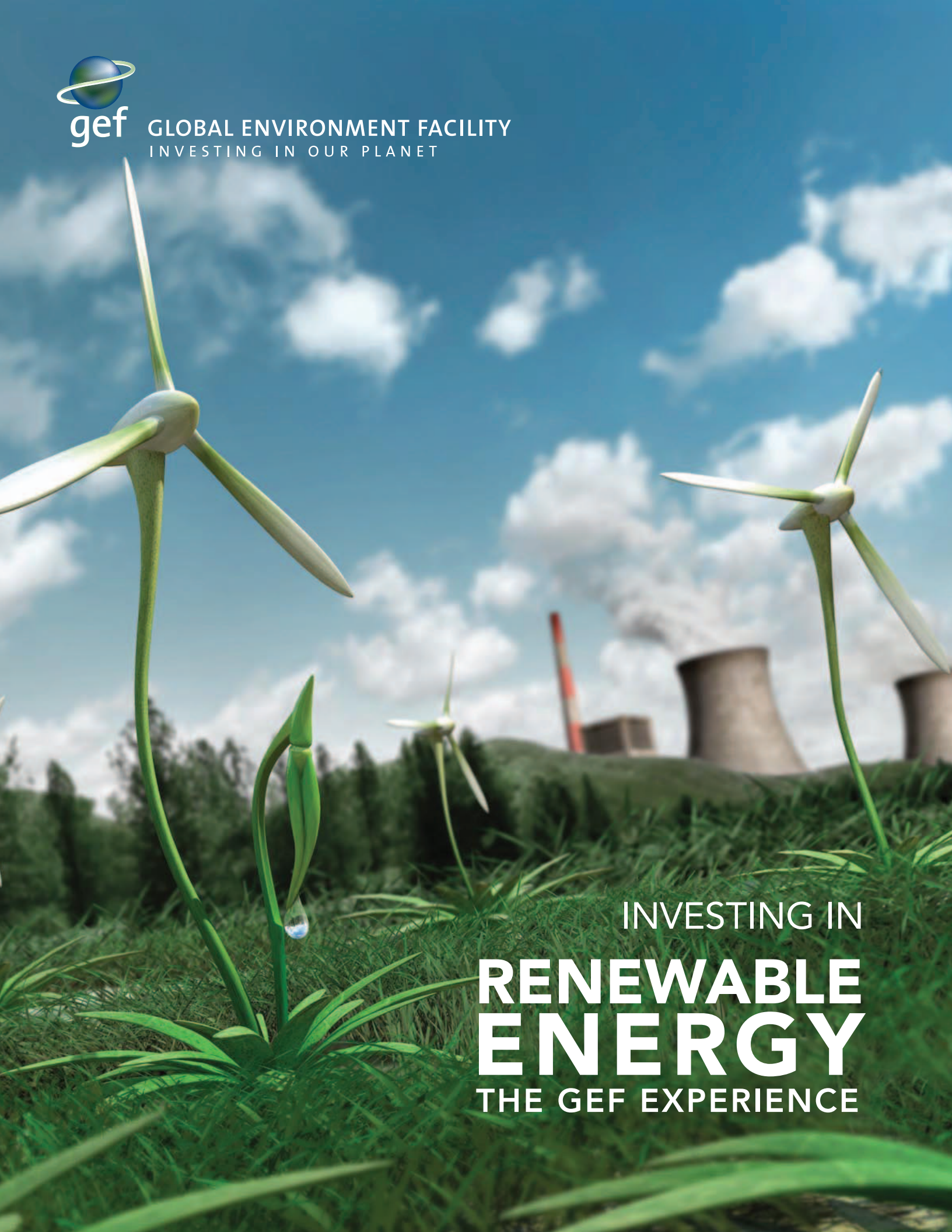

gef
GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET
INVESTING IN
RENEWABLE
ENERGY
THE GEF EXPERIENCE

Foreword

Monique Barbut
CEO and Chairperson
Global Environment Facility

Light of hope - powered by small wind and photovoltaic

The world is at critical crossroads for the future of energy. Climate change, increasing dependence on oil and other fossil fuels, growing imports, and rising energy costs are making the developing world more vulnerable than ever before. These challenges call for a comprehensive and ambitious response.

The renewable energy sector is the one energy sector that stands out—for its ability to reduce greenhouse gas emissions and pollution and to exploit local and decentralized energy sources—wind, solar, hydro-electric, tidal, geothermal, and biomass. These renewable sources are immune to the volatility of the fossil fuel markets and bring the added benefits of stimulating employment, technological development, and economic growth. There is no doubt that renewable energies constitute a key element of a sustainable future.

This is why renewable energy has been a fundamental pillar of the operations of the Global Environment Facility (GEF). Over the past 18 years, the GEF has demonstrated unique leadership by investing US$1.1 billion in renewable energy initiatives in almost 100 developing countries and economies in transition. These investments have been augmented by an additional US$8.3 billion in cofinancing. GEF support has been instrumental in putting renewable energy on the agenda of all major developing countries and emerging economies, 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 (RETs) in all levels of society—cook stoves and lighting at household levels; minigrids for communities; grid-connected bulk power for countries. These initiatives have helped the GEF become the largest public sector renewable energy technology transfer mechanism in the world, with investments that have contributed to the installation of 3 GW electric and 2.8 GW thermal of renewable energy capacity, resulting in an estimated direct avoidance of 290 million tonnes CO_2 over time. Through catalytic effects and replication, indirect Greenhouse Gas emission reductions are estimated to be 1.2 billion tonnes of CO_2.

The GEF was among the first to support market transformation for RETs and practices. GEF support has helped developing countries develop and apply effective RET promotion policies. One example is GEF support for the successful expansion of the renewable electricity market in China. The regulations and policy changes put in place have provided remarkable results and will yield benefits for decades to come. The GEF has also been at the forefront of advancing innovative market-based mechanisms and financial instruments to promote renewable energy, including energy service companies, partial-risk guarantees, and revolving and equity funds.

The GEF has also been a pioneer in the demonstration and deployment of new, precommercial RETs in developing countries. The most significant technology to receive support has been concentrating solar power (CSP). Support in such projects focuses on investments and on ensuring the technologies are demonstrated and deployed with a view toward future commercialization.

The GEF's work in renewable energy and climate change has benefited the 2 billion people in the developing world who lack adequate energy services and rely on traditional biomass to meet their basic energy needs. Examples include GEF leadership in financing and disseminating solar home systems, solar lanterns, and renewable power for water and irrigation pumps in Sub-Saharan Africa and South Asia and help provided to many utilities in developing countries to increase their capabilities and capacities to operate and integrate renewable power generation into existing facilities and grids.

The GEF remains committed to promoting renewable energy in developing countries and economies in transition as an essential component of sustainable development that can face the climate change challenge. We hope that the following pages will help readers gain a better understanding of our efforts in the field of renewable energy, and will inspire enthusiasm and more successes.

PV module manufacturing in China

Renewable Energy Challenges and Opportunities for the Developing World

As developing countries expand their economies and reduce poverty, they face major climate change and energy challenges. The mere facts are cause for alarm:

- World energy consumption is projected to increase from 138 TWh in 2006 to 162 TWh in 2015 and 199 TWh in 2030—an increase of 44 percent. Non-OECD countries are expected to increase their consumption by 73 percent, compared with only a 15 percent increase for OECD countries for the same period (EIA 2009).
- Developing countries today emit about half of global CO_2 emissions. Under "business as usual" scenarios, their future emissions increase faster than those of industrialized countries (den Elzen, M., and Hohne, N. 2008).
- 1.6 billion people today, most of them living in Sub-Saharan Africa and South Asia, do not have access to electricity. Over two billion people remain dependent on biomass for their basic cooking and heating energy needs. Eighty percent of Sub-Saharan Africa's population relies on kerosene and batteries in their households and diesel generators for their businesses (World Bank 2008).
- Gross domestic product per capita and energy per capita will remain lower in most of the developing countries than in industrialized countries over the next decades. Energy-related CO_2 emissions per capita will also remain significantly lower in most developing countries for the decades to come (World Bank 2008).
- In the face of growing energy demand, conventional energy sources are environmentally, economically, and socially unsustainable and their continued use will contribute greatly to an increase in CO_2 emissions (World Bank 2008).
- Energy use accounts for about 65 percent of the world's greenhouse gas emissions (OECD/IEA 2009).

