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GEF Experiences in Closing the Global Energy Efficiency Gap

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Abstract

The term "energy efficiency" has been widely used in global energy, economics, and environment, and it is well known that energy efficiency is one of the most cost-effective approaches in saving energy and mitigating greenhouse gas (GHG) emissions. However, it is still not clear how many metric tons of carbon dioxide ($MTCO_2$) can be mitigated if one dollar is invested in worldwide energy efficiency. This study tries to clear this issue. Using data of 49 completed energy efficiency projects funded by the Global Environment Facility (GEF), this study presents an analysis on investments of US$313 million in capacity building, asset acquisition, project development, and project implementation in 35 countries. Results show that every dollar invested by the GEF has mobilized 8.2 dollars in co-financing and can mitigate 1.89 $MTCO_2$. In addition, GEF investments in capacity building, national policy, legal and regulatory frameworks have long term impact on GHG emission mitigations which is beyond quantification with current approaches. We conclude that public funds have greatly facilitated capacity building, catalyzed the transfer of environmentally sound technologies, and helped remove a large number of regulatory and market barriers to energy efficiency in developing countries and countries with economies in transition.

Keywords

Climate Change Mitigation; Global Energy Efficiency Investments; Tangible and Intangible

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1. Introduction

Energy consumption will increase dramatically in the coming decades as economic development advances. Unless we find ways to use precious and finite resources more carefully, and unless we expand the use of clean and renewable resources, we may exhaust economically available energy supplies while damaging the environment in the process. For these reasons, the Global Environment Facility (GEF), since its inception two decades ago, has identified energy efficiency as a critical area of activity in protecting and improving the global environment. We also know from careful analysis of our programs that energy efficiency can be an extraordinarily powerful and cost-effective tool in addressing this challenge. However, there are still a large number of questions without clear answers today. These questions include:

1) What is the potential of global energy efficiency improvement and how much investment capital is required to harness the potential?

2) How effective are investments in energy efficiency in achieving global environmental benefits by reducing carbon emissions?

3) How successfully did GEF leverage co-finance funds from the government, the private sector, multilateral banks and financial institutions, and other resources to finance global energy efficiency enhancement efforts, and how was the mobilized co-finance utilized?

4) What has GEF done to facilitate technology transfer in energy efficiency from developed countries to developing countries?

Aiming at answering the above questions, this paper presents quantitative and qualitative analysis of the impacts of the GEF investments in 49 completed energy efficiency projects in 35 developing countries and countries with economies in transition. The objective of these investments is to bring the developing world the same energy efficient technologies now in wide use in developed countries. This paper shows, with detailed project and finance information, how funds contributed by developed countries for energy efficiency projects were used to mitigate greenhouse gas emissions. In analyzing our investments, we use four key indicators: time period of project preparation; the use of GEF funds in the projects; the utilization of co-finance mobilized by the GEF; and the global environmental benefits generated by the GEF projects. We also introduce two new terms in climate change project financing to use in our analysis because there have been no clear definitions on public funds that are used in investing in tangible assets (such as equipment) and intangible assets (such as brand names, policy, codes, and staff capacity). Our aim is to provide worldwide audiences with information on how targeted investment of finite public resources can mobilize additional investment in energy efficiency, and how energy efficiency investment barriers can be addressed. The results of our analysis lead to conclusions, lessons learned, implications, and recommendations that will assist national government policy makers, GEF Agencies, and professional staff in designing improved energy efficiency projects.

2. Literature Review on Energy Saving Potential and Energy Efficiency Gap

The major potential for energy savings and GHG mitigation through energy efficiency has been reinforced by a recent study by the International Energy Agency (IEA). Government energy efficiency policies that increase capital investment in energy efficiency technologies can lead to energy savings of 92 exajoule per year (EJ/yr) or reduce 8.2 giga metric tons of carbon dioxide equivalent (CO_2e) per year ($GMTCO_2e/yr$) by 2030 ([1] [2]). This level is equivalent to approximately twice the total energy-related carbon dioxide (CO_2) emissions from the European Union (EU) in 2010. To help provide information to contribute to the great potential for energy efficiency enhancement and GHG emissions mitigation, we present an analysis of GEF funded energy efficiency projects over the past two decades.

