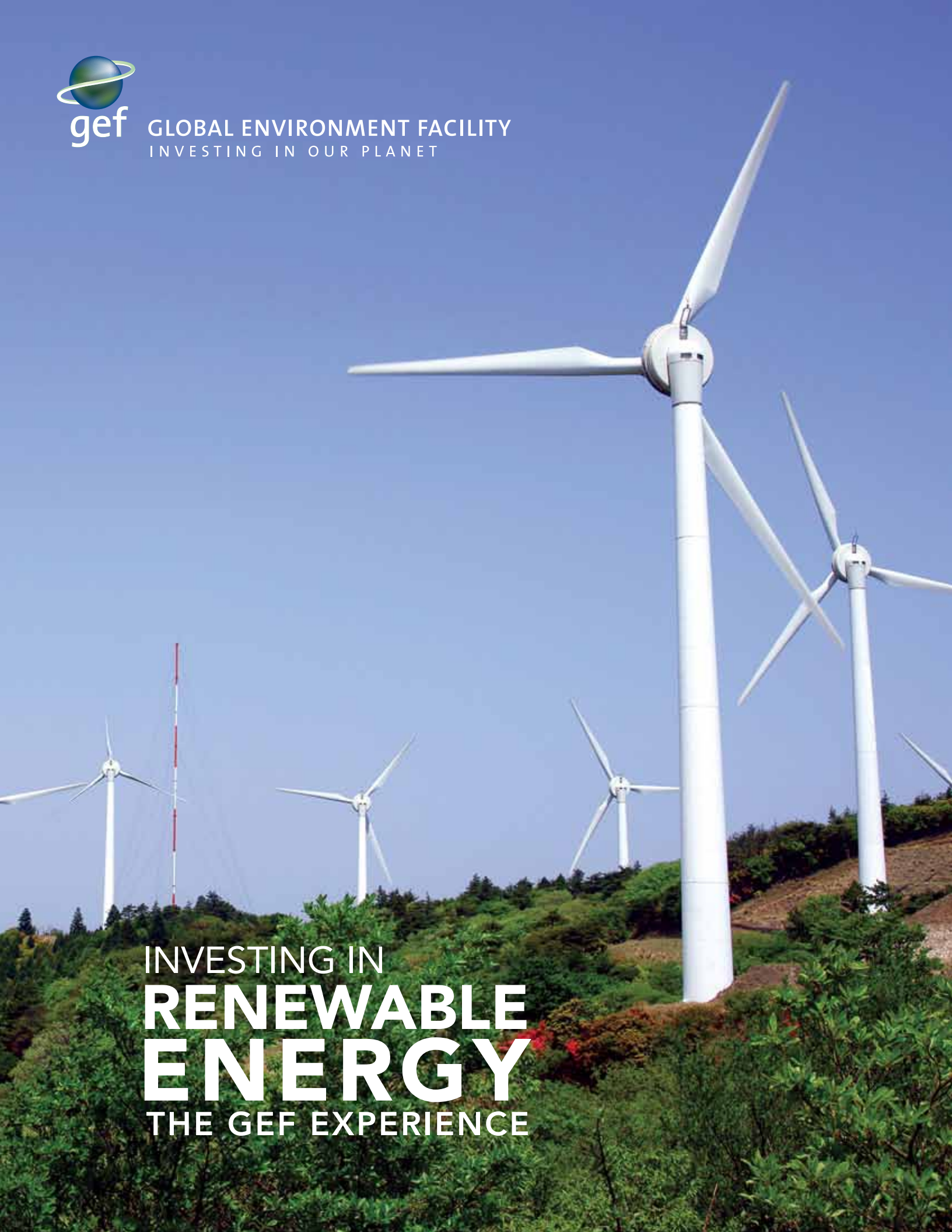
GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET



INVESTING IN RENEWABLE ENERGY

THE GEF EXPERIENCE

Foreword

Light of hope—
powered by small wind
energy photovoltaic panels

Dr. Naoko Ishii
CEO and Chairperson
Global Environment Facility

Dependable and affordable energy supplies are crucial to economic growth in both developed and developing countries—to power homes, connect communities, provide safe water, and promote economic and human development. Yet too often the world's most vulnerable citizens lack the means to make environmentally sustainable choices that would deliver their energy needs while protecting human health and the planet's natural systems. Renewable energy is a viable alternative to help meet the global energy demand. The application of renewable energy technologies can reduce greenhouse gas emissions and pollution using energy sources such as wind, solar, hydroelectric, tidal, geothermal, and biomass. These renewable sources are less vulnerable to the volatility of the fossil fuel markets, bring the added benefits of stimulating employment and technological development, and can contribute to economic growth.

Since its inception, the Global Environment Facility (GEF) has invested US$905 million in 186 stand-alone renewable energy projects, as well as $320 million in 69 mixed projects with renewable energy components, in 160 developing and transition countries. These investments have leveraged an additional $9.59 billion in co-financing. The support provided by the GEF has been instrumental in putting renewable energy on the agenda of most developing and transition countries, from China to India, from Argentina to Brazil, from Mexico to South Africa, from Morocco to Turkey, from Russia to Romania, and from Barbados to Tuvalu. The GEF has promoted the demonstration, deployment, diffusion, and transfer of renewable energy technologies at every level of society. These technologies range from cookstoves and lighting for households, mini-grids for communities, to grid-connected bulk power for countries.

The GEF was among the first to support market transformation in developing and transition countries through the removal of policy, regulatory, and technical barriers, which in turn creates markets for renewable energy technologies and practices. The GEF support has also helped these countries create and apply effective renewable energy promotion policies. One example is the GEF initiative to support the expansion of the renewable electricity market in China. Regulations and policy changes put in place in China have produced remarkable results in scaling up renewable energy investments in wind energy, biomass, and small-hydro projects. They will yield benefits for decades to come. The GEF has also been at the forefront of advancing innovative market-based mechanisms and financial instruments, including energy service companies, partial-risk guarantees, and revolving and equity funds.

Furthermore, the GEF has been a pioneer in the demonstration and deployment of innovative pre-commercial renewable energy technologies in developing and transition countries. For example, the GEF was a pioneer in its support of concentrating solar power. These investments ensure the technologies are demonstrated and deployed with a view toward commercialization.

The GEF's work is helping to address the needs of 1.4 billion people globally who lack adequate energy services and rely on traditional biomass to meet their basic energy needs (Global Energy Assessment (GEA) 2012). At the household and village level, for instance, the GEF is a leader in financing and disseminating solar home systems, solar lanterns, and renewable power for water and irrigation pumps in Sub-Saharan Africa and South Asia. The GEF also supports utilities to increase their capacity to operate and integrate renewable power generation into existing facilities and grids.

These initiatives, many of them innovative efforts to scale-up renewable technologies, reflect my vision of the GEF as a partner of choice and a champion of the global commons. The GEF remains committed to promoting renewable energy in developing countries and transition economies as an essential component of addressing sustainable development and the climate change challenge. I hope that this brochure will help readers gain a better understanding of our efforts in the field of renewable energy, and will inspire enthusiasm and more successes.

Renewable Energy Challenges for the Developing World

Photovoltaic (PV) module manufacturing in China

As developing countries expand their economies and reduce poverty, they face major climate change and energy challenges, including the need to:

- Improve living conditions and enhance economic opportunities for the 1.4 billion people without access to electricity (GEA 2012).
- Increase energy security for all nations, regions, and communities, while at the same time reducing greenhouse gas (GHG) emissions. The International Energy Agency (IEA) estimates that energy use accounts for about 65 percent of the world's GHG emissions.
- Reduce the adverse environmental effects and ancillary risks associated with current energy systems and increase prosperity.
- Supply clean fuels to about three billion people who rely on solid fuels for cooking worldwide, which reduces indoor air pollution resulting from cooking with biomass and coal causing almost two million deaths annually from pneumonia and chronic lung disease (UNDP 2009).