Energy is at the heart of widespread social, economic, and climate problems. Energy must be at the heart of the solution. Without access to clean, reliable, and efficient energy services, the poor are deprived of the most basic opportunities for economic development and improved living standards.

Clearly, energy demand and supply patterns both must be altered. This is a major challenge that demands comprehensive and sustainable solutions. In this context, the importance of renewable energy (RE) is beyond dispute. 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 and power cottage industries, to light homes, schools, and hospitals—all services of premier importance and immeasurable impact in the remote rural areas.

Renewable energy technologies can also play crucial roles in employment and economic growth. They are more labor-intensive than conventional technologies for the same energy output (Pachauri, R. 2009)—but at the same time renewable energy technologies (RETs) employ both local and decentralized workers. For an investment in RETs of US$ 1 million over10 years:

- Wind energy generates 5.70 person-years of employment.
- Solar photovoltaics generate 5.65 person-years.
- The coal industry generates 3.96 person-years.

Most renewable energy resources are virtually untapped in the developing world. Their local and distributed nature means investments in transmission grids are largely unnecessary. This is a cost-saving advantage developed countries do not enjoy, as their centralized energy grids are less appropriate for distributed energy applications.

The main barrier to the widespread use of renewable energy is the high up-front cost, particularly for installing equipment, particularly given the limited economic resources of the people most in need of the technology—most often the rural poor. Strengthening capacity building, promoting enabling environments, developing policy frameworks, and improving demands for RETs can help mitigate steep transaction costs and underdeveloped markets to some degree. However, significantly decarbonizing power production will require considerably more investment in renewable energy, of which at least 75 percent should be directed to non-OECD countries (IEA 2009).

Woman fixing solar charge controller

The GEF Strategy on Renewable Energy

The Global Environment Facility (GEF) addresses the issues related to climate change through two approaches: mitigation and adaptation. On mitigation, the focus is on reducing Greenhouse Gas (GHG) emissions through energy efficiency, renewable energy, and solutions for sustainable transport. On adaptation the focus is on activities that minimize the adverse effects of climate change. Recognizing the importance of energy to economic development, the unfavorable effects of fossil fuels, and the sustainability of renewable energy sources, the GEF has made it a strategic objective to support projects that promote transfer of renewable energy technologies and work with regulatory institutions to reform policies and rules for this vital sector.

Evolution of the GEF Renewable Energy Strategy

During the GEF's pilot phase (1991–94), the strategy was to demonstrate a viable range of technologies useful for stabilizing the concentrations of GHGs in the atmosphere. After restructuring, from GEF-1 (1994–98), to GEF-2 (1998–2002) and GEF-3 (2002–06), the GEF focused on renewable energy technologies that were mature, available on the international market, and profitable, but were prevented from dissemination by informational, institutional, technological, policy, or financial barriers. Projects implemented under the strategy were termed "barrier-removal" projects, as they sought to remove such barriers to promote faster adoption of new technologies and practices. Support has been provided to countries to open up electricity regulations to renewable energy generation and, especially in the field of biomass GEF support has focused largely on the utilization of biomass wastes and residues.

In 2004, this barrier-removal strategy was defined even further to focus on interventions in the following fields:

- **Policy frameworks:** 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 models:** Market-based approaches are preferred; businesses and institutions must be in place to deliver to and service those markets.

- **Availability of financing:** 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 concentrated solar power (CSP), the technology and its costs were themselves the barrier to greater dissemination.

Current Renewable Energy Strategy

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 (2006–10), the GEF committed to two strategic programs on renewable energy: one that promotes market approaches for the supply of and demand for renewable electricity in grid-based systems, and one that promotes sustainable energy production from biomass. 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. The support of not yet mature RETs and the promotion of off-grid renewable energy are not considered a priority for GEF-4.

Fire wood transporter

STRATEGIC PROGRAM ON PROMOTING MARKET APPROACHES FOR RENEWABLE ENERGY

This strategic program promotes market approaches to the supply of and demand for renewable electricity in grid-based systems. The emphasis is upon developing policies and regulatory frameworks that provide limited incremental support to strategically important investments. The outcome is the growth in markets for renewable heat power in participating countries. In order to maximize GHG impacts, priority is given to projects with a large replication potential. Further priority is given to supporting utility-scale power production and cogeneration. One target is to ensure that all countries have adopted regulations leveling the playing field for on-grid renewable energy. Projects include a combination of technical assistance for policy reform and regulation and initial investments to jump-start the market for a specific renewable technology.

STRATEGIC PROGRAM ON PROMOTING SUSTAINABLE ENERGY PRODUCTION FROM BIOMASS

A successful outcome of this program is the adoption of modern and sustainable practices in biomass production, conversion, and use as energy. GEF support goes only to projects that ensure biomass energy use is sustainable and does not, therefore, undermine food security, exacerbate existing availability problems, or violate GEF's sustainability principles relating to biodiversity conservation or sustainable land and water management. Projects support the use of biomass for the production of energy services (electricity, heat, and so on) in modern, efficient technologies.