The IEA [1] also estimated the potential for efficiency improvements to be in range of approximately 20 to 50 percent of total final energy consumption. Energy efficiency policies in 11 member countries of the Organisation for Economic Co-operation and Development (OECD) (Australia, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, United Kingdom, and United States) between 1973 and 1998 had saved approx-

imately 49 percent of actual energy use. Jollands *et al*. [3] showed that energy efficiency policies and technologies would help save an average of 20 percent of final energy consumption from 2010 to 2030 in five major sectors, namely buildings, equipment, lighting, transport, and industry, in OECD countries (**Figure 1**). If other sectors are considered, the saving potential would be more than 20 percent. The trend in potential is expressed as the percentage of energy that could be saved over the total final energy consumption, and is expected to decline from 1975 to 2030 as energy efficiency becomes closer to its potential (**Figure 2**). The potential for energy efficiency savings in developing countries could be higher than IEA/OECD countries because of the widespread use of inefficient energy technologies.

The energy efficiency gap is a term that is widely used in the literature by many organizations. It refers to the difference between levels of investment in energy efficiency that appear to be cost effective based on engineering-economic analysis and the lower levels actually occurring [4]. The efficiency gap can also be defined as the difference between the actual level of energy efficiency and the higher level that would be cost-effective from an individual's or firm's point of view. The concept of an energy efficiency gap and market barriers to energy efficiency investment have been used since the early 1970s. Lovins [5] was among the first to develop a definition of energy efficiency: using less energy to produce greater economic output. This definition, coupled with a review of the apparently highly inefficient use of energy by society, indicates that markets alone cannot produce the most desirable social outcomes in the use of energy without government policy intervention [1]. Barriers cause market failures and lead to insufficient investment in energy efficiency.

It is difficult to forecast how much funding should be invested in global energy efficiency, since investments in global energy efficiency depend on many factors including the GHG emissions mitigation targets set by the international community, future oil prices, climate change policies of national governments, and breakthroughs in energy efficiency technologies. Many international organizations and individuals have attempted to estimate worldwide capital costs for end-use efficient technologies to mitigate GHG emissions. The IEA [6] projects that a total of additional US$2364 billion (**Figure 3**) is needed to improve energy efficiency in three major sectors to address the efficiency gap from 2005-2030 worldwide. Investment in the transport sector would increase by US$1076 billion, which is close to half of the total additional end-use energy efficient investments in all sectors in the world. Investment in the residential and services sectors (including agriculture) is approximately US$926 billion, whereas the industrial sector has an extra investment of US$362 billion. In summary, from 2012 to 2030 the world needs to invest approximately US$95 billion per year (US$2364 billion over 25 years) to address the energy efficiency gap in the industrial, transport, and residential and services sectors [6]. In the developing countries alone the investment need will be US$35 billion per year in these three areas (**Figure 3**).