The purpose of this brochure is to present the portfolio of renewable energy projects supported by the GEF. The brochure features experiences of the GEF and its partners in developing policies and regulations to catalyze renewable energy technologies in developing countries and transition economies.

Renewable Energy Opportunities for the Developing World

Renewable energy opportunities in the world are growing (IEA 2012). For example:

The share of non-hydroelectric renewable energy in power generation is expected to increase from three percent in 2009 to 15 percent in 2035. China and the European Union will drive the expansion, providing nearly half the growth.

This growth will be underpinned by annual subsidies to renewables that will rise almost five times to US$180 billion by 2035.

Even though the subsidy cost per unit of energy produced is expected to decline, most renewable energy sources will need continued support in order to compete in electricity markets. While this will be costly, it is expected to bring long-term benefits in increased energy security and greater climate and environmental protection.

Accommodating more electricity from renewable sources, sometimes in remote locations, will require additional investment in transmission networks amounting to ten percent of total transmission investment: in the European Union, a quarter of the investment in transmission networks is needed for this purpose.

The contribution of hydropower to global power generation remains at around 15 percent, with China, India and Brazil accounting for almost half of the 680 gigawatts (GW) of new capacity.

Energy demand and supply patterns can be altered with the development of renewable energy on a large scale. This is a major challenge that demands comprehensive and sustainable solutions. Clean energy technologies are vital to alleviating poverty, expanding rural development, and maintaining environmental quality. The productive use of renewable energy in rural areas helps raise incomes and improve health, providing power to pump water for irrigation, to process crops, to power cottage industries, and to light homes, schools, and hospitals—all services of first importance and immeasurable impact in remote rural areas.

Advanced technologies for new renewable power generation integrated with smart grids have been tested and proven in the field. If optimized and applied widely around the world, these technologies will generate substantial economic and environmental benefits.

Renewable energy technologies can also play crucial roles in employment and economic growth. These technologies are more labor-intensive than conventional technologies for the same energy output—employing a mixture of local and decentralized workers. For an investment in renewable energy technologies of $1 million over 10 years (Pachauri 2009):

- Wind energy generates 5.70 person-years of employment.
- Solar photovoltaic (PV) generates 5.65 person-years.
- The coal industry generates 3.96 person-years.

Despite the global growth in renewable energy generation, most renewable energy resources are virtually untapped in the developing world. When designed in a distributed manner, renewables can help deliver power without large investments in transmission grids.

The primary barrier to the widespread adoption of renewable energy is its high initial construction cost, particularly for installing equipment, especially given the limited economic resources of those in greatest need of the technology—most often the rural poor. Strengthening institutional capacities, promoting enabling environments, developing policy frameworks, and improving demand for renewable energy technologies can help reduce barriers, mitigate steep transaction costs, and promote underdeveloped markets. However, significant expansion of renewable power production will also require the mobilization of considerably more investment in renewable energy, of which at least 75 percent should be directed to developing countries (IEA 2009).

Ain Beni Mathar Integrated Combined Cycle Thermo-Solar Power Plant

The GEF Strategy on Renewable Energy

During the GEF's pilot phase (1991–1994), the strategy was to demonstrate a viable range of technologies useful for stabilizing concentrations of GHGs in the atmosphere, including such projects as—to choose an individual example—a solar water-heating project in Tunisia. After restructuring, from GEF-1 (1994–1998) to GEF-2 (1998–2002) and GEF-3 (2002–2006), the GEF focused on renewable energy technologies that were mature, available on the market, and profitable, but were prevented from dissemination by informational, institutional, technological, policy, or financial barriers. Projects implemented under this strategy were termed "barrier-removal" projects, as they sought to remove barriers to promote faster adoption of new technologies and practices. Support was provided to countries to improve the regulatory regime for integration of renewable energy generation. The GEF has also strongly supported use of biomass waste and residue for renewable power generation.

During GEF-3, in 2004, this barrier-removal strategy was refined further to focus on interventions in the following fields:

- **Policy framework:** Governments must play an essential role in setting policies favorable to the adoption of environmentally sound technologies (ESTs).
- **Technology:** The range of available technologies should be robust and operational—more mature technologies are easier 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 model:** Market-based approaches are preferred; businesses and institutions must be in place to deliver to and service target markets.
- **Finance Availability:** Financing must be available for technology dissemination, though it is insufficient in itself to ensure the market penetration of ESTs.

In addition, GEF-3 focused on reducing the long-term costs of low-GHG-emitting electricity generation technologies. The technologies considered were not yet commercially available and were very expensive relative to the baseline or conventional alternatives. In these cases, such as concentrating solar power (CSP), the immature technology and its high costs were themselves the barrier to greater dissemination.

Renewable Energy Strategy in GEF-4 (2006–2010)

Following policy recommendations from the GEF Council at the replenishment of the GEF Trust Fund in 2006, the GEF reviewed and revised its climate change focal area strategy, which was approved by the GEF Council in September 2007. Within GEF-4 (2006–2010), the GEF committed to two strategic programs on renewable energy: one that promoted market approaches to the supply of and demand for renewable electricity in grid-based systems, and one that promoted sustainable energy production from biomass (consisting of wood, crop residues, dung, and other biological material). The development of a separate strategic program for biomass was considered necessary in order to highlight its importance and ensure consistency with other focal areas, given the emphasis placed upon sustainable forest management in the remainder of the GEF portfolio.

Renewable Energy Strategy in GEF-5 (2010–2014)

In the GEF-5 period (July 2010–June 2014), GEF support covers not only on-grid renewable energy programs but also decentralized production of both electric power and heat using new indigenous renewable sources such as biomass, solar, wind, small hydro, and geothermal. The GEF projects can promote local small and medium enterprises (SMEs) by enhancing their technical capacities to provide installation, operation, and maintenance services for new renewable energy technologies. Furthermore, GEF support will extend to recovering methane from biomass wastes or landfills for power generation and heat production. Finally, GEF support may also extend to supporting sustainable production of biomass for solid and liquid biofuels as a substitute to fossil fuels where there are appropriate conditions, including safeguard policies.

In developing biomass applications, sustainability criteria are critical to ensure that GEF support for modernization of biomass usage does not undermine food security, contribute to deforestation, reduce soil fertility, increase GHG beyond project boundaries, or violate sustainability principles relating to biodiversity conservation or sustainable land and water management.

The GEF intervention under this GEF-5 renewable energy strategy can take the form of technical assistance for policy and regulatory support, building technical and institutional capacity, and of financial assistance, establishing financing mechanisms for investment in the deployment and diffusion of renewable energy technologies. The GEF support in the form of direct investment is particularly applicable in least developed countries. Financial sustainability should be taken into consideration where the GEF is directly involved in investment activities.

The GEF Investment in Renewable Energy

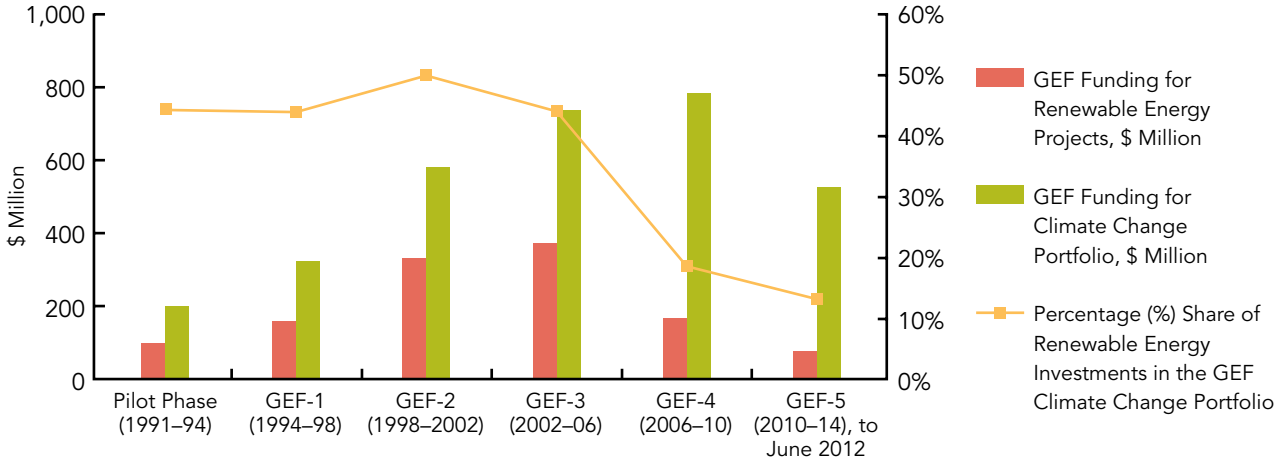
Cleaning solar panels. Ain Beni Mathar Integrated Combined Cycle Thermo-Solar Power Plant.