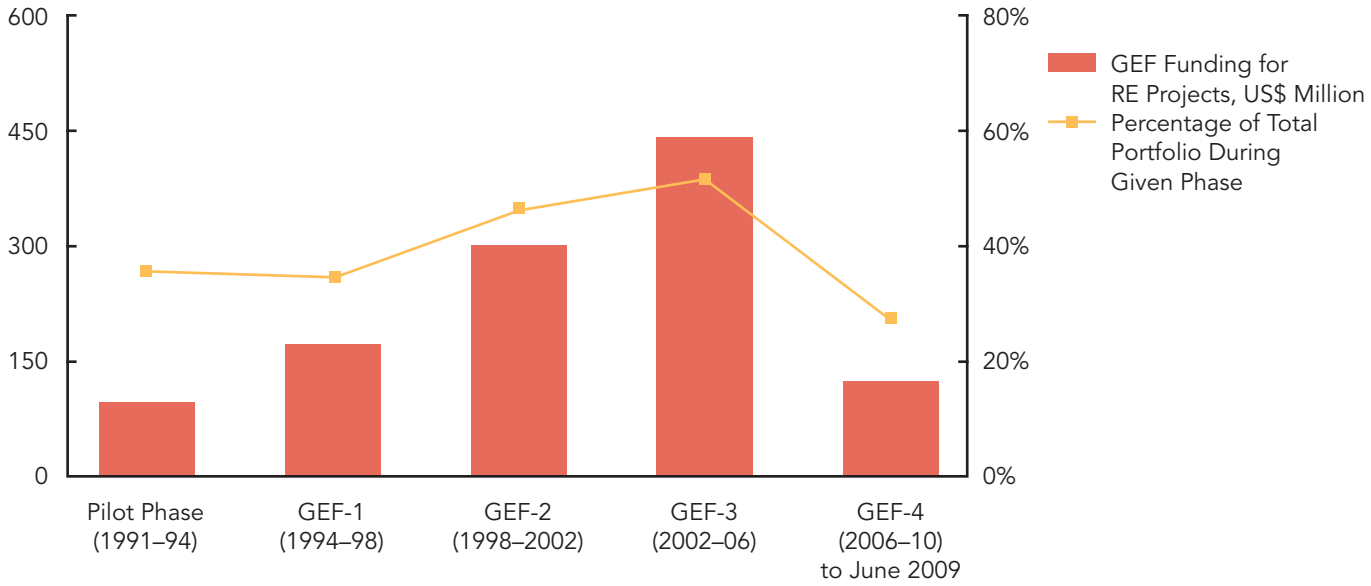
Construction of CSP in Egypt

The GEF's Investment in Renewable Energy

Overview of the Portfolio

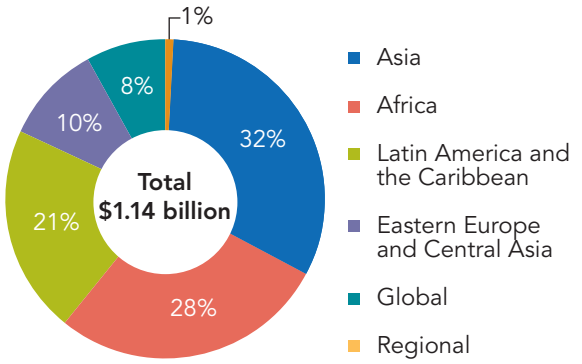
From 1991 to June 2009, the renewable energy portion of the GEF's climate change portfolio amounted to about US$1.14 billion, with an average of US$5.5 million per project. This GEF funding has been supplemented with US$8.3 billion in cofinancing. Funding for the renewable energy portfolio increased from the pilot phase up to GEF-3 (figure 1); however, the share of renewable energy portfolio has decreased in GEF-4. This is due to the expansion of the energy efficiency and other portfolios; the high amount of funding directed to RE projects (such as concentrated solar power (CSP) projects) approved under GEF-3, which are still under implementation; and the decision not to pursue the strategic objective for the promotion of off-grid RETs in GEF-4.

FIGURE 1: RENEWABLE ENERGY SHARE OF THE GEF CLIMATE CHANGE PORTFOLIO



Source: GEF Project Tracking and Management Information System, August 2009.

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

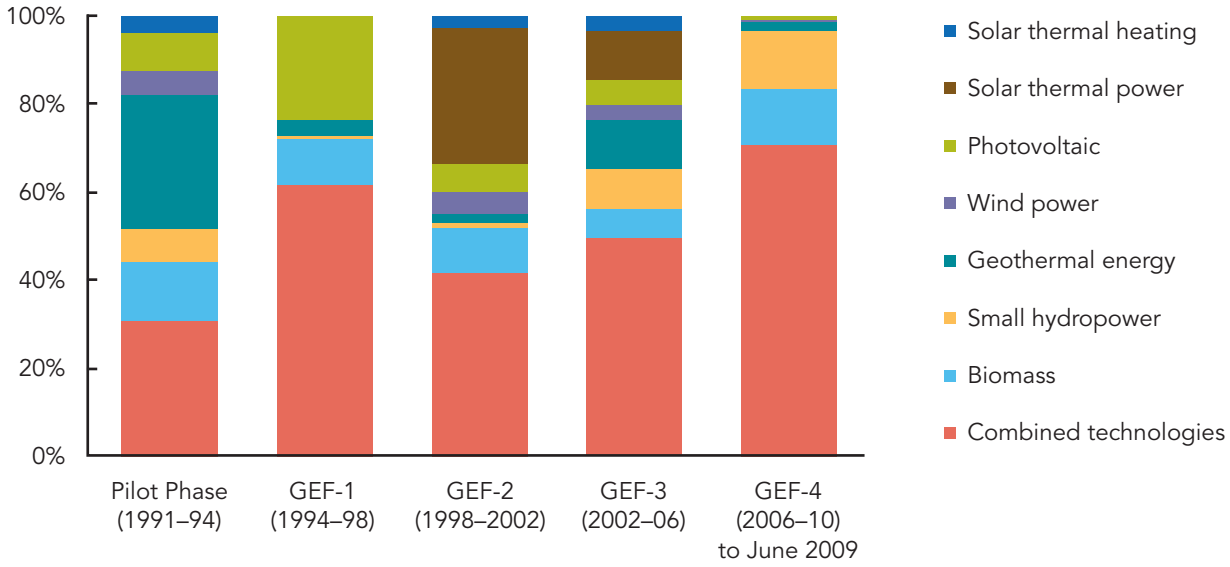


Source: GEF Project Tracking and Management Information System, August 2009.

Since its inception, the GEF has supported 208 renewable energy projects. Most of the renewable energy investments have taken place in Asia, Africa, and Latin America and the Caribbean, (figure 2).

The majority of GEF funding is directed to projects that promote a range of RETs (figure 3) without indicating specific technologies. This is because the GEF's role is to catalyze and transform energy markets generally, not to pick single RETs 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.

FIGURE 3: GEF INVESTMENT, BY RENEWABLE ENERGY TECHNOLOGY, %



Source: GEF Project Tracking and Management Information System, August 2009.

The average cost-effectiveness of GEF funding for renewable energy projects is estimated to be about US$3.97 per tonne of CO_2 directly avoided. Over their lifetime, RE projects approved by the GEF to June 2009 are estimated to avoid, directly and indirectly, 290 million and 1.2 billion tonnes of CO_2, respectively.

Interventions for Advancing Renewable Energy Technologies

The GEF's catalytic approach to the promotion of renewable energy is multidimensional, mixing interventions that range from "soft" actions (barrier removal and capacity building) to tangible actions (direct financing of investments in RETs). The RE 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 the development of market conditions for increased renewable energy production and use through development of enabling policies and regulatory frameworks, standards and certification, information and awareness, and capacity building.

National policies are seen as critical in creating the conditions necessary for RE markets 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 RE development.

Another area where the GEF has been successful is in developing standards, testing, and certification of RETs. This is a vitally important contribution; effective standards and testing can significantly improve quality, reliability, and consumer acceptance. (Eberhard 2004)

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 RETs. The GEF also helps recipient countries build technical and institutional capacity by organizing workshops and training government officials, local engineers, and other technical staff.

Finance for investments

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

A common GEF practice is to test the use of innovative approaches to increase access to local sources of financing. These 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. Sales-based models may require a degree of financing for suppliers and dealers, but the main need is microfinance for consumers. Over the past 18 years, the GEF, through its agencies, has:

- **Provided grants and contingent financing for project preparation and investment.** The GEF offers contingent loans and grants to cover investment capital costs. In the same manner, the GEF sponsors the up-front costs for project development, which can constitute up to 5 percent or more of the total investment cost. 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.

- **Mitigated 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. 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.

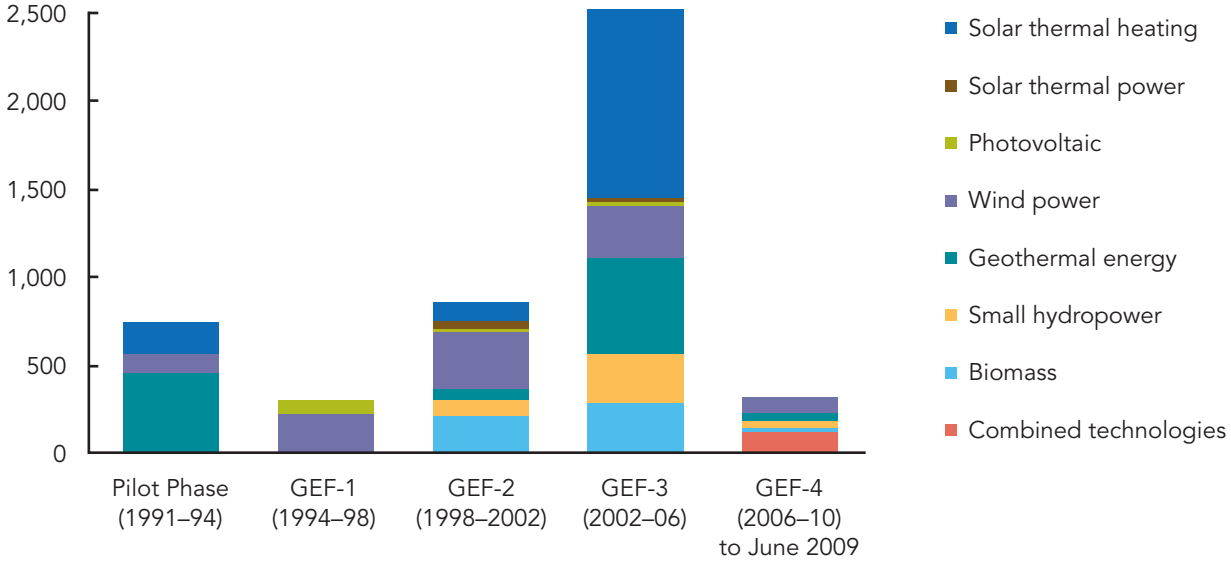
- **Initiated microfinance schemes.** Financing of private consumers as households and small enterprises for the purchase of renewable energy equipment is often considered a low priority by financial institutions (FIs), especially in the developing world. The GEF has supported existing FIs or developed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