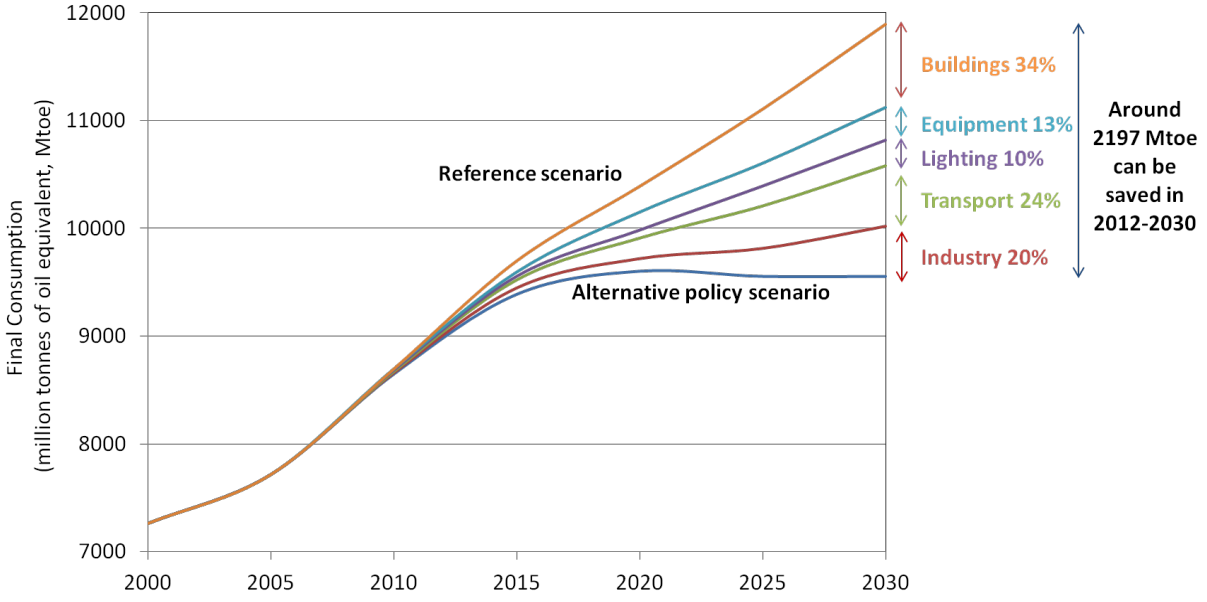

Figure 1. Impact of energy efficiency policy and technologies on world energy consumption (2000-2030). Source: Developed from data of Jollands *et al*. [3].

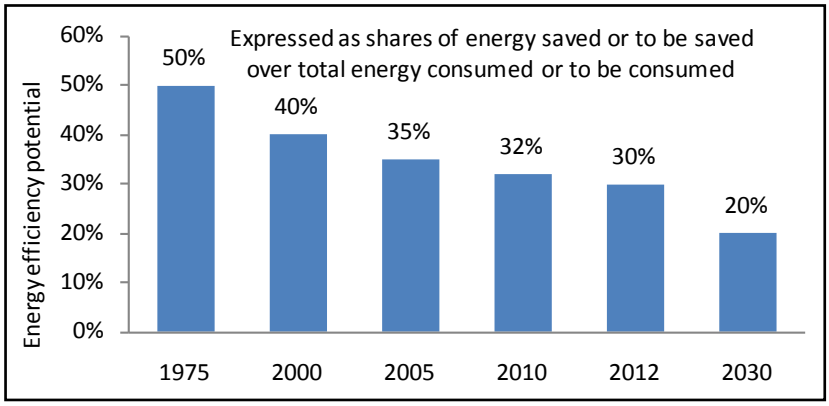

Figure 2. Trends in energy efficiency saving potential in OECD countries (1975-2030).

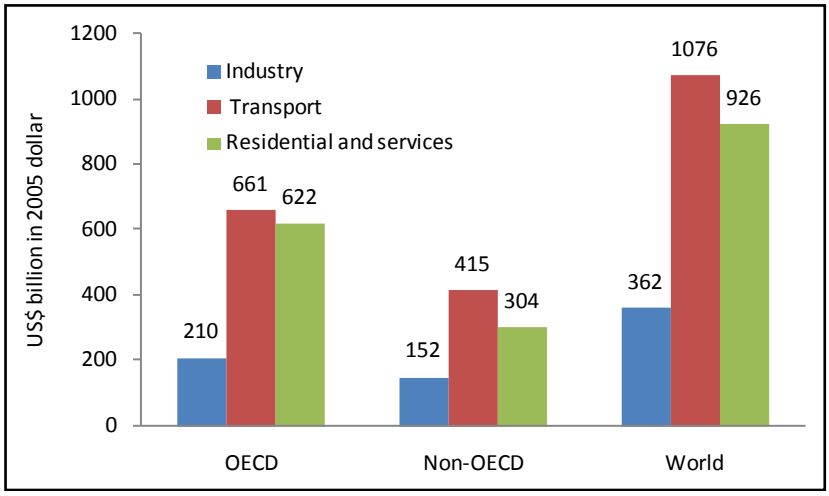

Figure 3. Capital investments needed to fill the global energy efficiency gap (2012-2030). Source: Developed from data of the IEA [6].

3. Methodology

This analysis mainly employs a quantitative methodology, although a qualitative methodology is also used to present a typical energy efficiency project. The quantitative methodology is designed in accordance with the available data that can be collected from all of the projects on the values of the indicators. These indicators include GEF funds, co-finance funds, months of project preparation, and GHG emissions. Information on some other important indicators, including an indication of technology transfer (such as the number of people trained through GEF projects) was not included in the framework due to lack of data for all projects. However, the effects of these factors are included in the analysis, when data are available. For example, when accounting for the impacts of technology transfer from a project in a particular country, the number of technology transfer patents, the number of trained people, and the amounts of funds used in technology transfer are reported.