Overview of the Portfolio

From October 1991 to June 2012, the renewable energy portion of the GEF's climate change portfolio amounted to about $1.22 billion, with an average of $4.9 million per project. This GEF funding has been supplemented with $9.59 billion in co-financing. Funding for the renewable energy portfolio increased from the pilot phase up to GEF-3 as shown in Figure 1.

However, the percentage of the renewable energy project portfolio over the climate change project portfolio has decreased in recent years. This is due to a variety of factors: the expansion of the energy efficiency and other portfolios; the high amount of funding directed to renewable energy projects (such as CSP projects) under GEF-3; and the decision not to pursue the strategic objective of promoting off-grid renewable energy technologies in GEF-4.

FIGURE 1 GEF RENEWABLE ENERGY INVESTMENTS BY GEF PHASES



Source: GEF Project Tracking and Management Information System, 2012.

Since its inception, the GEF has supported 186 stand-alone renewable energy projects. Most of the renewable energy investments have taken place in Asia, Africa, and Latin America and the Caribbean as shown in Figure 2. The majority of GEF funding is directed to projects that promote a variety of technologies as shown in Figure 3. The reason is that the GEF's role is to catalyze and transform energy markets generally, not to pick individual renewable energy technologies within the market. That said, however, when local climatic and market conditions clearly favor investing in specific technologies, the GEF has responded effectively by allocating targeted funds.

Interventions for Advancing Renewable Energy Technologies

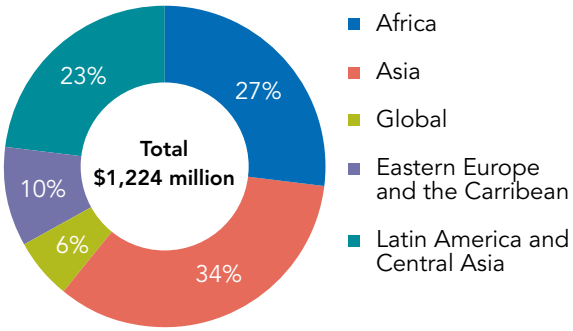
The GEF's catalytic approach to promoting renewable energy is multidimensional, mixing interventions that range from barrier removal and capacity building to direct financing of investments in renewable energy technologies. The renewable energy projects undertaken also involve many stakeholders—governments, private firms (manufacturers and dealers), financial intermediaries, recipients of technical assistance, technology suppliers and contractors, and project developers.

Building favorable market conditions

The GEF pursues establishment of market conditions for increased renewable energy production and use through the development of enabling policies and regulatory frameworks, standards and certification, information and awareness, and capacity building.

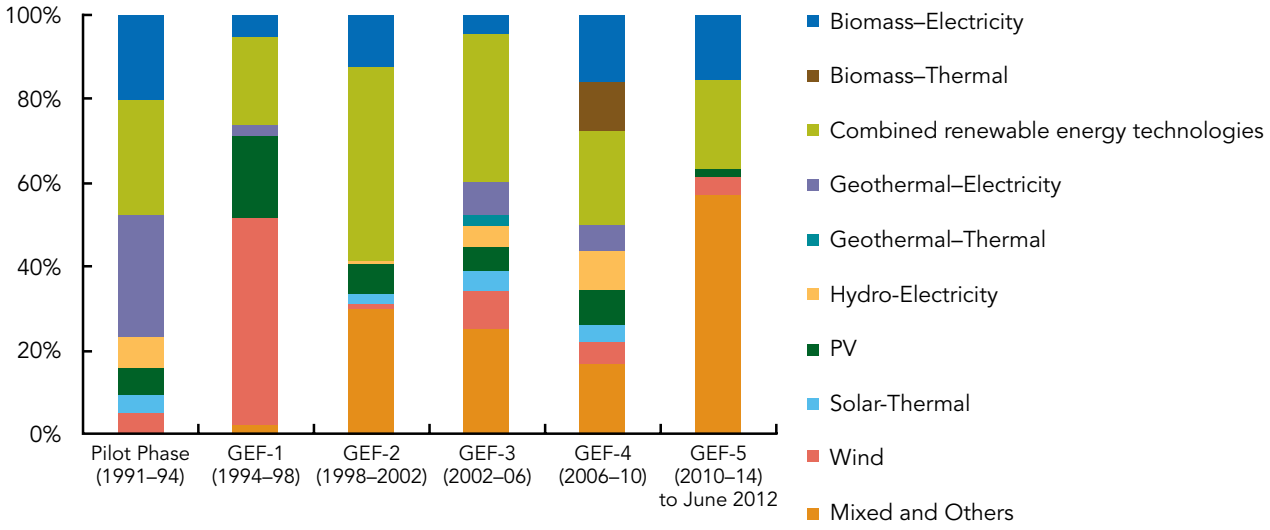
National policies are seen as critical to creating the conditions necessary for renewable energy market development. Most GEF projects have contributed directly to the development of such policies, for example, by drafting or revising national strategies, or by developing roadmaps and national action plans for renewable energy development.

FIGURE 2 REGIONAL DISTRIBUTION OF THE GEF PORTFOLIO IN RENEWABLE ENERGY, BY FUNDING LEVEL



Source: GEF Project Tracking and Management Information System, 2012.

FIGURE 3 GEF INVESTMENT SHARE, BY RENEWABLE ENERGY TECHNOLOGY TYPES (%)



Source: GEF Project Tracking and Management Information System, 2012.

Another area where the GEF has been successful is in developing standards, testing, and certification of renewable energy technologies. This is a vitally important contribution; effective standards and testing can significantly improve quality, reliability, and consumer acceptance.

In parallel, most GEF projects support awareness-raising activities such as distribution of promotional material and production of audiovisual tools that help build community trust in renewable energy technologies. The GEF also helps recipient countries build technical and institutional capacity by organizing workshops and by training government officials, local engineers, and other technical staff.

Finance for investments

The availability of affordable finance remains a key barrier for renewable energy investments, especially in developing countries. The GEF projects focus on understanding the nature of financial barriers so that effective barrier removal can be targeted—whether at financial intermediaries (banks, development finance institutions, and micro-lenders), equipment suppliers, dealers, service companies, end-users, or a combination of several or all of these.

A common GEF practice is to test innovative financing approaches in order to increase access to local funding. Such approaches differ according to the status of the local financial sector, the type of financial barriers to be overcome, and the type of business model employed. For example, in the case of distributed small-scale power generation, sales-based business models may require a degree of financing for suppliers and dealers. However, the main need is microfinance for consumers. Over the past 21 years, the GEF, through its Agencies, has strived to:

- **Provide grants and contingent financing for project preparation and investment.** The GEF offers contingent loans and grants to cover up-front project development capital costs. A contingent loan has an interest rate and payment schedule similar to a traditional loan, but the loan can be forgiven if certain conditions are met.