50 MW Manjil Windfarms in Iran

Renewable Energy Technologies Supported by the GEF

Over the past 18 years, through direct investments alone, GEF projects have contributed to the installation of 3 GW electric and 2.8 GW thermal of renewable energy capacity. The GEF pilot phase started with proven and viable technologies, and during GEF-1 the share of projects for each technology stayed the same, but the number of projects increased. A significant diversification of technologies occurred during GEF-2 and GEF-3, with most in wind, biomass, hydro, and photovoltaic (PV). During GEF-3, fewer than a dozen solar thermal heat and geothermal projects led to a notable increase in installed RE capacity. Concurrently, the technologies portfolio was further diversified by opening up the strategy to less proven and more pre commercial technologies.

FIGURE 4: INSTALLED CAPACITY, BY RENEWABLE ENERGY TECHNOLOGY, MW



Source: GEF Project Tracking and Management Information System, August 2009

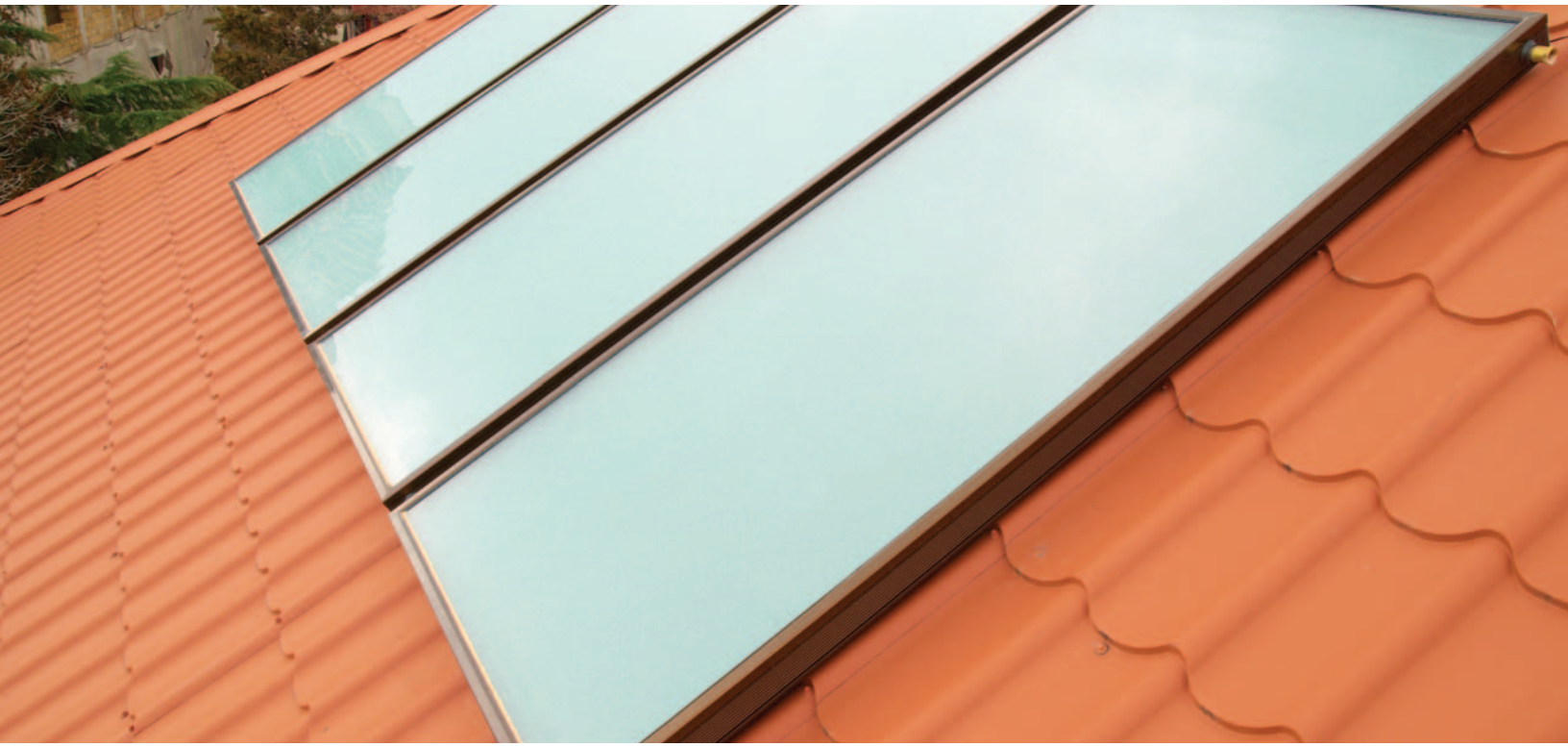
Solar Energy

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 make solar energy technologies ideal for the developing world.