The methodology to address these specific project characteristics consists of six steps (**Figure 4**)

1) Analyze the portfolio of GEF energy efficiency projects;

2) Classify the GEF energy efficiency projects into sub-areas;

3) Apply three major comparison indicators that are suitable for GEF projects in sub-area analysis;

4) Analyze at an aggregate level the resources and uses of the GEF funds and the mobilized co-finance resources;

5) Cast studies for 49 GEF completed energy efficiency projects; and

6) Summarize the analysis and the major results (**Figure 4**).

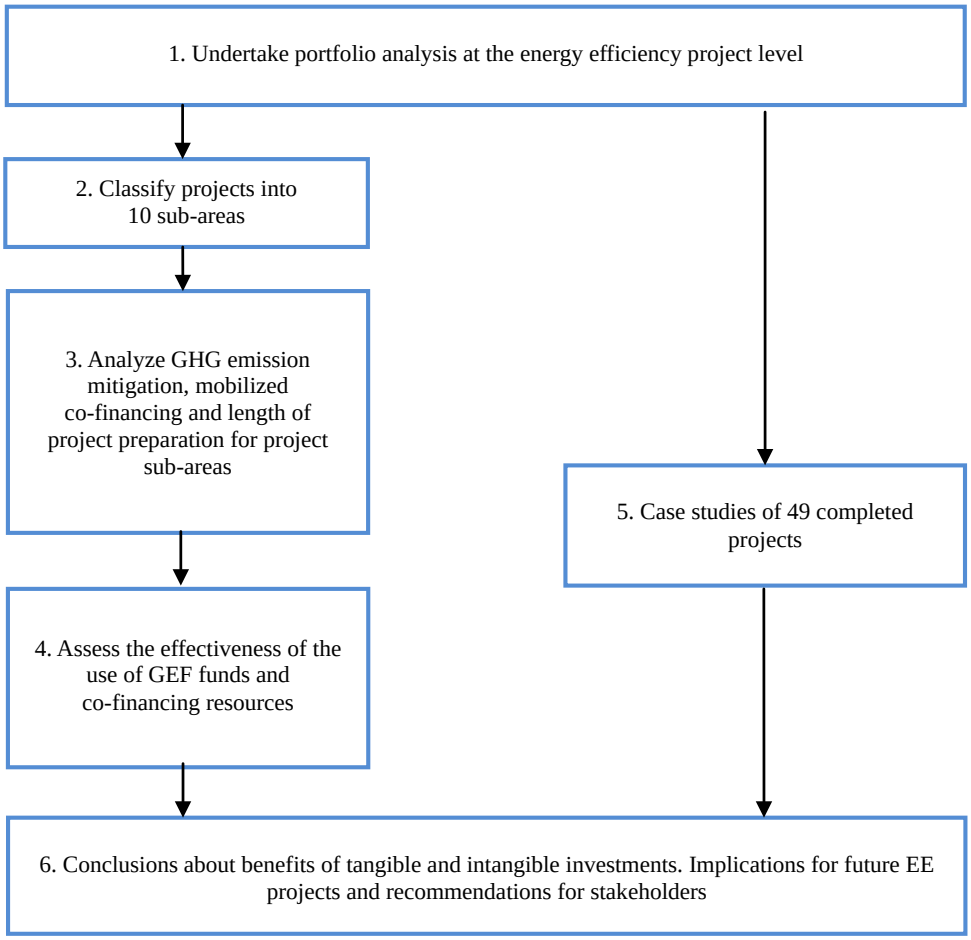

Figure 4. Methodology framework for this analysis.

GEF investments in tangible assets are categorized using two new terms: 1) tangible hardware assets: GEF funding that is used to acquire an asset such as a boiler directly; and 2) tangible software assets: GEF funding that is used to facilitate acquisition of the tangible hardware assets, such as training for professionals, establishing policies, or building up institutions that are required to provide support for tangible hardware asset acquisition and operation within the same project. Without such support the tangible hardware asset acquisition would not have taken place would not have been in operation. For example, in the GEF/World Bank China energy efficient boiler project, a portion of GEF funds were used for the training of local professionals in using the newly transferred technologies. Without GEF funds for training, the new boiler technologies could not have been acquired or put in service. Thus, the GEF funds used for such activities are also defined as investing in tangible assets. If a GEF project does not include any component of asset acquisition, the GEF funds utilized in supporting new policies, standards and codes, and capacity building, and institutional development, are defined or classified as intangible investments. **Table 1** shows this distinction in more detail.