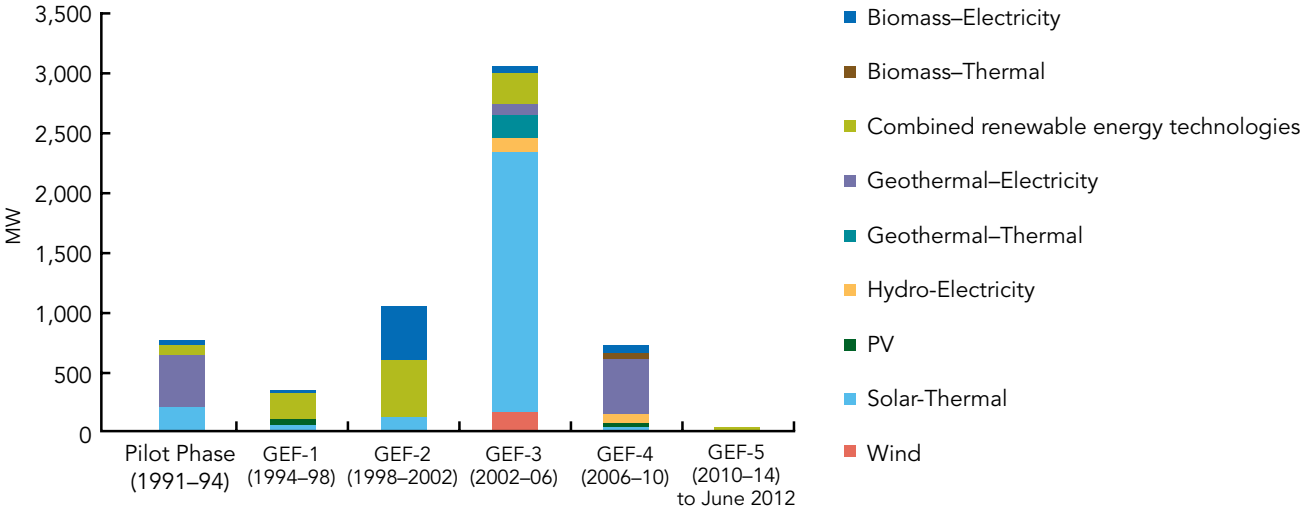
- **Mitigate technology-specific project risks.** For example, the highest risk during geothermal plant development occurs when the first well is drilled, even if there has been successful surface-based geophysical exploration. The GEF projects in Africa, the Caribbean, and Eastern Europe are developing risk mitigation facilities to insure investors against the geological and technical risks during development of such projects.

- **Initiate microfinance schemes.** Extending financing to private consumers, such as households and small enterprises, for the purchase of renewable energy equipment is often considered a low priority by financial institutions (FIs), especially in the developing world. The GEF has supported existing FIs or developed new microfinance institutions to provide lending to such recipients, for example, for the purchase of solar home energy systems in Bangladesh and Uganda.

Renewable Energy Technologies Supported by the GEF

From October 1991 to July 2012, through direct investments alone, GEF projects have contributed to the installation of approximately 6.2 GW of renewable energy generating capacity. This installed capacity consists of solar energy, wind power, geothermal energy, small hydro-power, and biomass for either heat or power generation. Some projects involved the installation of more than one technology, and therefore are classified as combined technologies as shown in Figure 4.

FIGURE 4 INSTALLED CAPACITY, BY RENEWABLE ENERGY TECHNOLOGIES



Note: MW (include both thermal and electricity) corresponds to 186 stand alone renewable energy projects (as of June 2012).

Source: GEF Project Tracking and Management Information System, 2012.

Solar Energy

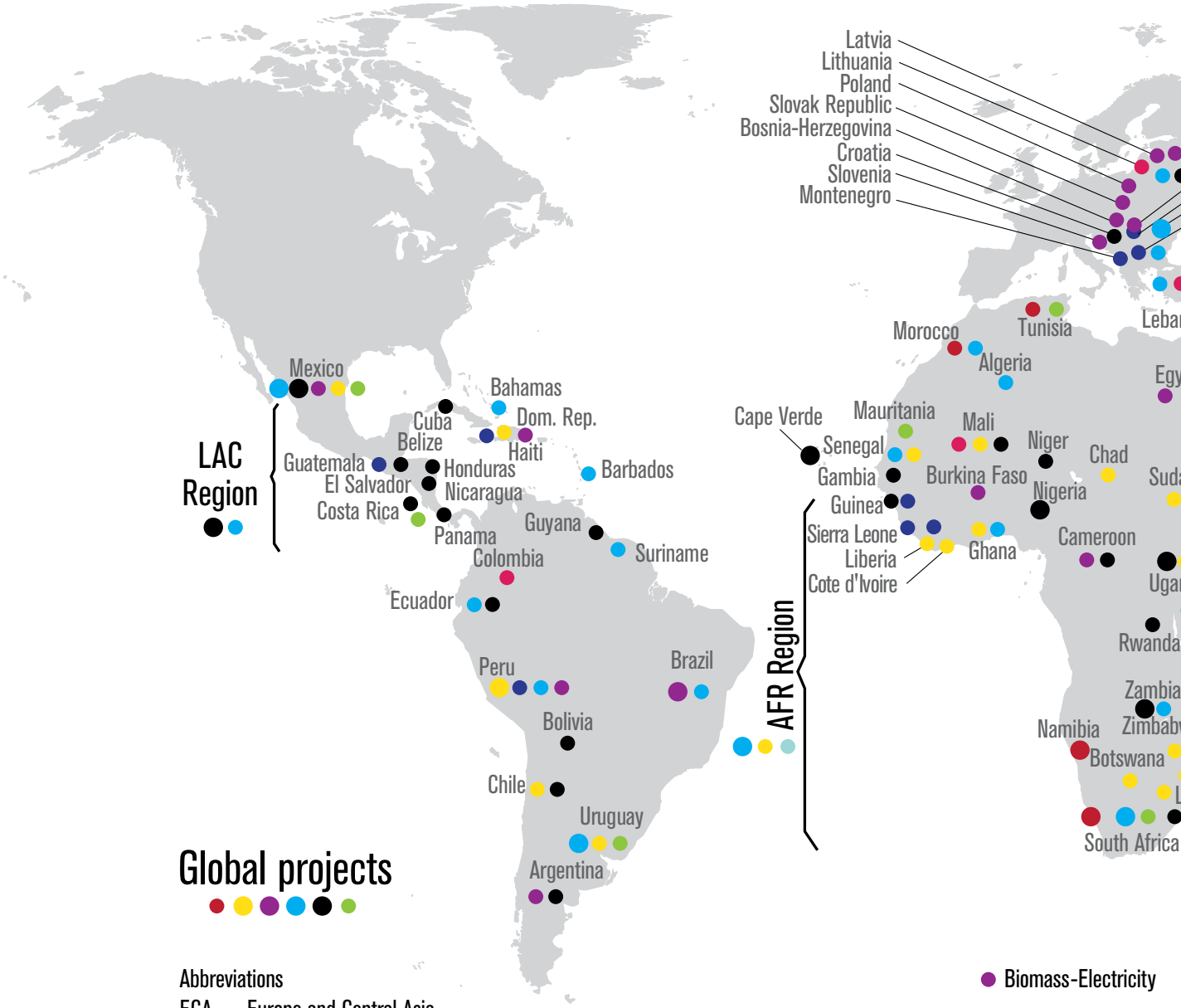
Solar energy systems can harness the sun's rays as a high-temperature clean energy source for heat or electricity. Solar energy can be used directly to heat water, or for household heating systems by means of solar thermal collectors. Solar energy can be converted to electricity through PV systems, and can be concentrated to produce high-temperature heat to power thermodynamic cycles for producing electricity. The abundance of solar radiation in most developing countries makes solar energy technologies a priority for the developing world.

Solar Thermal Heating

The GEF has supported 14 national and multi-national solar thermal projects in 30 countries with financing of $186.1 million. The GEF funds have mobilized $393.1 million in co-financing and have led to the installation of approximately 2.5 GW of thermal power.

Although solar water heater technology is sometimes considered straightforward, the quality of fittings, solar collectors, and installation have a large impact on overall effectiveness. Inexpensive materials, poor workmanship, and shoddy installation have often resulted in nonfunctional units and abandoned systems. The GEF's experience has shown that well-trained technicians and quality assurance practices are critical to the successful dissemination of this technology.