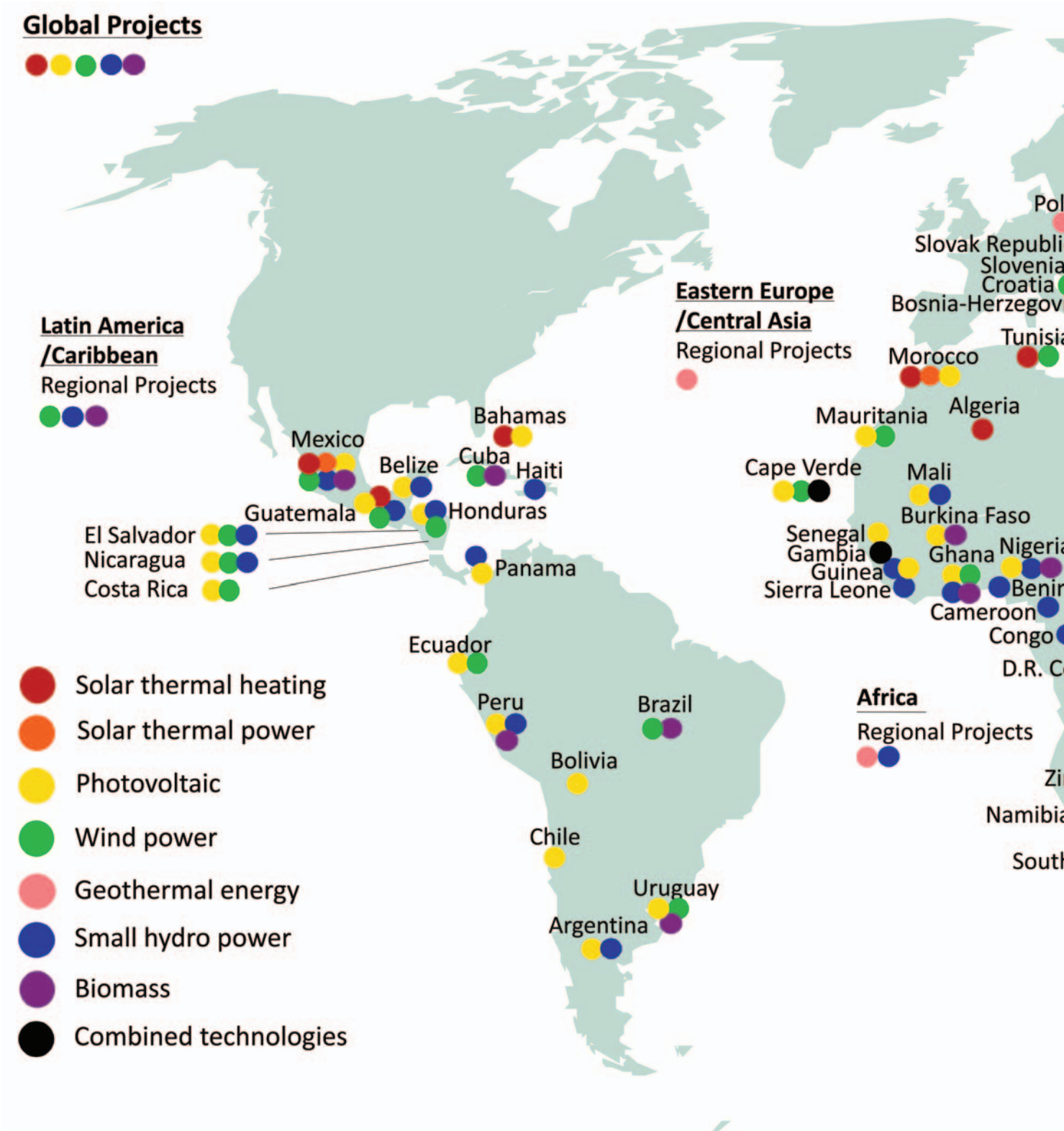
Solar thermal heating

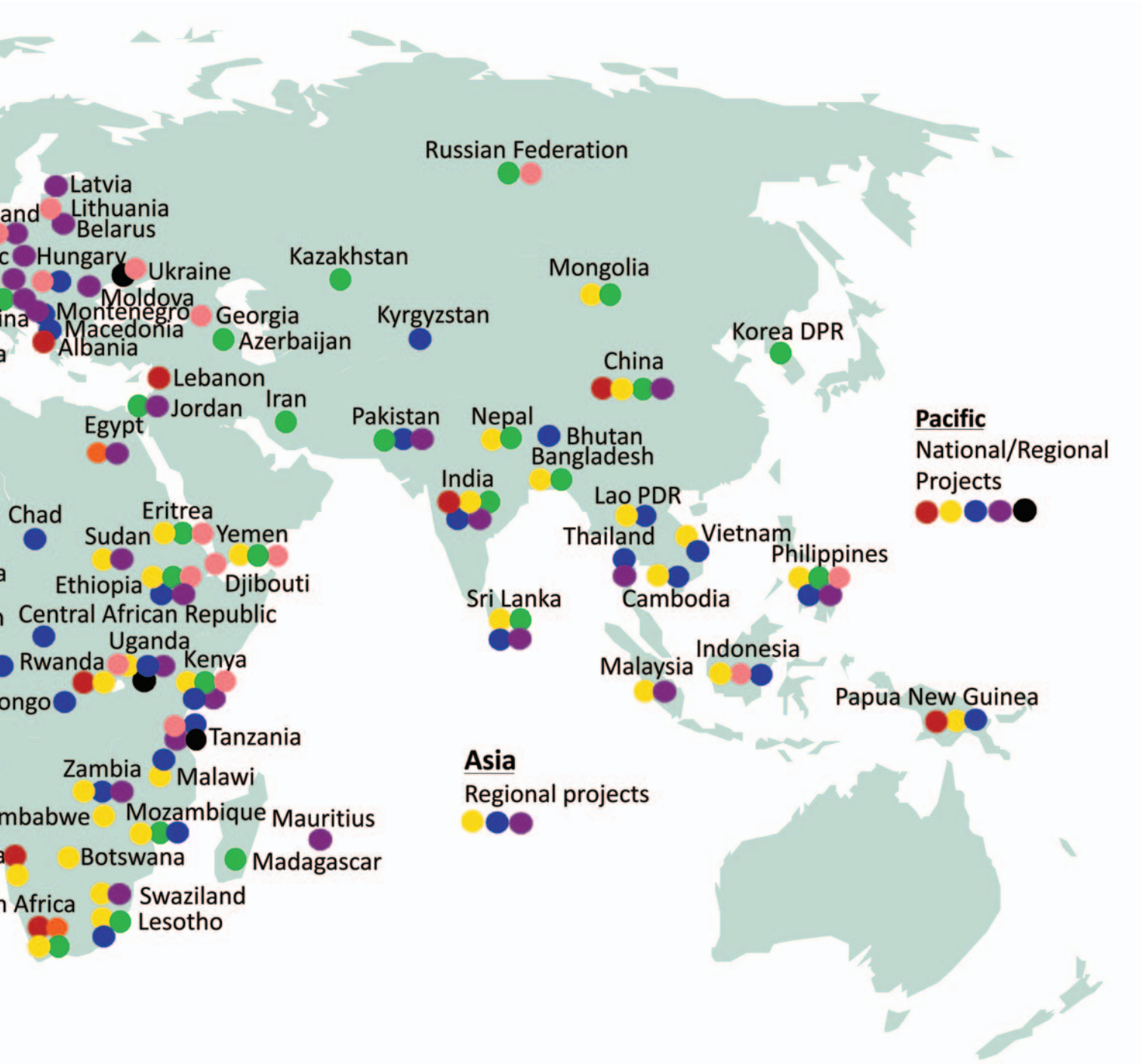
The GEF has supported 14 national and multicountry solar thermal projects in 29 countries with financing of US$39.7 million. The projects were leveraged at a ratio of 1:3.7 in cofinancing and have led to the installation of an estimated nominal thermal power of 2.45 GW.

Although solar water heater technology is sometimes considered simple, the quality of the fittings, the solar collectors, and the installation have substantial impact on satisfactory operation. Inexpensive materials, poor workmanship, and shoddy installation have often resulted in nonfunctional units and abandoned installations. 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




Russian Federation
Latvia
Lithuania
Belarus
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Ukraine
Moldova
Kazakhstan
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Mauritius
Botswana
Madagascar
Swaziland
Lesotho
Indonesia
Malaysia
Papua New Guinea
Pacific
National/Regional
Projects
Asia
Regional projects

Solar hot water systems on roofs

CASE STUDY: TUNISIA—SOLAR WATER HEATING

Project Title:	Solar Water Heating in Tunisia
GEF Agency:	World Bank
GEF:	US$4.0 million
Cofinancing:	US$16.9 million
Dates of Implementation:	1994–2004

OBJECTIVE

The project aimed (1) to help Tunisia encourage substituting solar energy for fossil fuels in public and commercial private institutions in order to mitigate global warming by maximizing CO_2 displacement, and (2) 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 cofinancing, helped incentivize users to invest in solar water heaters rather than in conventional, less environmentally friendly 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 in the framework of the project. The CO_2 emission reductions that can be attributed to the GEF project amount to about 25,000 tonnes annually. Good quality control and system maintenance mechanisms in place will ensure efficient and effective ongoing operation.

Solar thermal power

The most significant technology to have received GEF support is CSP technology. The GEF has supported three countries and a global project to harness the potential of solar thermal power. The projects were funded with US$149 million of GEF resources and leveraged US$890 milliion in confinancing. They will lead to the installation of an electric capacity of 70 MW.

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. Only recently have new plants been planned and constructed in developed countries, most notably in Spain, where generous incentives were provided through a high feed-in tariff for solar energy. Spurred by these activities, the projects in Egypt, Mexico, and Morocco are moving forward.

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.

CASE STUDY: EGYPT—SOLAR THERMAL POWER

Project Title:	Solar Thermal Hybrid Project
GEF Agency:	World Bank
GEF:	US$50 million
Cofinancing:	US$97 million
Dates of Implementation:	2007–present

OBJECTIVE

The objectives of the project are (1) provision of modern infrastructure by efficient private suppliers and operators; (2) increased generation capacity derived from renewable resources that can reduce local and regional pollution; (3) increased capacity to develop large-scale, innovative, renewable energy projects; (4) Egypt positioned as a potential source of expertise and equipment in future solar thermal power projects internationally; and (5) development of the supply side for private sector projects.

OUTCOMES

The main benefits of the project are: (1) demonstration of operational viability of hybrid solar thermal power generation in Egypt; (2) contribution to accelerated market penetration of large-scale backstop power generation technologies; and (3) reduction of GHG emissions from power generation.

