 2007).

Urbanization trends typically hit developing countries hardest and exacerbate on-going problems with air pollution, oil consumption and reliance on imports, and GHG emissions. In addition, urbanization will continue to be a primary driver for local investment in mass transportation and other infrastructure projects including roads, bridges, tunnels, garages, and pollution abatement equipment.

The GEF has supported sustainable urban transport projects since 1999, including investments in 45 projects world by the end of GEF-4 in June 2010. These projects received $249 million from the GEF and approximately $2.5 billion in cofinancing. GEF efforts currently reach over 70 cities with a combined population of more than 250 million people. The project portfolio includes both technology development and transportation strategies such as “stand alone” investments in public transportation infrastructures, or comprehensive urban transportation plans (Figure 2). For example, in technology development, the GEF has invested in FCB projects in China and Brazil and hybrid bus and three-wheeler projects in India and Egypt (GEF 2009d).

FIGURE 2: GEF SUSTAINABLE URBAN TRANSPORT INVESTMENTS BY PROJECT TYPE



The GEF's urban transport project portfolio grew from $30 million in GEF-2 to almost $120 million in GEF-4, constituting the world's largest investment in environmentally sound urban transportation. While significant, these funds represent a relatively small down payment on the global investment that is needed for cleaner and more modern and sustainable urban transportation systems. As a result, urban transport is expected to play an important role in the GEF-5 portfolio of climate change projects.

To leverage the GEF investments effectively, technology transfer efforts need to encompass projects that lead to stronger urban transport plans as well as projects that involve new technologies that may not be market-ready but need to be demonstrated to verify performance and attract private investment.

Project Description

FCBs are important clean energy technologies that are nearing commercial readiness but that need demonstration projects to verify performance, assess potential, and determine needs for co-located hydrogen supplies and fueling infrastructure. FCBs are considered to be more feasible near term than other types of fuel cell vehicles because buses normally operate on fixed routes with fixed schedules, and rely on centralized infrastructure, including the provision of training for engineering, maintenance, and support personnel.

With a national vision and roadmap for hydrogen energy development, and major problems in urbanization and mass transportation, China provides an important opportunity for demonstrating FCBs. The FCB projects in Beijing and Shanghai aim to provide early adopters of FCBs with important information on technology performance and costs, as well as maintenance issues and consumer acceptance. The projects involve $11.6 million of GEF funds and $23 million in cofinancing. UNDP is assisting with the implementation of the projects.

China's commitment to these projects stems from the growing sustainability challenges faced by the country. For example, China's economic growth has sparked an increase in automotive fleets. Vehicle sales in China grew from 2.1 million units in 2000 to 5.8 million in 2005 and 13.6 million in 2009 (Sullivan 2010). In Beijing and Shanghai, public buses are major contributors to air pollution due to the large fleets, high engine power, large fuel consumption, long daily running distances, and congested roads. For example, in Beijing in 2005 there were more than 18,000 buses in service, of which 8,026 were diesel-fueled. In Shanghai in 2005 there were also more than 18,000 buses in service, of which more than 10,000 operated on diesel(Ministry of Finance 2010).

Since the project's inception, Chinese officials from the Ministry of Science and Technology (MOST), Beijing and Shanghai local governments, Tsinghua University, and domestic and international private companies participated as key stakeholders in the projects. The overall objectives of the project are to:

- Begin the process of demonstrating the feasibility and effectiveness of FCBs in urban transport applications in China;
- Verify reductions in air pollution and GHG emissions that result from the operation of the FCBs,
- Demonstrate the operational performance of FCBs and their refueling infrastructure under Chinese conditions; and
- Stimulate manufacturers to scale-up production and bring down costs

Planning was conducted prior to project inception and identified four phases: (1) Feasibility Studies, (2) Demonstrations, (3) Expanded Demonstrations, and (4) Mass-production. The first phase, which took place from 1998 to 2001, involved research, data collection, and analysis by Chinese experts to provide a basis for the design of the overall project. The feasibility studies showed that since the 1990s significant progress had been made in hydrogen energy production and storage and fuel cell vehicle technologies in many countries including China. The second phase began in 2002 and is expected to be completed in 2011. As part of this phase, the public transport companies of Beijing and Shanghai each obtained and put into operation six FCBs. This phase also includes capacity building activities to strengthen the basis for proceeding to the third phase, which is expected to take place from 2012 to 2020 and involve a larger FCB demonstration effort in other Chinese cities.[6]

[6] The third and fourth phases have not begun and are not expected to involve GEF.

Technology Description

The technologies for the projects include both the FCB and the hydrogen fueling infrastructure. These systems are not generally commercially available except for limited deployment in demonstration projects. There is still a high level of risk related to the costs and performance of fuel cell vehicles particularly under the rigorous conditions presented by large buses serving urban mass transportation markets. While a proven technology, fuel cell costs are still prohibitive compared to other vehicle propulsion systems, including non-traditional alternatives such as compressed natural gas and hybrid electric buses. In addition, the fueling infrastructure for supplying hydrogen requires its own production, storage, and dispensing facilities and these costs need to be factored into the overall effort.

The manufacturers, demonstration schedules, and locations for the FCBs projects are shown in the table on the next page.

The Citaro, manufactured by Daimler-Chrysler uses a proton-exchange-membrane (PEM) fuel cell involving a 205 KW fuel cell stack manufactured by Ballard Power Systems, Inc., and an alternative current induction motor. The Citaro uses nine hydrogen storage tanks manufactured by Dynetek Industries, Ltd. Each tank can hold up to 40 kilograms of hydrogen at a storage pressure of 350 bars.