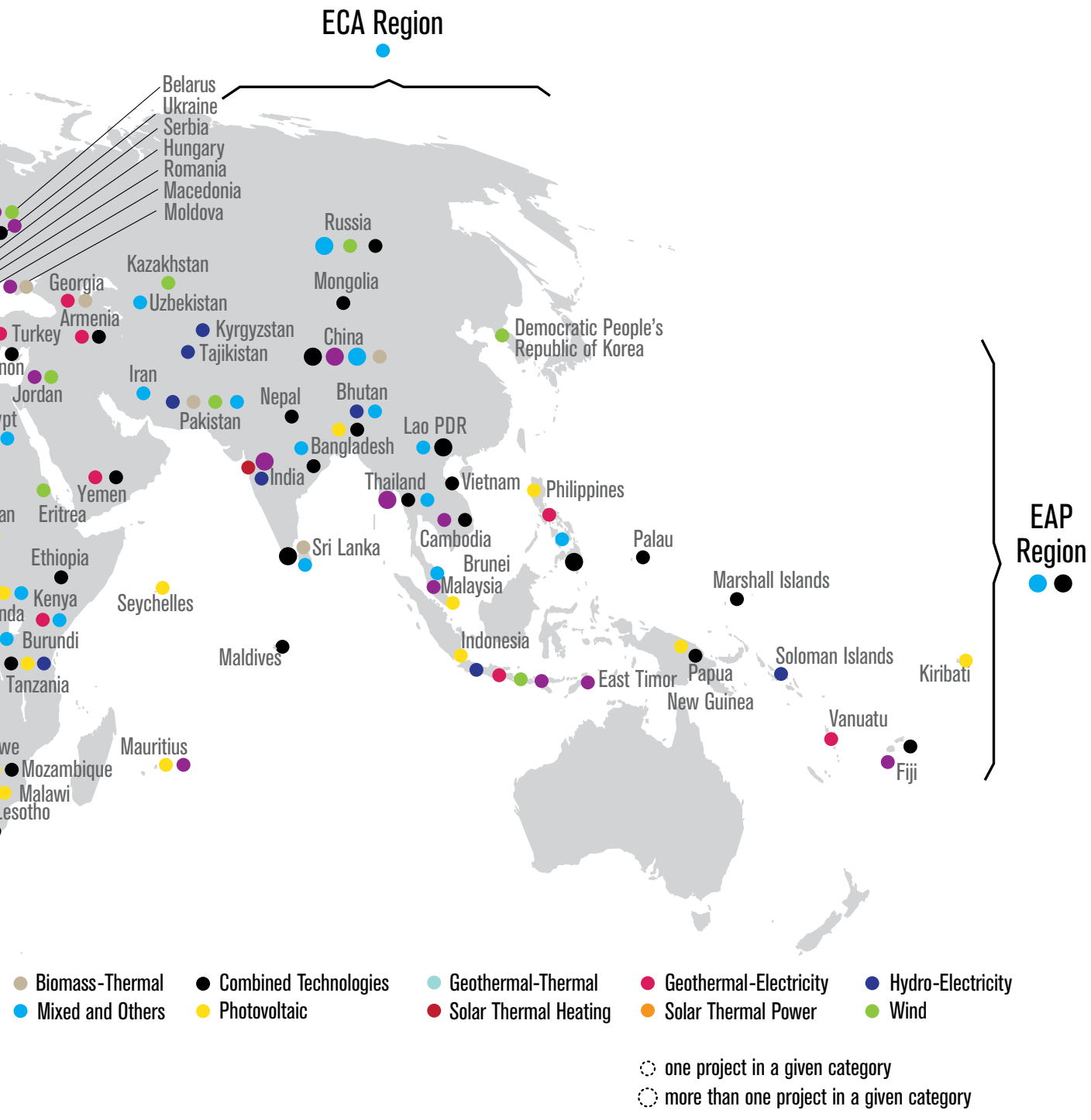
GEF Renewable Energy Projects around the World



Abbreviations

ECA	Europe and Central Asia
AFR	Africa
EAP	East Asia and the Pacific
LAC	Latin America and the Caribbean

Combined Technologies: Projects combining several renewable energy technologies
Mixed and Others: Projects combining renewable energy with other GEF5 climate change mitigation objectives (e.g. energy efficiency)


ECA Region
Belarus
Ukraine
Serbia
Hungary
Romania
Macedonia
Moldova
Russia
Kazakhstan
Georgia
Uzbekistan
Mongolia
Armenia
Turkey
Kyrgyzstan
Tajikistan
China
Democratic People's Republic of Korea
Iran
Jordan
Nepal
Bhutan
Pakistan
Lao PDR
Bangladesh
India
Thailand
Vietnam
Philippines
Yemen
Eritrea
Sri Lanka
Cambodia
Palau
Ethiopia
Brunei
Malaysia
Marshall Islands
Kenya
Seychelles
Burundi
Maldives
Indonesia
Soloman Islands
Kiribati
Tanzania
East Timor
Papua New Guinea
Vanuatu
Mauritius
Mozambique
Malawi
Fiji
EAP Region
Biomass-Thermal
Combined Technologies
Geothermal-Thermal
Geothermal-Electricity
Hydro-Electricity
Mixed and Others
Photovoltaic
Solar Thermal Heating
Solar Thermal Power
Wind
one project in a given category
more than one project in a given category

CASE STUDY: TUNISIA—SOLAR WATER HEATING

Project Title:	Solar Water Heating in Tunisia
GEF Agency:	World Bank
GEF Financing:	$4.0 million
Co-financing:	$16.9 million
Dates of Implementation:	1994–2004

Objective

The project aimed to help Tunisia substitute solar energy for fossil fuels in public and commercial institutions and to demonstrate solar water heating's potential to reduce global warming.

Outcomes

By contributing 35 percent of the cost of investment before tax in solar water heaters (including installation), the GEF grant, together with Belgian co-financing, helped incentivize users to invest in solar water heaters rather than in conventional water heating technologies. During project implementation, solar water heater installations tripled: about 80,000 m^2 (56 MW) of solar water heater panels were installed, of which 51,060 m^2 (35 MW) were installed within the framework of the project. The carbon dioxide (CO_2) emission reductions that can be attributed to the GEF project amount to about 25,000 tonnes annually. Quality control and system maintenance ensured efficient and effective ongoing operation.

Solar Thermal Power

The GEF has utilized most of its solar thermal energy funding on CSP technology. The GEF has supported five countries to harness the potential of solar thermal power. The projects were funded with $152.5 million of GEF resources, while leveraging $1.30 billion in co-financing. They will lead to the installation of 75 MW of electric generating capacity. The GEF, in partnership with the World Bank, developed a portfolio of three CSP demonstration plants in Mexico, Morocco, and Egypt. The projects built solar fields, typically of 30 MW, as part of hybrid gas-turbine plants. Successful hybridization of gas turbine and solar power plants enables such projects to dispatch power at will, making them more economically attractive. However, these projects have progressed very slowly, indicating that the technology did not meet with the enthusiastic uptake originally anticipated.

One lesson from these experiences is that it is difficult for developing countries to adopt technologies that are not fully commercialized; failure to achieve market viability in developed countries damages the technology's credibility elsewhere. In the case of the CSP plants, construction costs increased as the projects progressed. Host countries were burdened with both additional costs and the risk that the projects might not produce the rated power on a firm basis. In fact, in two cases, the additional costs exceeded the GEF's funding. Both countries had to provide significant cash subsidies to enable the plants to move forward.

Mirrors of CSP in Egypt

CASE STUDY: EGYPT—SOLAR THERMAL POWER

Project Title:	Solar Thermal Hybrid Project
GEF Agency:	World Bank
GEF Financing:	$49.8 million
Co-financing:	$277 million
Dates of Implementation:	2007–2011

Objectives

The objectives of the project were:

- To provide of modern infrastructure by efficient private suppliers and operators;
- To increase energy generating capacity from renewable resources that can reduce local and regional pollution;
- To increase capacity to develop large-scale innovative renewable energy projects;
- To position Egypt as source of expertise and equipment in future solar thermal power projects internationally; and
- To develop renewable energy supply with private investments.