The incremental physical benefits of the project over a conventional combined-cycle gas turbine are expected to be: increased renewable electricity production (about 80-85GWh/year) and reduced carbon emissions (about 149,975 tonnes over the life of the project).

Mirrors of CSP in Egypt

Off-grid photovoltaic

Since its inception, the GEF has helped deploy solar energy technologies to those lacking access to electricity. As these people often live in remote areas, expansion of the power grid is neither cost effective nor affordable.

In response to this need, the GEF has funded over 70 projects in 68 countries that provide access to electricity through the use of solar home systems and off-grid photovoltaic electricity. The GEF has supported these projects with US$361 million, cofinanced at a ratio of 1:7.2. They have led to the installation of estimated nominal peak power of 124 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 man stands in front of his solar-home-system

Solar panels powering a rural cultural and drama centre

CASE STUDY: INDIA—OFF-GRID PHOTOVOLTAIC

Project Title:	Alternate Energy
GEF Agency:	World Bank
GEF:	US$26 million
Cofinancing:	US$424 million
Dates of Implementation:	1993–2002

OBJECTIVE

The project aims to: (1) promote commercialization of renewable resources technologies by strengthening the Indian Renewable Energy Development Agency's (IREDA) capacity to promote and finance entrepreneurial investments in alternate energy; (2) create marketing and financing mechanisms for the sale and delivery of alternate energy systems based on cost-recovery principles; (3) strengthen the institutional framework for encouraging private sector investments in nonconventional power generation; and (4) promote environmentally sound investments to reduce the energy sector's dependence on fossil fuels.

OUTCOMES

GEF financing for PV capacity was 2.1 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. In addition, 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 21 projects. An estimated PV peak power of 40 MW has been installed, mostly in combination with small wind and hydro, and often to support minigrids. The GEF funded these projects with US$160 million, cofinanced with almost US$1.6 billion.

CASE STUDY: PHILIPPINES—ON-GRID PHOTOVOLTAIC

Project Title:	CEPALCO Distributed Generation PV Power Plant
GEF Agency:	World Bank/IFC
GEF:	US$4 million
Cofinancing:	US$3.5 million
Dates of Implementation:	2003–04 (*2009)

OBJECTIVE
The overall objectives of the CEPALCO (Cagayan de Oro Electric Power & Light Company) project are 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
A 1 MW (6,500 solar panels on 2 hectares of land) PV power plant was built and 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 of 1,200 tonnes per year.

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

This project marks significant progress toward solving the storage issue faced by many renewable energy technologies. If conjunctive use allows current hydro facilities to be used for storage, many renewables, including PV and wind, can be viewed in combination as a "firm hybrid"—a completely renewable source of power.

CEPALCO is considering replicating this plant with a 30-hectare solar park that would be commissioned by 2012.

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

*The GEF fund is a loan that turns into a grant after CEPALCO operates the plant successfully for five years.


CEPALCO 1 MW on-grid PV in Philippines

Wind Power

Current studies indicate that the earth's potential wind energy supply significantly exceeds global energy demand. Yet, despite 40 percent annual growth in wind-generating capacity over the past 25 years, only 1 percent of global electricity demand is currently met by wind power. More than 98 percent of total current wind power capacity is installed in OECD countries, China, and India.

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

The GEF has supported a variety of wind power projects in 38 countries. These have led to installation of almost 1GW of electric power. On 40 projects with a wind power component, the GEF has spent US$252 million, which has leveraged US$1.9 billion of cofinancing.

Experience has shown that resource availability and familiarity with the technology are key considerations. However, the most significant barriers to successful growth in the wind market are regulations that deter renewable generators' access to the grid and the incremental costs to distributors of turbine-generated electricity.

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

Wind power at the Centro Regional de Tecnología Eólica in Mexico

CASE STUDY: MEXICO—WIND POWER

Project Title:	Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power
GEF Agency:	UNDP
GEF:	US$4.74 million
Cofinancing:	US$7.07 million
Dates of Implementation:	2004–09

Project Title:	Large Scale Renewable Energy Development Project
GEF Agency:	World Bank
GEF:	US$ 24.4 million
Cofinancing:	US$ 247.5 million
Dates of Implementation:	2007–present

Project Title:	Promotion and Development of Local Wind Technologies in Mexico
GEF Agency:	IDB
GEF:	US$ 5 million
Cofinancing:	US$ 18.6 million
Dates of Implementation:	2010–14

Mexico is one of the most promising yet untapped areas for wind energy development in Latin America. Mexico has a tremendous wind energy potential conservatively estimated at more than 40 GW. However, its development has been extremely slow by global wind industry standards. This is due both to lack of adequate financial incentives for private developers and investors, as well as various issues with the existing regulatory framework and policies relating to wind energy.

These projects in Mexico show the development of wind energy technology in a country, starting from creating the enabling environment, investments in the technology, and development and transfer of a technology for local production.

In 2004, Mexico's Electrical Research Institute and the UNDP started the "Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power in Mexico". Under this Action Plan, Mexico accelerated the depreciation of investments in renewable energy technologies, began assessments on wind resources, started proposals on the legal, regulatory, and institutional framework, and started a green development fund. Further the Regional Wind Technology Centre (Centro Regional de Tecnología Eólica) was created, which aims to offer support to interested wind turbine manufacturers, means to train local technicians, an easily accessible national technology display that facilitates the encounter between wind turbine manufacturers and Mexican industries, and many more. The development of the La Venta II wind power project in Oaxaca (83.5 MW, which became operational in January 2007), supported by carbon financing, is an impact of the GEF project.

The "Large Scale Renewable Energy Development Project" by the World Bank has: provided technical assistance to various Government of Mexico agencies involved in the wind sector, and supported a higher tariff for La Venta III, the first private wind Independent Power Producer with US$25 million GEF grant. The La Venta III wind farm will have an installed capacity of 102 MW. Construction started in 2009 and the facility is slated to come on stream in November 2010.

The technology transfer pilot project "Promotion and Development of Local Wind Technologies in Mexico" by the IDB will support the local development of a national wind turbine market, by structuring a value chain for the production of goods and services at the national level in the wind energy sector, and by building human and technical capacities for the manufacturing, testing and certification of wind turbines.

Leyte-Luzon geothermal project in Philippines

Geothermal Energy

The GEF has supported 11 projects to help countries exploit their geothermal energy potential. These were financed with US$103 million of GEF resources and cofinanced at a ratio of 1:16.4. The energy to be extracted is expected to be 927 MW electric plus 119 MW thermal.

This experience has shown that, in addition to the barriers to access of renewable energy generators to the grid, 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 recent approach is 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—which creates 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	US$30 million
Cofinancing	US$1,303 million
Dates of Implementation:	1995–2000

OBJECTIVE

The project aimed to: (1) meet the rapidly increasing demand for power in Luzon using indigenous and environmentally superior geothermal energy; (2) strengthen the energy sector by implementing institutional, planning, and financial improvements recommended by the Energy Sector Plan; (3) support large ongoing private sector participation in power generation, and facilitate it by extending the national grid; (4) strengthen National Power Corporation's (NPC) capabilities in environmental and social impact analyses; (5) introduce enhanced cofinancing operations in the Philippines; and (6) ensure the financial viability of NPC and Philippine National Oil Corporation for undertaking a long overdue investment program.

OUTCOMES

Although the GEF grant of US$30 million seems small in the overall investment of US$1.3 billion, it has been critical to the investment decision and has influenced the government's preference for geothermal over coal.

Geothermal capacity of 385 MW was installed, 59 producer and injector wells were drilled (9 percent fewer than the appraisal estimate of 65 wells), and construction of steam-gathering systems and related subtransmission systems was completed on schedule in mid-1997. The capacity developed is lower than the appraisal estimate of 440 MW because the Alto Peak sector proved problematic and was abandoned. Nevertheless, the combined system surpasses 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 mitigates GHG emissions, as an alternative coal-fired based plant would have meant incremental CO_2 emissions of about 2.2 million tonnes per year. Overall, the output of the geothermal project component has been rated as highly satisfactory.