The next batch of three FCBs was manufactured by China's Beiqi Foton Motor Company with funding from MOST and technical assistance provided by the GEF. During this part of the projects, these FCBs provided service in the 2008 Beijing Olympic Games as one of the technology showcase projects. The final six FCBs used hybrid fuel cell systems, manufactured by Shanghai Automotive Industry Corporation (SAIC). They have been purchased for demonstration and operation at the World Expo in Shanghai in 2010. These six FCBs provided true zero-emission service for visitors shuttled along the main bus route at the World Expo.

TABLE 2: FCB PROJECT INFORMATION

Manufacturer	Number of FCBs	Schedule	Location
DaimlerChrysler-Citaro	3	June 2006–October 2007	Beijing
Beiqi Foton Motor Company	3	August 2008–July 2009	Beijing
Shanghai Automotive Industry Association (SAIC)	6	February 2010–present	Shanghai

Hydrogen fueling infrastructure is a key aspect of this project, resulting in construction and operation of China's first hydrogen fueling station. With the cooperation of SinoHytec, BP, and Tsinghua Tong Fang Corp., the Beijing hydrogen fueling station was built inside Beijing New Energy Vehicle Demonstration Park, located in Yongfeng High Technology Economic Development Zone approximately 10 kilometers west of the Olympic Stadium. The station began service in November 2006 with hydrogen supplies from an external natural gas reformer.
The facility has the capacity to fuel eight to ten buses with hydrogen at a time, three to four times per week. This fueling station served the three Citaro FCBs demonstrated in the Beijing project and provided valuable data for the construction and operation of a fueling station in Shanghai.

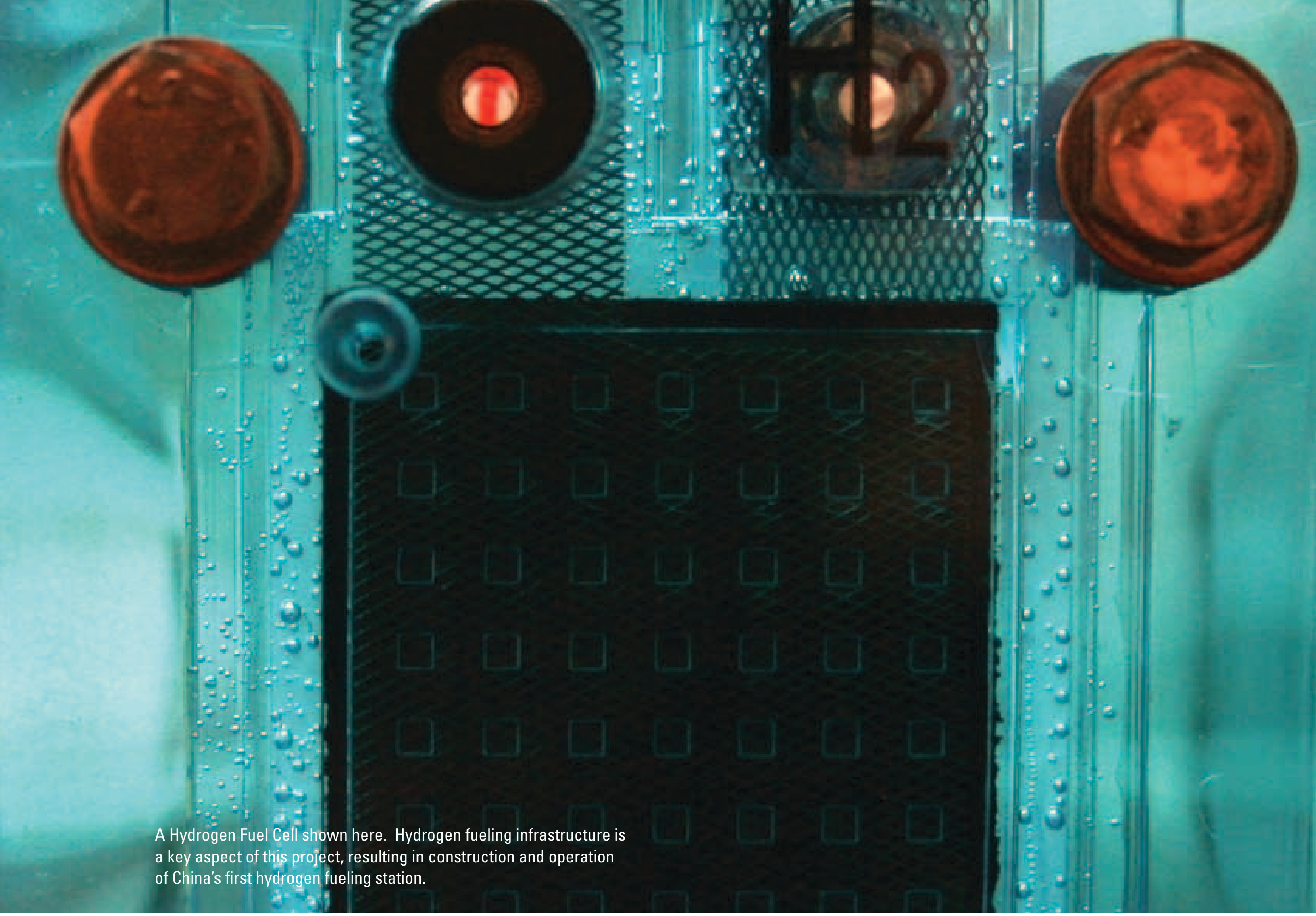
Expected Results and Outcomes

Data collected to date demonstrates that the FCBs and fueling infrastructure have performed successfully. For example, the three Citaro FCBs operated in Beijing from June 2006 to October 2007 as public buses running standard routes with zero emissions and low levels of noise. The FCBs traveled a total of 92,116 kilometers with an 88% operation rate, operated for 5,699 hours, and carried 56,973 passengers. The FCBs were not involved in any accidents or emergencies, and received favorable reviews from passengers and operators.