Outcomes

The outcomes of the project included:

- Demonstration of viability of hybrid solar thermal power generation in Egypt;
- Accelerated market penetration of large-scale back-up power generation technologies; and
- Reduction of GHG emissions.

The incremental physical benefits of the project included the following: (1) increased renewable electricity production by 35.1 GWh/year, and (2) reduced GHG emissions by 15,410 tonnes of carbon dioxide equivalent (CO_2 eq) (World Bank 2012).

Off-Grid Photovoltaic

Between October 1991 and July 2012, the GEF helped deploy solar energy technologies to many individuals lacking access to electricity. As those without electricity often live in remote areas, expansion of the power grid to them is neither cost effective nor affordable.

In response to this need, the GEF has funded over 20 stand-alone and about 45 mixed (i.e., including additional GEF program areas, such as energy efficiency and transport) and technology transfer projects in 68 countries that provide expanded access to electricity through use of solar home systems and off-grid PV electricity. The GEF has supported these projects by investing $379 million from the GEF Trust Fund and by mobilizing $2.86 billion through co-financing. These projects have led to the installation of an estimated peak power of 125 MW.

GEF projects have led also to the rapid growth of the PV industry in several countries, improving the quality of production and reducing costs, thereby expanding the market for solar home systems and other off-grid PV applications.

A solar system in a tent city

CASE STUDY: INDIA—OFF-GRID PHOTOVOLTAIC

Project Title:	Alternate Energy
GEF Agency:	World Bank
GEF Financing:	$26 million
Co-financing:	$424 million
Dates of Implementation:	1993–2002

Objectives

The project objectives were as follows:

- To promote commercialization of renewable energy technologies by strengthening the Indian Renewable Energy Development Agency's (IREDA) capacity to promote and finance entrepreneurial investments in alternate energy;
- To create marketing and financing mechanisms for the sale and delivery of alternate energy systems based on cost-recovery principles;
- To strengthen the institutional framework for encouraging private-sector investments in non-conventional power generation; and
- To promote environmentally sound investments to reduce the energy sector's dependence on fossil fuels.

Outcomes

The GEF financing for PV capacity was 2.1 Megawatt-peak (MWp) in 78 sub-projects, slightly below the target of 2.5 MWp. Products financed ranged from 5 Wp solar lanterns, 900 Wp PV irrigation pumps, 500–2500 Wp solar power packs, and 25 kWp village power schemes to a 200 kWp grid-tied system. The IREDA financed an additional 4 MWp of PV irrigation pumps with assistance from the Ministry of Nonconventional Energy Sources. Evidence of positive development impacts from PV use among poorer consumers are emerging, including: five-fold income increase among farmers using PV pumps; a 50 percent increase in net income among some traders using solar instead of kerosene lighting; income increases of 15 to 30 percent in some rural households because of increased home industry output; and longer study hours, under better lighting conditions, for children.

On-Grid Photovoltaic

The GEF has supported the market transfer and installation of grid-connected PV systems in 31 projects. An estimated PV peak power of 52 MW has been installed, mostly in combination with small wind and hydro, and often to support mini-grids. The GEF funded these projects with $172.7 million, obtaining co-financing of almost $1.93 billion.

CASE STUDY: PHILIPPINES—ON-GRID PHOTOVOLTAIC

Project Title:	CEPALCO Distributed Generation PV Power Plant
GEF Agency:	World Bank/International Finance Corporation(IFC)
GEF Financing:	$4 million
Co-financing:	$1.8 million
Dates of Implementation:	2003–2004 (*2009)

Objectives

The overall objectives of the CEPALCO (Cagayan de Oro Electric Power & Light Company) project were to act as a demonstration plant for grid-connected applications of PV power plants in the developing world and to demonstrate the principle of conjunctive PV-hydro peak power generation.

Outcomes

The project supported the construction of a 1 MW (6,500 solar panels on 2 hectares of land) PV power plant which was integrated into the 80-MW distribution network of CEPALCO, a private utility on the Philippine island of Mindanao. The PV system operates in conjunction with a 7 MW hydroelectric plant with dynamic load control, enabling the joint PV/hydro resource to reduce distribution-level and system-level demand, effectively providing reliable generating capacity. The PV plant helped postpone the need for additional substation installations in the distribution system for up to three years, reducing the need for CEPALCO to purchase additional thermal-plant-based power and reducing its GHG emissions by 1,200 tonnes per year.

More importantly, the plant provided the first full-scale demonstration of the environmental and economic benefits of the conjunctive use of hydro- and PV-based power—and represented the first significant use of grid-connected PV in a developing country.

This project marked a significant progress toward solving renewable energy storage issues faced by many renewable energy technologies. The project has developed both solar PV and hydro power feeding into the same grid. If the solar PV power generation plants were sufficient to meet the system demand, the hydro power plants would stop operations to save hydro energy. Otherwise, the hydro power plants would operate to provide additional power to meet the system demand. This arrangement established a good hybrid model using a reservoir of a hydro power to store renewable energy.

Further information is available at:
http://www.cepalco.com.ph/solar.php

*The GEF funding was a loan that turned into a grant after CEPALCO operated the plant successfully for five years.

Wind Power

Wind power is the fastest growing renewable energy resource. By the end of 2011, worldwide capacity reached 197 GW with 3.6 GW added in 2010 alone. Wind power showed a growth rate of 23.6 percent in 2010, the lowest growth since 2004 and the second lowest growth of the past decade. All wind turbines installed by the end of 2010 worldwide can generate 430 Terawatthours (TWh) per annum, more than the total electricity demand of the United Kingdom, the sixth largest economy of the world, and equaling 2.5 percent of global electricity consumption. The wind sector in 2010 had revenue of over $50 billion and employed 670,000 persons worldwide (World Wind Energy Association (WWEA) 2011) .

As of July 2012, the wind power industry faces a large number of technical, economic, financial, institutional, market, and other barriers. To overcome these barriers, many countries have employed policy instruments, including capital subsidies, tax incentives, tradable energy certificates, feed-in tariffs, grid access guarantees, and mandatory standards.

The GEF has financed 54 wind power projects in more than 34 countries. GEF funds and co-financing in these projects were $352 million and $2.53 billion, respectively. These investments have led to installation of almost 972 MW of electric power.

Experience has shown that resource availability (i.e., wind) and familiarity with the technology are key considerations. However, the most significant barrier to successful growth in the wind market are regulations that deter renewable generators' access to the grid.

Worldwide experience demonstrates several successful solutions to this problem of access, including the creation of a renewable portfolio standard and a guaranteed renewable "feed-in" tariff. The GEF has helped countries understand and adopt appropriate policies and regulations.

CASE STUDY: CHINA—WIND POWER

Project Title:	Renewable Energy Scale-Up Program (CRESP), Phase 1
GEF Agency:	World Bank
GEF Financing:	$40.2 million
Co-financing:	$188.6 million
Dates of Implementation:	2000–2011

Objective

The objective of the project was to scale up China's renewable energy market by developing the mandated market share policy of China and engaging other interventions and commercial renewable energy suppliers in the market.

Outcomes

This China project utilized GEF funds cost-effectively in terms of both co-financing and GHG emission reductions. Experience in China further demonstrated that integrating the GEF, the World Bank, and carbon financing could have a transformative impact on the scaling up of renewable energy. Under this China Renewable Energy Scale-up Program (CRESP), the World Bank initiated active policy dialogues with the Chinese government to introduce international best available technologies and practices of renewable energy market policies and to assist the government in developing renewable energy policy frameworks. As a result, China passed a renewable energy law to require mandatory purchase of renewable energy by the grids and to allow the incremental costs to be shared nationwide. The policy dialogue was complemented by three World Bank scaling-up projects:

- A World Bank investment ($ 173 million) in 200 MW wind farms,
- A 25 MW biomass power plant, and
- Small hydro projects.