232-MW Malitbog geothermal power plant in Philippines

Small Hydropower

Small hydro is a mature technology, but it is not well disseminated. The GEF has supported this technology in 54 countries from the outset and has identified several barriers to its adoption, including lack of information about the technology and about the resource itself; unsupportive institutional frameworks; regulatory obstacles; and absent or inadequate financing.

In general, minigrid systems 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, minigrid hydro installations were built, owned, and operated by the communities through electricity cooperative societies that were set up specifically for that purpose.

Small hydropower is supported by the GEF through 44 projects with US$170 million of GEF funding and US$1.34 billion of cofinancing. Among other outcomes, these projects have led to investments in 411 MW installed capacity, mostly for rural and decentralized electrification.

Under the Strategic Program for West Africa, some countries are implementing projects to develop the market environment to improve access to mini hydro-based energy services. The essential elements of the market-based approach envisaged for these projects are a critical mass of skilled and knowledgeable technicians; increased awareness of the appropriate technologies and best practices; and access to innovative financial mechanisms. These projects will establish two–three demonstration pilot sites each in off-grid, isolated communities and implement them using a learning-by-doing approach to build local capacity.

CASE STUDY: INDONESIA—SMALL HYDROPOWER

Project Title:	Integrated Microhydro Development and Application Program, Part I
GEF Agency:	UNDP
GEF:	US$2.1 million
Cofinancing:	US$18.5 million
Dates of Implementation:	2007–present

OBJECTIVE

Microhydro resources in Indonesia are abundant but remain largely untapped. This project is designed to remove key market, policy, technical, and financial barriers to microhydro development and utilization, and complements the ongoing and planned renewable energy and rural electrification initiatives of Indonesia's government and private sector. The project aims to reduce GHG emissions from fossil fuel-based power generation.

OUTCOMES

The four main outcomes of the project are expected to be: (1) enhanced private sector interest and involvement in capacity building in the microhydro business community; (2) increased number of community-based microhydro projects as a result of effective institutional capacity building; (3) improved local knowledge and availability of the technology and its applications; and (4) increased implementation of microhydro projects for electricity and productive purposes. The project targets a GHG reduction of 60,800 tonnes of CO_2 per year; creation of at least 40 community based microhydro projects for productive use each year; and cumulatively, in 3 years, 130 GWh produced, with 100 GWh sold.

Further information is also available at: http://imidap.org/.

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

Biomass

Biomass projects are of interest to the GEF because it represents an energy source with zero net carbon emissions if produced sustainably. 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 37 countries, the GEF has funded investments in 330 MW electric and 185 MW thermal with US$270 million that leveraged US$2 billion of cofinancing.

Over 50 GEF projects have now implemented pilots that successful demonstrated imported technology. 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.

CASE STUDY: THAILAND—BIOMASS COGENERATION

Project Title:	Removal of Barriers to Biomass Power Generation and Cogeneration
GEF Agency:	UNDP
GEF:	US$6.8 million
Cofinancing:	US$92.5 million
Dates of Implementation:	2001–09

OBJECTIVE

The objective of the project is to: (1) build capacity to provide information and services to potential biomass power project investors; (2) improve the regulatory framework to provide financial incentives to biomass cogeneration and power projects; (3) increase access to commercial financing for biomass cogeneration and power projects; and (4) facilitate the implementation of two initial biomass power pilot plants through support for commercial guarantees that will reduce technical risks associated with the deployment of this new technology.

OUTCOMES

Two pilot power plants with a total capacity of 32 MW electric power have been constructed with GEF support, that serve as valuable demonstration plants for rural communities. Significant impacts are influences to government policy, and measures on adding feed-in tariff to make biomass power generation more commercially viable. The work of the initiated Biomass One Stop Clearing House responds well to biomass investors and public interest.

The project has facilitated/influenced the installation of 398 MW of electricity capacity that generate over 358 GWh of electricity annually from biomass power plants and avoid 194,722 tonnes CO2 per year.

Further information is available at http://www.efe.or.th

Biogas Baan Maekon in Thailand

CASE STUDY: INDIA—BIOMASS GASIFICATION

Project Title:	Biomass Energy for Rural India
GEF Agency:	UNDP
GEF:	US$4.2 million
Cofinancing:	US$4.6 million
Dates of Implementation:	2001–present

OBJECTIVE

The project aims to: (1) demonstrate the technical feasibility and financial viability of bioenergy technologies—including biomass gasification for power generation—on a significant scale; (2) build capacity and develop mechanisms for project implementation, management, and monitoring; (3) develop financial, institutional, and market strategies to overcome barriers to large-scale replication of the bioenergy package for decentralized applications; and (4) disseminate bioenergy technology and relevant information on a large scale in 24 villages in Karnataka's Tumkur district.

OUTCOMES

The project has 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 has also resulted in 171 families replacing fuel wood with biogas—reducing GHG emissions by 256 tonnes annually over the past 3 years.

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

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:	US$0.8 million
Cofinancing:	US$2.7 million
Dates of Implementation:	2001–05

OBJECTIVE

This project was designed to remove barriers to the widespread use of wood waste for heat and hot water delivery at municipal levels in Latvia. It was intended to coinvest in four–six biomass-based municipal heating systems and to lay the foundation for future investments in other municipalities. The project was to correspond to all elements included in Latvian energy policy and is expected to assist the government of Latvia in meeting its goal of an 8 percent reduction in greenhouse gas emissions from 1990 levels by the year 2010.

The project aimed to: (1) promote the use of wood waste by removing or reducing barriers to replacing imported heavy fuel oil (mazut) with local, sustainably produced wood waste in municipal heating systems; (2) promote the development and implementation of an economical, commercially run, municipal heating system, providing generation, transmission, and distribution in the municipality of Ludza; and (3) 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 project inception, 11,200 tonnes of CO_2 emissions have been avoided annually in Ludza, accounting for about 80 percent of the emissions from using heating oil. The project and the financial scheme developed through the project 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 avoided annually.

Boys standing in front of PV panels for a Solar Home System

A View to the Future

The GEF has supported developing countries and economies in transition in opening up their regulations to renewable energy generation. Meanwhile, it has kept building and enhancing local capacities to adopt, finance, install, operate, and maintain renewable energy technologies. Investments in promising precommercial and commercial RETs have been an essential element of the GEF strategy. Over the past 18 years, the GEF has supported the transfer of more than 20 RETs to the developing world. To June 2009:

- The renewable energy portion of the GEF climate change portfolio amounts to US$1.1 billion with a cofinancing of US$8.3 billion. The GEF is the largest public-sector funding source to support new, emerging renewable energy technologies and practices in the developing world.
- GEF-supported activities on RETs so far are expected to directly avoid at least 290 million tonnes of CO_2 On average, the GEF spends US$3.97 per tonne of CO_2 emissions avoided.

In the near future, the GEF support to renewable energy will focus on the following areas:

Create conducive markets to renewable energy: GEF intervention under this objective will be a combination of technical assistance for policy and regulatory support, building the technical and institutional capacity, and establishing financing mechanisms for investment in the deployment and diffusion of renewable energy technologies.

Invest in the transfer of RETs: The GEF will expand its investments in the transfer of commercially proven RETs and emphasize market demonstration and commercialization of new, promising 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, where most people, especially in rural areas, have no access to electricity and rely on traditional biomass and imported fossil fuels to meet their basic energy needs.