4. GEF Cost-Effective Achievements of Energy Savings and CO_2 Emissions Mitigation

GEF has a number of program strategies to save energy and mitigate GHG emissions. These strategies include demonstration, deployment, and transfer of innovative low-carbon technologies, market transformation for energy efficiency in the industry and building sectors, investment in renewable energy technologies, energy efficient and low-carbon transport systems in cities, and conservation and enhancement of carbon stocks through sustainable management of Land Use, Land-Use Change and Forestry (LULUCF) [7]. Energy efficiency investment has been a GEF priority, and the share of GEF funds utilized for energy efficiency ranks at the top

Table 1. Investment types for the use of GEF funds: tangible and intangible.

Tangible investments	Intangible investments
Acquiring hardware assets (e.g. lighting bulbs, air conditioning, industrial boilers); Acquiring software assets (e.g. patent or license purchases); Building capacities that are directly associated with asset acquisition.	Removing energy efficiency investment barriers, such as policies, capacity building, training, standards, codes, labeling that have long term impact for the country in energy efficiency improvement but are not associated with any GEF funded asset acquisition.

among the above-listed program strategies. By the end of the GEF fourth replenishment (GEF-4) period on June 30, 2010, GEF had invested approximately US$9.1 billion in over 150 countries worldwide in all types of projects. Of this amount, approximately 32 percent was utilized in the climate change focal area. In the energy efficiency sub-area, the investments amounted to US$872 million, accounting for 30 percent of the total investments in the climate change focal area.

GEF project data is used to analyze the cost-effectiveness of the energy efficiency investments and assess their global environmental benefits. Based on the results of the analysis, on average, one dollar of GEF investment in energy efficiency, including enabling and capacity building activities, has yielded direct GHG emissions mitigation of 1.89 $MTCO_2$, which means an average cost of US$0.53 per $MTCO_2$. This reduction is directly attributable to activities such as pilot demonstrations that were financially supported by GEF, and indirectly attributable to activities such as national policy, standards, codes, institutional frameworks that were developed under GEF projects. This impact is greater than that of any other sub-focal areas of the GEF. For example, one dollar of GEF investment in renewable energy, low-carbon transport, and LULUCF on average yields emissions mitigation of 0.78 $MTCO_2$ (*i.e.*, US$1.28 per $MTCO_2$)

In addition to significant GHG emissions mitigation, GEF energy efficiency investments yield a number of other benefits. These include facilitating technology transfer and supporting the development and enforcement of policies, standards, and regulations to achieve larger-scale energy efficiency improvements and GHG emissions reductions. These additional benefits are not captured in the cost-effectiveness analysis mentioned above, but they do strengthen the value of energy efficiency investments.

5. Co-Finance and Mobilizing Private Sector Investments

Since October 1991, the GEF invested US$313 million in 49 global energy efficiency projects that were completed by June 2010. This amount of GEF resource mobilized a total of approximately US$2.6 billion in co-financing for the 49 projects. The most significant investments of GEF resources are in hardware and software asset acquisitions. Of the GEF US$313 million resources, US$48.7 million (16 percent) are invested in tangible asset acquisitions such as purchasing key parts for energy efficient boilers, and US$82 million (26 percent) are invested in intangible asset acquisitions such as purchasing license to produce energy efficient boilers and training professionals. Capital expenditure in technology transfers is in this category since technology transfers are related to asset acquisitions. GEF investments in capacity building, including policy and regulatory framework development that are not related to asset acquisitions ranks the second largest, utilizing US$100 million or 32 percent of GEF resources. The remainder of the GEF's resource is invested in other activities such as developing market mechanisms for energy efficiency products and project development. Even though asset acquisition activities used the largest amount of the total investment, the GEF distributed its funds more evenly between asset acquisition and capacity building, compared with co-finance or the total funds (**Figure 5**).

The US$313 million of GEF resource has yielded a co-finance ratio of 1:8.2 (**Table 2**). This ratio is higher than the average co-finance ratio of the GHG emissions mitigation project portfolio at the GEF as of June 2010. The ratio is 1:6.0 (US$2.89 billion to US$17.20 billion) for projects in the climate change focal area, and 1:4.6 for the entire GEF project portfolio (US$10.1 billion to US$47.1 billion) as of June 2010. The amount of mobilized co-finance varies significantly across sub-areas of energy efficiency projects. Heating projects have the largest co-finance ratio because energy efficiency projects in this sub-area involve heating system renovations, for which governments, multilateral banks, and other Agencies committed large capital investments. Energy Service Companies (ESCOs) projects leveraged the second highest co-finance, with a ratio of 8.7, because of increased financial allocation for technical assistance and risk sharing in these projects (**Table 2**).