The Foton FCBs operated in Beijing from August 2008 to July 2009, traveled 75,460 kilometers, and carried 60,198 passengers. These FCBs operated for 3,646 hours and consumed 5,753 kilograms of hydrogen at a consumption rate of about 9.56 kilograms per 100 kilometers traveled. Operating statistics on the SAIC FCBs are not available as of November 2010.

Operation of all 12 FCBs is expected to avoid about 1,010 tonnes of CO_2 emissions. If the FCBs are adopted by 30% of China's municipal bus fleet by 2030, then 9.3 million tonnes of CO_2 emissions can be avoided annually.

Going forward, the GEF will continue to look for opportunities to support cost effective FCB projects that build on the lessons learned from Beijing and Shanghai, and other fuel cell and hydrogen demonstrations worldwide. Research and development remains an important part of the strategy for driving down costs and improving performance for fuel cells, and hydrogen production, storage, delivery, and fueling infrastructure. Demonstration projects are also important to provide technology developers with information on technology deployment problems and to inform research and development directions and priorities.



A Hydrogen Fuel Cell shown here. Hydrogen fueling infrastructure is a key aspect of this project, resulting in construction and operation of China's first hydrogen fueling station.

The GEF FCB projects have contributed useful information about the costs and performance of hydrogen fuel cells and fueling infrastructure in urban mass transportation applications. Through these demonstrations hundreds of thousands of passengers have traveled on fuel cell buses, thus introducing the technologies to the public and raising awareness. The projects have also supported China's commitment to the development of hydrogen and fuel cell vehicles and their program to expand deployment of FCBs.

In pursuing technology transfer opportunities for FCBs, several key lessons have emerged to inform future efforts. For example:

- **Understand investment needs:** The amount of investment needed to purchase FCBs, and to construct and operate the supporting hydrogen fueling infrastructure is substantial and a primary

- **Assess alternatives:** Many types of clean energy systems are being demonstrated for sustainable urban transport. The relative merits of FCBs and these other systems need to be fully assessed so that sustainable urban transport projects meet the full needs of the urban community and the host country.

- **Secure commitment:** The level of commitment by the Chinese government to hydrogen energy development has been a key factor. The level of national commitment will be an important consideration in identifying additional FCB projects in other countries.

Innovative Financing—Hungary Energy Efficiency Cofinancing Program

Budapest, Hungary

Introduction

Energy efficiency is among the lowest cost approaches for saving energy and reducing GHG emissions. The widespread adoption of financial instruments for energy efficiency is essential for expanding the adoption of energy efficient technologies, tools, and techniques. GEF projects to develop and transfer financial instruments for energy efficiency have been successfully implemented in many countries worldwide including Hungary, Bulgaria, Slovakia, Thailand, and China. These projects have resulted in significant reductions in energy consumption and GHG emissions.

There are several general types of financial instruments that the GEF and others have used worldwide for energy efficiency investments. As was the case in Hungary, it is common to combine these instruments in various ways to suit local conditions and needs. The types include:

- Loans or loan guarantees through commercial banks, special development agencies, or government funds;
- Energy savings performance contracts through third party businesses known as energy services companies (ESCOs); and
- Demand-side management programs through energy distribution companies that provide financing, incentives, and technical assistance.

The GEF has been at the forefront of efforts to advance innovative financial instruments that promote energy efficiency in developing countries and economies in transition. Development, implementation, and evaluation of these instruments address a major global need to stimulate their replication and sharing lessons learned.

Financial instrument projects represent about 22% of the value of the GEF's energy efficiency portfolio. Through these projects the GEF provides essential financial tools and techniques—along with technical assistance and training—for expanding deployment of energy efficient appliances and equipment in residential and commercial buildings and manufacturing and process industries worldwide.

GEF efforts with financial instrument projects are part of a portfolio that includes technology demonstrations and diffusion, standards and labeling, market-based approaches, and policy and regulatory development.

GEF has supported small and medium-sized enterprises in China and other developing countries to improve their energy efficiency and reduce GHG emissions.

Project Description

The Hungarian Energy Efficiency Cofinancing Project (HEECP) built a sustainable commercial lending sector in Hungary—in partnership with local financial institutions—for energy efficiency investments across a range of technologies, applications, and sectors. The project is a useful example of GEF efforts to develop and transform project financing and markets for energy efficiency investments in countries and economies in transition. Like other countries in Eastern Europe, and the newly independent states of the former Soviet Union, Hungary operated under a centrally planned economy that was shielded for decades from market forces and thus developed institutions and infrastructure that were based on relatively low and subsidized energy prices. Without adequate market signals, there were no economic incentives for energy efficiency and Hungarian lenders had no experience offering and servicing energy efficiency loans.

This project started in 1997 when Hungary's financial sector was beginning to change, operate on a commercial basis, and able to begin financing energy efficiency projects, particularly in the SME sector. However, there were significant hurdles and the GEF project was essential for building basic capabilities, knowledge, and know-how. The GEF provided $5.7 million for this project with $113.2 million in cofinancing. Project implementation was supported by the International Finance Corporation (IFC).
The HEECP was designed in two phases:

- HEECP I: A $5 million pilot project that generated considerable interest a mong Hungarian financial institutions in this market; and
- HEECP II: Expansion of guarantees and technical assistance to support the financing of energy efficiency-related projects.

Financed projects included investments in energy efficient lighting, district heating, boiler and building control systems, motors, and industrial process improvements. The program continues today in a third phase, which started in 2005, which is now merged with the Commercializing Energy Efficiency Finance Program.

The financial mechanism developed for HEECP involved two strategies for strengthening Hungarian commercial lending for energy efficiency:

- Offering and servicing specialized financial products, and
- Building local expertise in energy efficiency technologies, tools, and techniques.

The main financial product included a partial loan guarantee provided by the IFC to participating Hungarian financial institutions. Capacity building included technical assistance and training. HEECP marked the first time that a partial loan guarantee financial instrument was used to facilitate commercial energy efficiency lending, a strategy that has since been refined and applied in other GEF and IFC projects worldwide (Taylor et al. 2008).