ABBREVIATIONS AND ACRONYMS

CEPALCO	Cagayan de Oro Electric Power & Light Company
CSP	Concentrating Solar Power
EIA	Energy Information Administration, US Department of Energy
ESTs	Environmentally Sound Technologies
FIs	Financial Institutions
GEF	Global Environment Facility
GHG	Greenhouse GasIDB
IDB	Inter-American Development Bank
IEA	International Energy Agency
IREDA	Indian Renewable Energy Development Agency
NPC	National Power Corporation
OECD	Organisation for Economic Co-operation and Development
PV	photovoltaic
RE	Renewable Energy
RETs	Renewable Energy Technologies
UNDP	United Nations Development Programme

UNITS OF MEASURE

Acre	4,047 m^2
GW	Gigawatt (billion Watts)
GWh	Gigawatt-hour (billion Watt-hours)
MW	Megawatt (million Watts)
MWp	Megawatt-peak
TWh	Terawatt (trillion Watts)
Wp	Watt-peak

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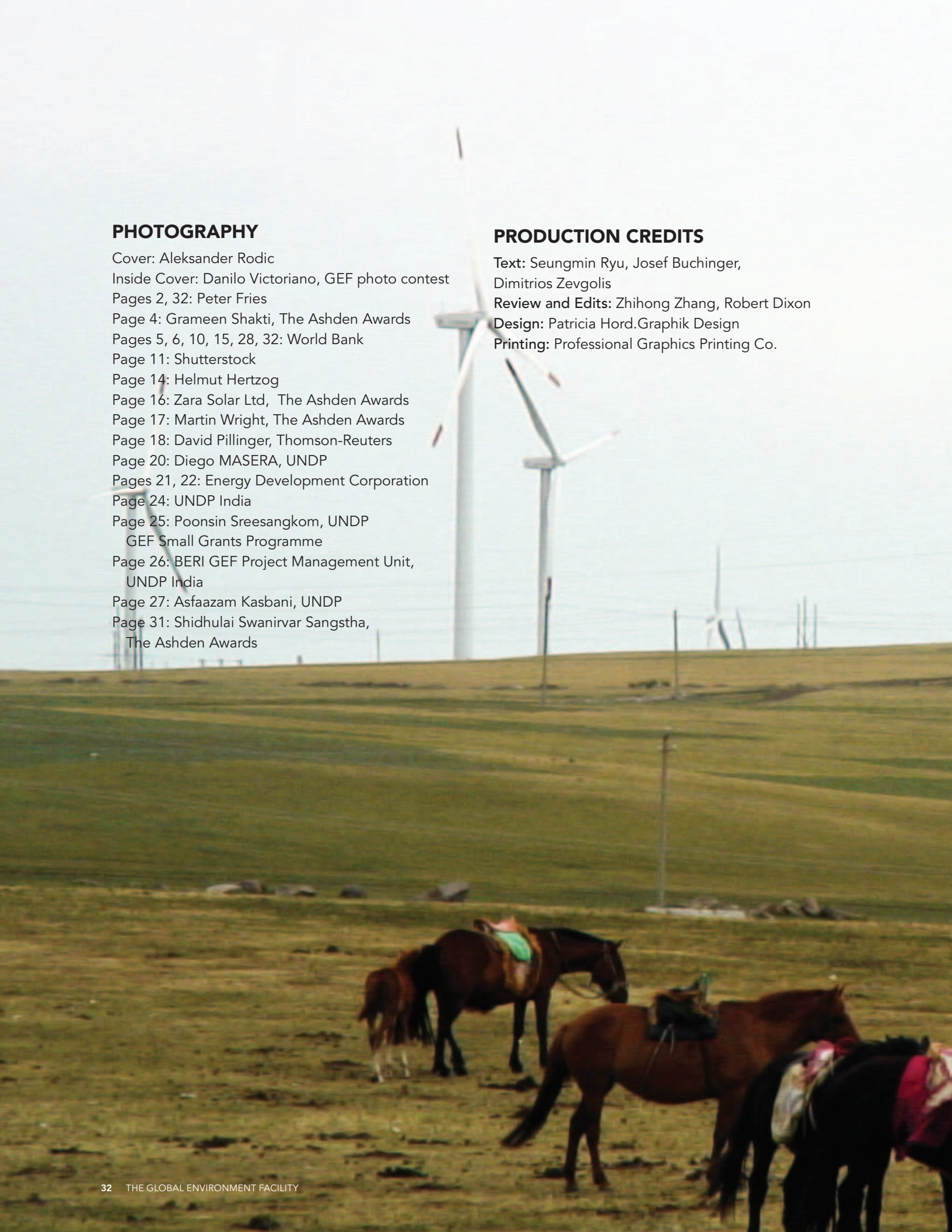
Home study by solar light - batteries are re-charged using electricity from solar PV panels



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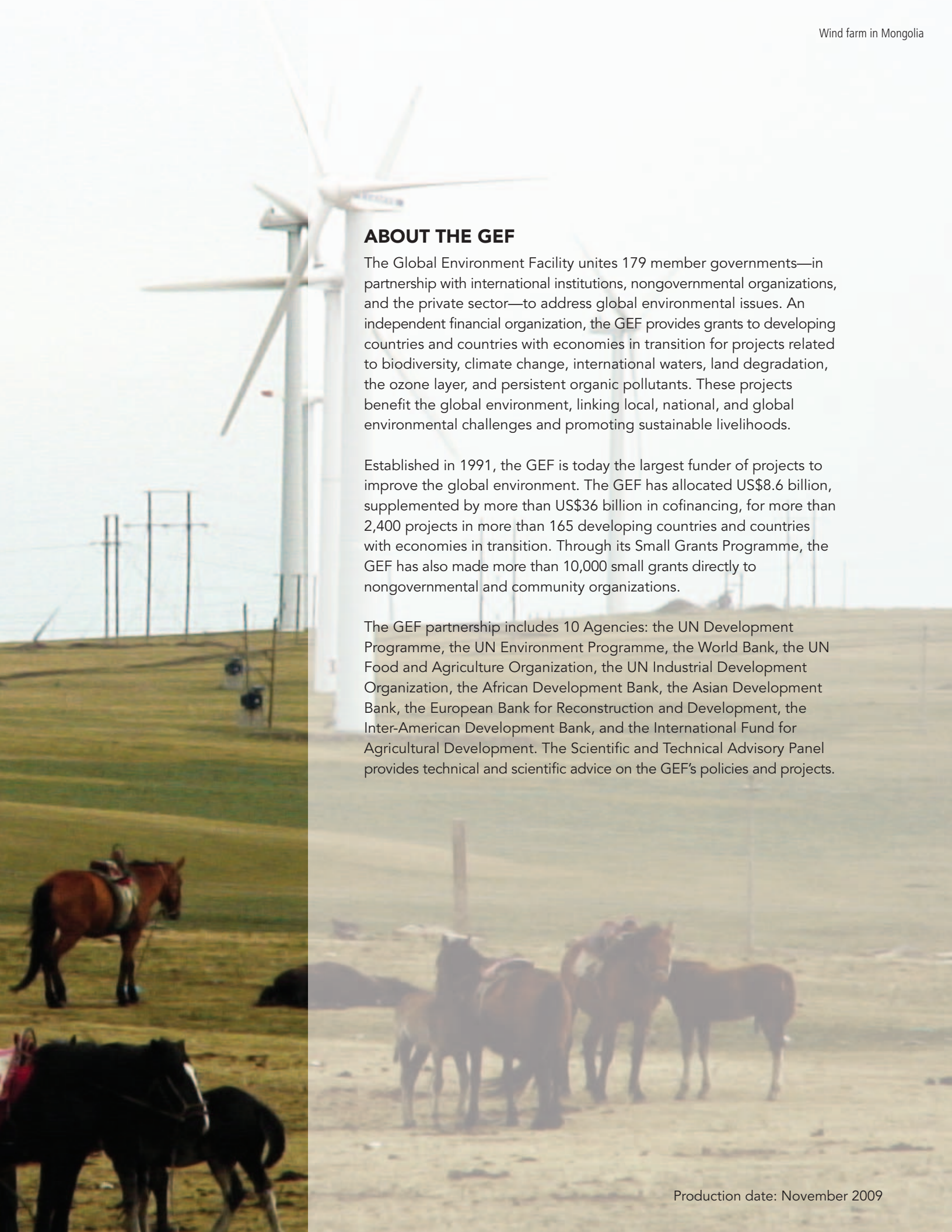

Wind farm in Mongolia

ABOUT THE GEF

The Global Environment Facility unites 179 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 US$8.6 billion, supplemented by more than US$36 billion in cofinancing, for more than 2,400 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 10,000 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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