These were one of the first groups of such large-scale wind and biomass power plants in China. Similarly, the World Bank's carbon financing played a key role in improving the financial viability of the Inner Mongolia wind farm, which was not financially viable at a power tariff of $0.06/kWh set by the government. In addition, the CRESP provided cost-shared research and development (R&D) to domestic wind manufacturers supporting joint design with international design institutes to transfer international wind turbine technologies to China. The market-pull approach provided by favorable tariff policies—together with technology-push through cost-shared R&D and the government's requirement of 70 percent local content—has boosted the domestic wind manufacturing industry (World Bank, 2010).

Wind power at the Centro Regional de Tecnologia Eólica in Mexico

CASE STUDY: MEXICO—WIND POWER

Project One Title:	Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power
GEF Agency:	UNDP
GEF Financing:	$4.74 million
Co-financing:	$7.07 million
Dates of Implementation:	2004–2011

Project Two Title:	Large Scale Renewable Energy Development Project
GEF Agency:	World Bank
GEF Financing:	$25 million
Co-financing:	$247.5 million
Dates of Implementation:	2007–2014

Project Three Title:	Technology Transfer-Pilot (GEF 4): Promotion and Development of Local Wind Technologies in Mexico
GEF Agency:	Inter-American Development Bank (IDB)
GEF Financing:	$5.5 million
Co-financing:	$33.6 million
Dates of Implementation:	2012–2015

Objectives

The main objectives of these projects are as follows:

- To create an enabling environment for the development and use of distributed wind power that is connected to the grid by removing the existing regulatory and technical barriers;
- To assist Mexico in stimulating and accelerating the commercialization of renewable energy applications and markets, particularly at the grid-connected level; and
- To assist Mexico in developing initial experience in commercially-based grid-connected renewable energy applications by supporting construction of an approximately 101 MW wind farm financed by independent power producers.

Outcomes

The outcomes of these projects include:

- Development of Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power in Mexico;
- Creation of a Regional Wind Technology Centre (Centro Regional de Tecnología Eólica), which offers support to interested wind turbine manufacturers and provides training to local technicians;
- Development of the 83.5 MW La Venta II wind power project in Oaxaca that became operational in January 2007;
- Effective regulatory and institutional framework to enable distributed wind power development;
- Project development capacities among national stakeholders, including improved access to finance to allow for widespread replication of distributed wind power;
- A successful independent power producer tender resulting in construction and operation of a 101 MW wind farm; and
- Institutional capacity to issue subsequent tenders for additional wind farms and other renewable energy resource development at a higher reference price and/or lower incentive support level (World Bank 2006).

Geothermal Energy

The GEF has supported 11 projects to help 31 countries exploit their geothermal energy potential in the past 21 years. The projects were financed with $90.9 million of GEF resources, which mobilized $1.70 billion in co-financing. The energy to be extracted is expected to be more than 1,059 MW of electricity plus 117 MW of thermal (or heat) energy.

This experience has shown that, in addition to barriers of access to the grid faced by renewable energy generators, an additional—and especially difficult—barrier is the cost of confirming the presence and location of exploitable geothermal resources. Traditionally, each site is confirmed exploitable by drilling—at a cost of up to several million dollars. To deal with this barrier, the GEF has established several contingent funding mechanisms to reimburse the costs of drilling nonproductive wells.

Another way of reducing the risk of drilling nonproductive wells may be found in the Joint geophysical imaging for geothermal reservoir assessment in East Africa. Advanced geophysical imaging techniques have been used to locate commercially exploitable geothermal power; results to date indicate that wells found using this approach, when combined with directional drilling, yield 4 to 6 MW per well as opposed to the previous 2 MW per well. The success rate for test wells has also improved, as has targeting of wells for reinjection of spent geothermal fluid creating sustainable geothermal field output over time.

CASE STUDY: PHILIPPINES—GEOTHERMAL POWER

Project Title:	Republic of the Philippines Leyte-Luzon Geothermal Project
GEF Agency:	World Bank
GEF Financing:	$30 million
Co-financing	$1,303 million
Dates of Implementation:	1995–2000

Objectives

The objectives of the project included the following:

- To meet the rapidly increasing demand for power in Luzon using indigenous and environmentally superior geothermal energy;
- To strengthen the energy sector by implementing institutional, planning, and financial improvements recommended by the Energy Sector Plan of the government of the Philippines;
- To support large ongoing private-sector participation in power generation, and facilitate this by extending the national grid;
- To strengthen the National Power Corporation's (NPC) capabilities in environmental and social impact analysis;
- To introduce enhanced co-financing operations in the Philippines; and
- To ensure the financial viability of NPC and the Philippine National Oil Corporation by undertaking a long-overdue investment program.

Outcomes

While the GEF grant of $30 million may seem small in the overall investment of $1.3 billion, it was critical to the investment decision and influenced the government's choice of geothermal over coal.

Geothermal capacity of 385 MW was installed; 59 producer and injector wells were drilled (nine percent fewer than the appraisal estimate of 65 wells), while construction of steam-gathering systems and related sub-transmission systems was completed on schedule in mid-1997. The capacity developed was lower than the appraisal estimate of 440 MW, because the Alto Peak sector proved problematic and was abandoned. Nevertheless, the combined system surpassed the required annual energy output specified under the agreement with NPC, with the power plants operating within the plant factor commitment in the build-operate-transfer contract. Further, the project significantly mitigated GHG emissions, as an alternative coal-fired plant would have meant incremental CO_2 eq of about 2.2 million tonnes per year.

Small Hydropower

Small hydro power is a mature technology, but it is not well disseminated. The GEF has supported the technology in 20 countries while identifying barriers to its adoption, including: lack of information about the technology and its underlying resource; unsupportive institutional frameworks; regulatory obstacles; and absent or inadequate financing.

In general, mini hydroelectric grids are progressing from pilot demonstration projects to policy options for rural villages. Hydroelectric resources often require joint community management, participation, leadership, teamwork, and coordination. Under a project in Sri Lanka, mini-grid hydro installations were built, owned, and operated by the communities through electricity cooperative societies that were set up specifically for that purpose.

From October 1991 to July 2012, small hydropower was supported by the GEF through 61 small hydro projects in more than 50 countries with $230.5 million of GEF funding and $1.84 billion in co-financing. Among other outcomes, these projects have led to investments in 414 MW of installed capacity, mostly for rural and decentralized electrification.

In West Africa, some countries are implementing projects to develop a market environment for improved access to mini hydro-based energy services. The essential elements of the market-based approach envisaged are a critical mass of skilled and knowledgeable technicians; increased awareness of the appropriate technologies and best practices; and access to innovative financial mechanisms.

The West Africa projects aim to establish two to three pilot demonstration sites each in isolated off-grid communities and implement them using a learning-by-doing approach in order to build local capacity.

Jasmine crop grown through irrigation facility provided through the Biomass Energy for Rural India Project

CASE STUDY: INDONESIA—SMALL HYDROPOWER

Project Title:	Integrated Microhydro Development and Application Program, Part I
GEF Agency:	UNDP
GEF Financing:	$2.1 million
Co-financing:	$18.5 million
Dates of Implementation:	2007–2010

Objectives

The objectives of the project were to remove key market, policy, technical, and financial barriers to micro-hydro development and utilization, and to reduce GHG emissions from fossil fuel-based power generation.

Outcomes

The project had four main outcomes:

- Enhanced private-sector interest and involvement in capacity building within the micro-hydro business community;
- Increased number of community-based micro-hydro projects as a result of institutional capacity building;
- Improved availability and local knowledge of the technology and its applications; and
- Increased implementation of micro-hydro projects for electricity and production.

From 2007 to 2010, this project created at approximately 40 community-based micro-hydro projects for productive use and mitigated 60,800 tonnes of CO_2 eq per annum.