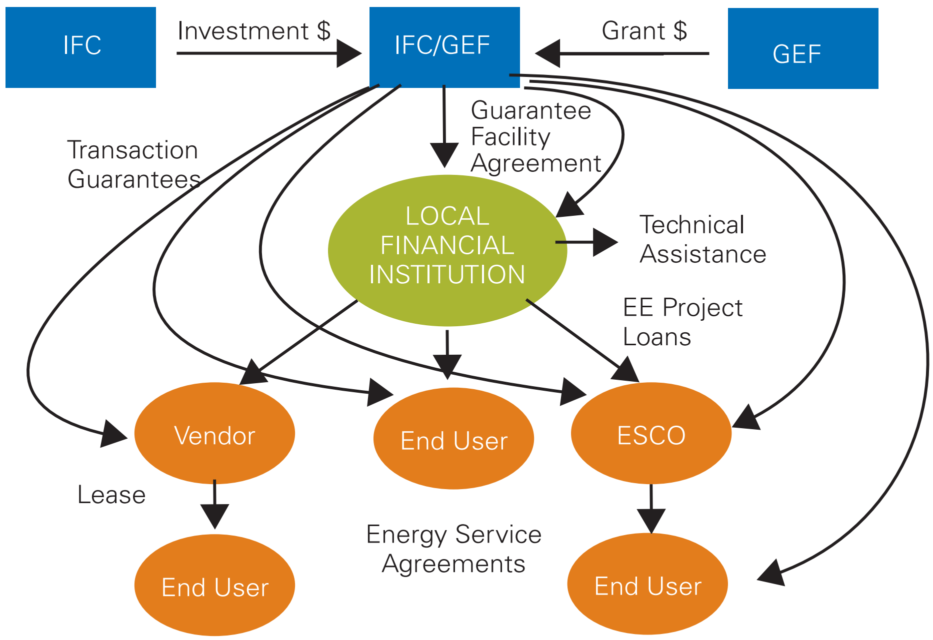
Implementation of the financial instrument involved development of specialized institutions, contract mechanisms, and agreements in a unique configuration. Under HEECP, the GEF and IFC issued Guarantee Facility Agreements (GFAs) for energy efficiency investments with Hungarian lenders. As each investment transaction was initiated by the lender with a loan recipient, the GEF and IFC issued a Transaction Guarantee Agreement (TGA) for each eligible transaction undertaken whether the recipient was an end user, vendor, ESCO, or teams involving all three.

Under the GFAs, the lenders are responsible for originating and structuring all of the transactions as well as performing the appropriate due diligence and credit analysis. They are also responsible for managing the loans from start to finish and for pursuing collection remedies in the event of default. As the financial instrument provides for only partial guarantees, there was an incentive for the lenders to identify and originate financially sound loans and pursue the most cost effective energy efficiency project investments (Taylor et al. 2008). Figure 3 provides a diagram which shows how the GFAs and TGAs were organized through the lenders to loan recipients, and how the financing was complemented by appropriate technical assistance and training.

Initially, when the Hungarian energy efficiency financing market was in its early stages, the HEECP partial loan guarantees were open to many different companies and organizations that might be able to use them to implement energy efficiency projects. However, as experience was gained, the preferred loan recipients were project developers (e.g., vendors, leasing companies, ESCOs, and SMEs) as these were the entities in the best position to aggregate small projects into larger ones, and most able to use the technical assistance and training that was provided.

Experts meet to discuss innovative carbon financing options with the GEF.

FIGURE 3: HEECP PROGRAM STRUCTURE



Source: Taylor et al. 2008

Results and Outcomes

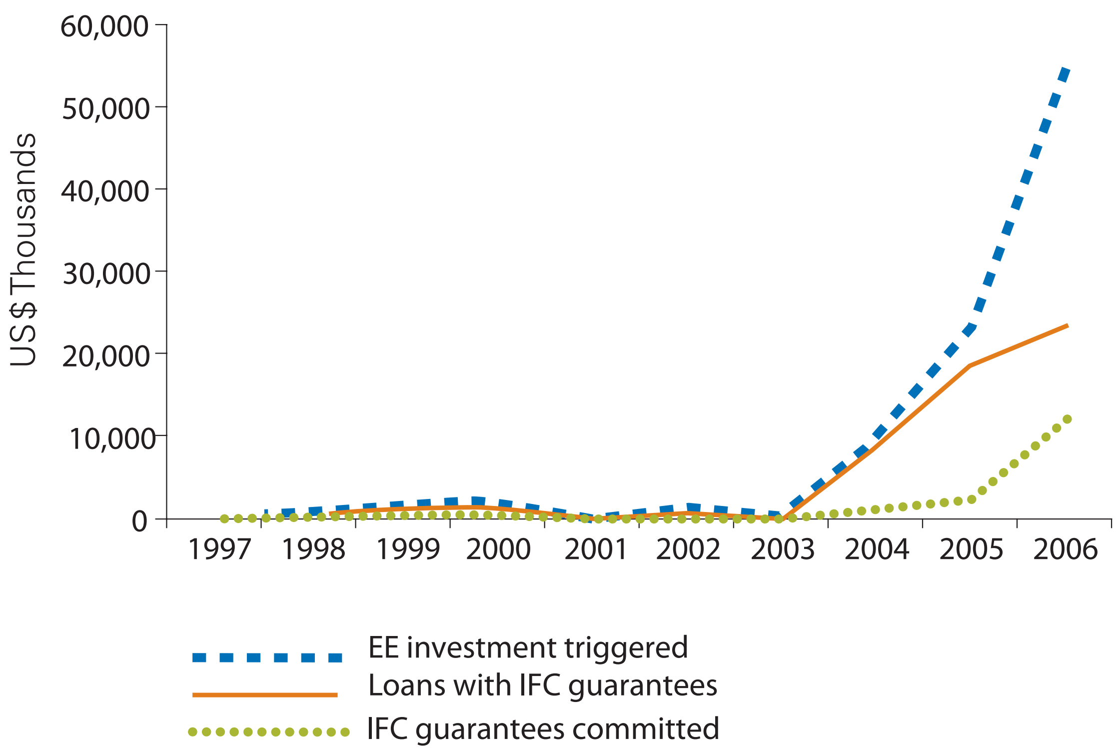
The expected outcomes of HEECP included:

- Reductions in capital costs for new electric transmission and distribution systems due to reductions in demand;
- Decreases in the country's reliance on imported energy due to reduction in the use of oil and natural gas; and
- Improvements in living standards, the competitiveness of the SME sector, municipal budgets due to reductions in energy costs.

Reductions in GHG emissions from HEECP were estimated to be about 2.6 million tonnes of CO_2 equivalent over the lifetime of the project. Analysis shows that HEECP's initial six years (1997–2003) involved a relatively slow start-up as lenders, loan recipients, and services providers absorbed the provided technical assistance, gained familiarity with the new financial instruments, and learned how to conduct feasibility studies/audits cost-effectively to identify the most promising and profitable energy efficiency projects.

From 2003 to 2006, HEECP entered a period where the level of loans and projects expanded rapidly. Figure 4 shows these results, illustrating a significant change towards self-sustaining energy efficiency markets in Hungary (Taylor et al. 2008). As time went on, increasingly fewer of the

FIGURE 4: HEECP RESULTS FROM 1997 TO 2006



Source: Taylor et al. 2008

With GEF support, this cement company constructed the first of its kind fuel-free power plant in China using waste heat from cement kilns.

energy efficiency loans relied on the partial loan guarantees. In fact, as greater experience was gained among lenders and recipients regarding the terms, risks, and cost/revenue streams from energy efficiency investments, opportunities for financing projects based on cash-flow alone increased. This enabled financing through the partial loan guarantees to focus on potentially profitable market opportunities that might otherwise have been ignored. Beneficiaries of this trend included block-house renovation, combined heat and power, district heating, and street lighting projects (Taylor et al. 2008).
In transferring financial instruments for energy efficiency to other nations and regions, key lessons should be addressed to ensure best practices are replicated. For example:

- Loan guarantees alone cannot solve systemic banking or credit problems but together with technical assistance and training they can successfully mobilize local lenders and private developers such as leasing agents and ESCOs.
- If a nation or region does not have well developed financial institutions or technical capabilities and energy efficiency expertise, it will take time and patience to build the capacity needed for a robust market to emerge. Lead times on the order of 6 months to 2 years should be expected for viable financial instruments to be developed and deployed.
- For loan guarantee mechanisms to have their greatest chance for success, they need to be implemented in commercial banking sectors that have adequate liquidity, attractive interest rates, competition, and reasonably mature financial institutions that are willing to take risks.

Going forward, the GEF will continue to invest in projects that create new financial instruments for energy efficiency. GEF assistance will be particularly important in those countries that lack both well-developed commercial lending sectors and companies with experience with energy efficiency projects.

Advising communities on sustainable livestock and rangeland management practices that will be readily replicated elsewhere is a priority portfolio project.

BOX 2: ADAPTION ACTIONS—A TOP GEF PRIORITY

Since the creation of the Strategic Priority on Adaptation in the GEF Trust Fund, and the establishment of the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF), GEF investments in adaptation projects have totaled about $313 million. While technology transfer has been a major component in most adaptation projects, there is less experience with successful cases compared to other GEF projects in ESTs as the adaptation portfolio is relatively new.

The portfolio of projects includes investments in a variety of adaptation technologies, tools, and techniques. For example, there have been projects for wetland and/or mangrove restoration, beach nourishment, innovative irrigation systems, drought-resistant crops, enhancing climate resilient infrastructure, and the physical transfer of high-tech electronics for data logging and alert systems. In addition, many of the adaptation projects have included techniques for the improved management of local practices. As a result, capacity building, public awareness, and support for "mainstreaming" adaptation strategies in local economic development, land-use, and environmental planning have been important components of many projects. Some technology transfer examples from the adaptation portfolio include the following:

- In Sierra Leone, 15 automatic weather stations and 20 regional rain gauges are being installed to revitalize the meteorological system which was severely damaged during the civil war. To operate these systems, post-graduate training will be provided for two senior meteorologists and several supporting technical staff. Weather analysis and forecasting is an essential tool for supporting local climate change adaptation decision making for projects in agriculture and water resource management.

- In Colombia, advanced climate and statistical models allow continuous evaluation of the effects of global climate change on dengue and malaria transmission. With technical assistance the models can be customized for other nations to help guide appropriate preventive actions.

- In Cape Verde, a country expected to experience severe climate change-related water stress, demonstration of climate-resilient techniques for harvesting, storing, conserving, and distributing water is being implemented. The technologies for this project include wind traps, underground screens that prevent groundwater seepage, and new water treatment techniques that will be applicable in other locations.

- In West Africa, use of alternative fuels in communities that previously collected firewood from sensitive coastal mangrove forests is underway. Use of fuels other than firewood reduces human pressure on the mangrove forests, which serve as a natural buffer against the effects of rising sea levels and storm surges, and can be an appropriate remedy in other places.

- In Bhutan, measures to reduce the risks of glacial lake outburst floods created by receding glaciers are underway. This project involves installing pumps to artificially lower lake levels below dangerous thresholds, and installing automated monitoring and alarm systems which will be applied for similar purposes in other regions.

- In Eritrea, agricultural extension personnel are being trained in climate-resilient rangeland management techniques. This project provides expertise and capabilities for advising communities on sustainable livestock and rangeland management practices that will be readily replicated elsewhere.

Effective technology transfer relies on the open exchange of information about projects such as these to help build awareness and experience for successful scale-up of activities to national and regional levels (GEF 2008, GEF 2009a).

TABLE 3 . ELEMENTS OF ADAPTATION TECHNOLOGY TRANSFER IN ECOSYSTEMS, AGRICULTURE, WATER MANAGEMENT, COASTAL ZONE MANAGEMENT, DISASTER RISK MANAGEMENT, AND HUMAN HEALTH

	Ecosystems	Agriculture	Water Management	Coastal Zone Management	Disaster Risk Management	Health
Technology information transfer	Pest management technologies introduced into sustainable forest management to combat severe pest problems caused by decreasing rainfall (Armenia)	Improved seasonal forecasts and improved access to seasonal climate information for farmers through extension services (Niger)	Demonstration of small-scale innovative techniques for climate-resilient harvest, storage, conservation, and distribution of water (Cape Verde)	Planting / conservation of protective mangroves (Sri Lanka)	Improvement of drought early warning systems and coordination of food and forage banks (Burkina Faso)	Climate and statistical models developed to monitor and track the effects of climate on malaria and dengue. (Colombia)
Infrastructure and hard technologies	Dissemination of alternative energy technology to reduce human stresses on important mangrove ecosystems, previously used for firewood collection (West Africa)	Promotion and dissemination of drought-tolerant crop varieties and technology; knowledge for improved dry- land farming (such as dry seeding, minimum tillage, etc.) (China)	Upgrade of irrigation facilities to promote efficient usage of available water resources (Malawi)	Installation of breakwater/ sea walls at key vulnerable coastal locations (Pacific Islands)	Reduced risks of glacial lake outburst floods (GLOFs) through artificial lowering of lake levels and automated monitoring/ warning system (Bhutan)	
Capacity building, coordination, and policy	Updating of coastal zoning and fisheries management based on detailed analysis of saline front changes induced by climate change (Uruguay)	Training of adaptation experts for agricultural extension services (Eritrea)	Development and implementation of integrated water management frameworks for rational prioritization of limited resources (Ecuador)	Improvements in human and technical capacity (such as GIS technology) for monitoring and responding to coastal erosion (West Africa)	Increased coverage of existing early warning system and improved flow of early warning information to vulnerable coastal communities (Bangladesh)	Increased capacity and understanding among local health professionals through pilot implementation of preventive and responsive public health programs specifically targeting climate change- induced illnesses (Samoa)

With GEF support, Xinggao Coking Group in Shanxi, China has successfully demonstrated the state-of-the-art clean coking technology, while recovering waste heat from the coke ovens for power generation.

GEF'S Role in Technology Transfer

Common Features and Lessons Learned of Successful EST Transfer

The case studies analyzed in this document articulate the process of technology transfer for each EST, and highlighted the crucial role the GEF has played at different stages. Some of the common features of successful EST transfer and lessons learned include the following:

- **Target the GEF support for transformational effects:** The case studies demonstrate that GEF financing for technical assistance and for investment support is a crucial tool to enable counties to try innovative pilot project designs and to partially off-set the high initial transaction costs of activities, and to defray initial risks (Taylor et al. 2008). Such targeted support is consistent with the principle of incremental cost, in which the GEF support is used to transform a project with national benefits into one with global environmental benefits, by providing targeted financing to cover the cost differential to make a project more environmentally sound.
- **Understand and address barriers:** Pilot projects and demonstrations could be one of the most tangible ways to address barriers to technology transfer, by showing how and where ESTs could be implemented. The Bangladesh brick making project addresses some of the common technical, capacity, and commercialization barriers to brick making, by replicating activities that have been successfully demonstrated in other Asian countries with GEF support. The innovative Hungarian financial project addressed institutional and economic barriers associated with limited economic incentives for energy efficiency and lack of experiences in offering and servicing energy efficiency loans. There is also a need for realistic baseline assessments and identification of options to address barriers that could be reasonably implemented within the project timeframe.

- **Obtain the commitment and sustained buy-in of partners:** All case studies featured a strong and sustained commitment of local and national partners to plan, implement, and manage various activity components. The featured case studies were implemented in multiple phases or over a long period of time, underscoring the importance of sustained buy-in of the partners. The level of commitment is an important criterion in identifying additional projects to replicate successful EST transfer.

- **Engage the private sector:** Each case study featured diverse styles of private sector engagement, as manufacturers of technologies being piloted, as design and construction contractors, as EST adopters in the manufacturing process, and as providers of financial services. Each project also assessed and improved policy-relevant and technical conditions to enable private sector engagement. Successful projects also had a clear business model from the outset.

- **Understand the relative merits of technology options:** The projects featured in the case studies provided extensive data and a wealth of experience needed to better-define the advantages and disadvantages of demonstrated ESTs. In order to make the case for EST replication and investments, the relative merits of available options need to be further assessed. They may have different financial, environmental, socio-economic, geographical, and infrastructure-related attributes, capacity needs, and policy- and institutional requirements for their successful transfer. Decisions to replicate/mainstream a particular technology system may require long-term, capital-intensive commitments, with path dependency. For instance, it is necessary to assess multiple clean energy systems available for sustainable urban transport before making the decision to commit to one type.

- **Sustain a comprehensive approach:** Technology transfer does not happen in a vacuum, by just making the equipment available. Similarly, financing alone cannot solve systemic problems that impact access to technologies. Successful projects featured multiple reinforcing components to support viability of EST transfer under local conditions. These components included: policy support, such as standards for renewable energy portfolio and grid access guarantees; incentives such as investment support, tradable energy certificates, production credits, and feed-in tariffs; market environment building; and capacity and institutional building at the national, sectoral, and firm levels.