Biomass

Biomass projects are of interest to the GEF because biomass represents an energy source with zero net carbon emissions if produced sustainably. The GEF-funded biomass projects include power production (combustion, gasification, cogeneration, and waste-to-energy) from forestry and agricultural wastes, including sugarcane bagasse and waste, husks, palm oil residues, wood chips, sawmill waste, municipal waste, and production of biofuels. Many of these projects focus on technology demonstration, but also include activities that seek to address enabling policies, availability of finance, business infrastructure, awareness, capacity development, and technology transfer.

In more than 40 countries, the GEF has funded 62 projects with 722 MW electric and 212 MW thermal with $275 million that leveraged $2.1 billion of co-financing. Technology itself is frequently no longer the barrier and can be obtained on a commercial basis. Rather, the challenge is demonstration of the commercial and institutional framework in which the technologies can be profitably deployed and replicated.

Biogas Baan Maekon in Thailand

CASE STUDY: THAILAND—BIOMASS COGENERATION

Project Title:	Removal of Barriers to Biomass Power Generation and Cogeneration
GEF Agency:	UNDP
GEF Financing:	$6.8 million
Co-financing:	$101.63 million
Dates of Implementation:	2001–2009

Objectives

This project had the following objectives:

- To build capacity to provide information and services to potential biomass power project investors;
- To improve the regulatory framework to provide financial incentives to biomass cogeneration and power projects;
- To increase access to commercial financing for biomass cogeneration and power projects; and
- To facilitate the implementation of two initial biomass power pilot plants through support for commercial guarantees that would reduce technical risks associated with deployment of this new technology.

Outcomes

Two pilot biomass power plants with a total capacity of 32 MW electric power were constructed with GEF support, which serve as valuable demonstration plants for rural communities. Significant project impacts also include influencing government policy, such as measures adding a feed-in tariff to make biomass power generation more commercially viable. A Biomass One-Stop Clearing House was also created and has responded well to biomass investors and public interest.

The project had facilitated the installation of 398 MW of electricity capacity that generate over 358GWh of electricity annually from biomass power plants and avoid 194,722 tonnes CO_2 eq per year.

Group biogas plant to provide clean cooking gas from Biomass Energy for Rural India Project

CASE STUDY: INDIA—BIOMASS GASIFICATION

Project Title:	Biomass Energy for Rural India
GEF Agency:	UNDP
GEF Financing:	$4.02 million
Co-financing:	$4.61 million
Dates of Implementation:	2001–2010

Objectives

The objectives of the project were to:

- To demonstrate the technical feasibility and financial viability of bioenergy technologies—including biomass gasification for power generation—on a significant scale;
- To build capacity and develop mechanisms for project implementation, management, and monitoring;
- To develop financial, institutional, and market strategies to overcome barriers to large-scale replication of the bioenergy package for decentralized applications; and
- To disseminate bioenergy technology and relevant information on a large scale in 24 villages in Karnataka's Tumkur district.

Outcomes

The project stimulated significant forest growth in the form of energy plantations (2,965 acres), forest regeneration (2,100 acres), and tree-based farming (about 2,471 acres) by villagers. The wood is used to generate electricity in locally manufactured gasifiers. The power generated is sold to the regional electrical distribution company to supply the local population. The project also resulted in 171 families replacing fuel wood with biogas—reducing GHG emissions by 256 tonnes annually.

Co-generation in the Palm Oil Mills in Malaysia

CASE STUDY: LATVIA—BIOMASS COMBUSTION

Project Title:	Economic and Cost-Effective Use of Wood Waste for Municipal Heating Systems
GEF Agency:	UNDP
GEF Financing:	$0.75 million
Co-financing:	$2.73 million
Dates of Implementation:	2001–2005

Objectives

The objectives of the project were to

- To promote the use of wood waste by removing barriers to replacing imported heavy fuel oil (mazut) with local sustainably-produced wood waste in municipal heating systems;
- To promote the development and implementation of an economical commercially-run municipal heating system, providing generation, transmission, and distribution in the municipality of Ludza; and
- To help remove or reduce technical, legislative, institutional, organizational, economic, information-related, and financial barriers related to the replication of a pilot project in the municipality.

Outcomes

Since the project's inception, 11,200 tonnes of CO_2 eq emissions have been avoided annually in Ludza, equating to about 80 percent of the emissions from using heating oil. The project and the financial scheme developed through it have encouraged more than 12 other municipalities to make use of forest wastes in their district heating networks, resulting in over 100,000 tonnes of CO_2 eq avoided annually.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A View to the Future

The GEF supports developing countries and transition economies to new opportunities in renewable energy generation. The GEF support enables enhancement of local capacity to adopt, finance, install, operate, and maintain renewable energy technologies. Investments in promising pre-commercial and commercial renewable energy technologies have been an essential element of the GEF strategy. Since October 1991, the GEF has supported the transfer of more than 20 renewable energy technologies to the developing world. By July 2012, the GEF has achieved the following:

- The stand-alone renewable energy portion of the GEF climate change portfolio amounts to $905 million with co-financing of $6.48 billion. Besides this, GEF has also invested $320 million in mixed and technology transfer projects with renewable energy components. The GEF is the largest public-sector funding source to support new emerging renewable energy technologies and practices in the developing world.
- The GEF-supported activities on renewable energy technologies so far are expected to directly avoid approximately 285 million tonnes of CO_2 eq and indirectly 1.55 billion tonnes of CO_2 eq. On average, the GEF spends $3.17 per tonne of CO_2 eq emissions avoided.

The GEF seeks work with its partner institutions to help countries achieve the following into the future:

- Create markets conducive to renewable energy: GEF intervention under this objective will be a combination of technical assistance for policy and regulatory support, building technical and institutional capacity, and establishing financing mechanisms for investment in the deployment and diffusion of renewable energy technologies.
- Invest in the transfer of renewable energy technologies: The GEF will expand its investments in the transfer of commercially proven renewable energy technologies and emphasize market demonstration and commercialization of promising new technologies. The GEF will step up its efforts to promote the next phase of intervention for successfully demonstrated technologies with the aim of removing further barriers to commercialization and bringing the cost down over time.
- Promote access to modern energy services: Given the acute demand for energy access and services in rural areas in developing countries, GEF support will also cover decentralized production of electricity and heat using indigenous renewable sources. GEF investments will be boosted, particularly in Sub-Saharan Africa, South Asia, and Small Island Developing States.

ABBREVIATIONS AND ACRONYMS

CEPALCO	Cagayan de Oro Electric Power & Light Company
CO_2	Carbon Dioxide
CO_2 eq	Carbon Dioxide Equivalent
CRESP	China Renewable Energy Scale Up Program
CSP	Concentrating Solar Power
EIA	Energy Information Administration, United States Department of Energy
EST	Environmentally Sound Technology
FI	Financial Institution
GEA	Global Energy Assessment
GEF	Global Environment Facility
GHG	Greenhouse Gas
IDB	Inter-American Development Bank
IEA	International Energy Agency
IFC	International Finance Corporation
IREDA	Indian Renewable Energy Development Agency
NPC	National Power Corporation
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
R&D	Research and Development
SME	Small and Medium-sized Enterprise
UNDP	United Nations Development Programme
WWEA	World Wind Energy Association

UNITS OF MEASURE

Acre	4,047 m²
GW	Gigawatt (billion Watts)
GWh	Gigawatt-hour (billion Watt-hours)
kWp	Kilowatt-peak
MW	Megawatt (million Watts)
MWp	Megawatt-peak
TWh	Terawatt (trillion Watts)
Wp	Watt-peak

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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.

Since 1991, the GEF has achieved a strong track record with developing countries and countries with economies in transition, providing US$ 10.5 billion in grants and leveraging $51 billion in co-financing for over 2,700 projects in over 165 countries. Through its Small Grants Programme (SGP), the GEF has also made more than 14,000 small grants directly to civil society and community based organizations, totaling US$ 634 million.

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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