The above findings are consistent with a recent independent evaluation of low carbon development projects by the World Bank, which found that the GEF support has been crucial in piloting technology transfer to mitigate clients' perceived risks (World Bank 2010). The evaluation also found that successful projects have supported the transfer and adaptation to local conditions of existing technologies, policies, and financial practices.

With GEF support, Xinggao Coking Group in Shanxi, China has successfully demonstrated the state-of-the-art clean coking technology, while recovering waste heat from the coke ovens for power generation.

GEF-5 Outlook

The GEF-5 climate change mitigation charts a course to promote a broad portfolio of environmentally sound, climate-friendly technologies with potential to achieve significant GHG reductions in GEF-recipient countries in accordance with national circumstances, as introduced earlier in this document. The GEF promotes technology transfer at various stages of technology development in the innovation chain, from demonstration of innovative, emerging, low-carbon technologies to diffusion of commercially proven, ESTs and practices.

The GEF strategy enables the recipient countries to access the GEF support on a wide range of areas, including energy efficiency in the industrial and building sectors, renewable energy technologies, low-carbon transport and urban systems, and innovation support. In addition, GEF-5 includes the promotion of conservation and enhancement of carbon stocks through sustainable management of LULUCF as well and carbon finance, as well as carbon finance (Boxes 3 and 4).

The GEF stands ready to facilitate the transfer of a wide range of ESTs to a larger number of countries and stakeholders, by catalyzing additional investments, in order to achieve its overall goal to support developing countries and economies as they transition towards a low-carbon development path. It is hoped that the case studies featured in this publication will inspire additional countries to move toward enhanced use of these low-carbon technologies.

BOX 3: ENHANCED LAND MANAGEMENT AND USE FOR CLIMATE MITIGATION

On a global scale, deforestation contributes 15-20% of GHG emissions, more than the world's entire transport sector. GEF-5 features a program to reduce GHG emissions across the LULUCF landscape. Land uses can be broadly categorized such as those for reporting national inventories under UNFCCC: forest land, cropland, grassland, wetlands (peat lands), settlements, and other lands. Land use changes and land use can emit greenhouse gases or sequester carbon, and management can reduce expected emissions or increase sequestration which contributed to climate change mitigation. Reducing deforestation and wetland degradation are especially effective approaches for reducing GHG emissions.

LULUCF objectives are to: (1) conserve, restore, enhance, and manage the carbon stocks in forest and non-forest lands, and, (2) prevent emissions of the carbon stocks to the atmosphere through the reduction of the pressure on these lands in the wider landscape. Success will be measured by the number of hectares of forest and non-forest lands restored and enhanced, tonnes of CO_2 equivalent avoided and sequestered, and number of countries adopting good management practices. Carbon stock monitoring systems are also critical for measuring progress.

Enhanced carbon stocks and sequestration across the landscape, and decreased deforestation due to LULUCF projects creates synergies that result in climate change mitigation, as well as other global environmental benefits including the protection of biodiversity, and combating land degradation to improve people's lives. The LULUCF program supports the GEF-5 Sustainable Forest Management/Reducing Emissions from Deforestation and Degradation plus (SFM/REDD plus) incentive mechanism which allows GEF projects to access additional funds for forest management to be fully responsive to the guidance provided by the UNFCCC, Convention on Biological Diversity, and the United Nations Convention to Combat Desertification. Because forests can be a source of biomass for energy production, LULUCF activities can result in additional synergies within the GEF climate change focal area including management to enhance forest carbon stocks made possible by reducing forest use through renewable energy technology investments and market transformations for energy efficiency such as more efficient cook stoves.

Potential innovative technology transfer activities in LULUCF include improvements in charcoal production technologies and reduction in charcoal use. Charcoal is one of the most important energy resources in Africa and is a major source of pollution and greenhouse gas emissions in cities where urbanization pressures are a growing problem. Charcoal production is not very efficient; about 90% of the carbon is emitted before the remaining 10% is delivered as charcoal. Wood production by afforestation and improved forest management techniques, coupled with improvements in charcoal production efficiency, would have significant global impact.

BOX 4: CARBON FINANCE–NEW OPTIONS TO EXPLORE

The GEF is uniquely positioned to play a role in carbon markets given its extensive network of partner institutions, its rich experience in financing and facilitating the transfer of environmentally sound technologies, and its strong track record in reducing GHG emissions cost-effectively from its investments. In fact, GEF's early intervention in many cases—be it demonstrating technologies for landfill gas and coal bed methane utilization or putting policy and regulatory frameworks in place to stimulate investment in renewable energy—has laid the foundation for carbon markets to function and replicate subsequently.

In fact, the GEF has supported several, innovative projects promoting carbon finance. For example, a project in India for the deployment of more energy efficient chillers has just been started with the World Bank and showcases an innovative financial mechanism that could be applied in other countries. The objective of this project is to accelerate the replacement of traditional centrifugal chillers with energy efficient, non-chlorofluorocarbon (CFC)-based centrifugal chillers through the provision of financial incentives. This project has mobilized cofinancing of approximately $77 million with GEF support of $6.3 million.

The project's financial incentive consists of an upfront payment (about 20% of the equipment standardized cost) to subsidize the cost of the replacement of the centrifugal chillers before the end of their useful lives. Carbon credits from the 215 chillers that will receive incentive payments under this project will then be transferred to provide additional resources to support replacement of an additional 155 chillers. This concept works like a revolving fund where carbon emission reduction revenue streams from initial replaced units are used to replace additional units. The goal is to replace 370 chillers, with expected greenhouse gas reductions of about four million tonnes CO_2 equivalent, including global warming potential of CFCs. The cost-effectiveness of the GEF contribution comes to approximately $1.6/tonne of CO_2 equivalent.

Without GEF's assistance to address the barriers for chiller replacement and allowing up-front financing arrangements, this project could have been a non-starter, given that the Clean Development Mechanism by itself will not be able to overcome the barriers due to: (1) high opportunity costs; (2) perceived technology risks regarding energy efficiency permanency under the environment conditions prevailing in India; (3) lack of awareness of potential savings that could be rendered by the new technology; and (4) competing investment priorities. Without the GEF funds to accelerate chiller replacement, CFC demand would have continued in the domestic market and thereby potentially triggering an illegal market for CFCs.

The Chiller Energy Efficiency Program supported by the GEF involves the use of a financial intermediary (Industrial Development bank of India) to aggregate eligible chiller replacements and reduce transaction costs for chiller owners which enables small projects to more easily participate in carbon finance markets. This methodology has been approved by the Clean Development Mechanism Executive Board and represents one of the first examples worldwide of a programmatic, rather than a case-by-case, approach to carbon finance markets.

Taking advantage of carbon finance market opportunities will be an important target for GEF-5 projects. Options to be explored include:

- Capacity building to help create enabling legal and regulatory frameworks;
- Support for programmatic carbon finance and other activities under the post-2012 climate regime;
- Demonstration of technical and financial viabilities of technologies;
- Provision of partial risk guarantees and contingent financing for carbon finance projects; and
- Cofinancing of innovative projects, with credits to be retained in the recipient country for further project replication.

Without GEF’s funds to accelerate chiller replacement, CFC demand would have continued in the domestic market and thereby potentially triggering an illegal market for CFCs in India.

These children above make charcoal illegally, using trees from protected area systems of Rwanda. Charoal production is not very efficient: about 90% of the carbon is emitted before the remaining 10% is delivered as charcoal.

ABBREVIATIONS AND ACRONYMS

BTK	Bull's Trench Kiln
BUET	Bangladesh University of Engineering and Technology
CFC	Chlorofluorocarbon
CFE	Federal Electricity Commission (Mexico)
COP	Conference of the Parties
CSP	Concentrating Solar Power
EGTT	Expert Group on Technology Transfer
ESCO	Energy Services Company
EST	Environmentally Sound Technology
FCB	Fuel Cell Bus
FCK	Fixed Chimney Kiln
GEF	Global Environment Facility
GFA	Guarantee Facility Agreement
GHG	Greenhouse Gas
GHK	Gas Hoffman Kiln
HEECP	Hungarian Energy Efficiency Cofinancing Project
HHK	Hybrid Hoffman Kiln
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
LDCF	Least Developed Countries Fund
LULUCF	Land Use, Land Use Change, Forestry
MOST	Ministry of Science and Technology (China)
NGO	Non-Governmental Organization
NREA	National Renewable Energy Agency (Egypt)
NREL	National Renewable Energy Laboratory (United States of America)
PEM	Proton Exchange Membrane
SAIC	Shanghai Automotive Industry Association
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCCF	Special Climate Change Fund
SFM/REDD	Sustainable Forest Management/Reducing Emissions from Deforestation and Degradation
SME	Small and Medium Enterprise
STRM	Short Term Response Measures
TNA	Technology Needs Assessment
TGA	Transaction Guarantee Agreement
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization

Units of Measure

Acre	4,047 m^2
GW	Gigawatt
MW	Megawatt
KW	Kilowatt

REFERENCES

Global Environment Facility (GEF). 1995. "GEF Operational Strategy." Washington, DC: GEF.

Global Environment Facility (GEF). 2008. "Transfer of Environmentally Sound Technologies – The GEF Experience." Washington, DC: GEF.

Global Environment Facility (GEF). 2009a. "Financing Adaptation Action." Washington, DC: GEF.

Global Environment Facility (GEF). 2009b. "Investing in Energy Efficiency – The GEF Experience" Washington, DC: GEF.

Global Environment Facility (GEF). 2009c. "Investing in Renewable Energy – The GEF experience." Washington, DC: GEF.

Global Environment Facility (GEF). 2009d. "Investing in Sustainable Urban Transport – The GEF Experience." Washington, DC: GEF.

Global Environment Facility (GEF). 2010. "Greening Opportunities at World Events – The GEF Experiences." Washington, DC: GEF.

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Working Group III Report "Mitigation of Climate Change"

Ministry of Finance. 2010. "GEF in China." People's Republic of China

Sullivan, K. 2010. China's Retail Auto Market. "China Business Review July-August 2010."

Taylor, R. Govindaraji, C., Levin, J., Meyer, A., and Ward, W. 2008. "Financing Energy Efficiency." Washington, DC: World Bank.

World Bank. 2010. "Phase II: The Challenge of Low-Carbon Development. Climate Change and the World Bank Group." Independent Evaluation Group Study Series. Washington, DC: World Bank

World Bank. 2006. "Assessment of the World bank/GEF Strategy for the Market Development of Concentrating Solar Thermal Power." Washington, DC: World Bank.

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ABOUT THE GEF

The Global Environmental Facility unites 182 member governments—in partnership with international institutions, nongovernmental organizations, and the private sector—to address global environmental issues. An independent financial organization, the GEF provides grants to developing countries and countries with economies in transition for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. These projects benefit the global environment, linking local, national, and global environmental challenges and promoting sustainable livelihoods.

Established in 1991, the GEF is today the largest funder of projects to improve the global environment. The GEF has allocated $9.2 billion, supplemented by more than $40 billion in cofinancing, for more than 2,700 projects in more than 165 developing countries and countries with economies in transition. Through its Small Grants Programme, the GEF has also made more than 12,000 small grants directly to nongovernmental and community organizations.

The GEF partnership includes 10 Agencies: the UN Development Programme, the UN Environment Programme, the World Bank, the UN Food and Agriculture Organization, the UN Industrial Development Organization, the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, the Inter-American Development Bank, and the International Fund for Agricultural Development. The Scientific and Technical Advisory Panel provides technical and scientific advice on the GEF's policies and projects.

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