GEF has catalyzed funds from both the public and private sectors to finance the projects supported by GEF. The mobilized co-finance funds consist of 24.7 percent from the governments of host countries, 30.7 percent

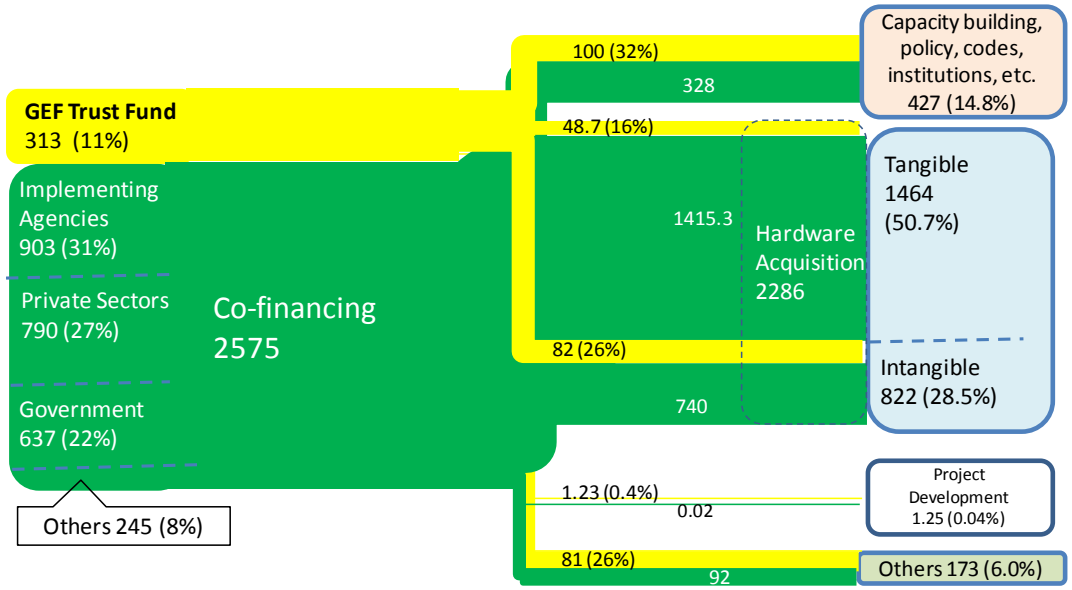

Figure 5. Flow diagram of resources for different project activities of the 49 closed EE projects (US$ million)[1]. Source: Developed from GEF [8].

Table 2. Mobilized co-finance for completed energy efficiency projects by sub-area (1991-2010).

Sub-areas	GEF Funds (US$)	Co-finance (US$)	Co-finance Ratio
Heating	64,942,000	1,368,728,000	21.1
ESCOs	75,529,265	659,635,255	8.7
Energy Supply	10,430,000	64,469,000	6.2
Others	19,131,800	78,034,564	5.1
Industrial Processes	30,182,119	105,605,676	3.5
National Strategy	43,924,000	136,607,000	3.1
Finance	26,550,000	80,360,000	3.0
Appliances & Equipment	11,320,000	33,422,863	3.0
Buildings	12,022,000	20,134,322	1.7
Lighting	19,189,985	27,819,331	1.4
Grand Total	313,221,169	2,574,816,011	8.2

Source: Developed from GEF [8].

from the private sector, and 44.6 percent from other resources, including multilateral banks, financial institutions, and non-governmental organizations (NGOs). Developing countries' private sectors contributed a total of US$789.5 million of co-finance to the 49 completed energy efficiency projects included in this analysis. Without the contributions from GEF partners, energy efficiency projects could not have achieved the substantial mitigation outcomes.

6. Energy Efficiency Technology Transfer

Technology transfer plays a critical role in closing the gaps in the level of energy efficiency investments, and is a key global issue for countries to combat climate change. The transfer of Environmentally Sound Technologies (ESTs) has been embodied in the United Nations Framework Convention on Climate Change (UNFCCC) [9]. Article 4.5 of the UNFCCC states: "*The developed country Parties and other developed Parties included in*

[1]Capital expenditure in capacity building that is related to tangible and intangible asset acquisitions in projects are also accounted at the category of capital investments for asset acquisitions.

Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention."

Since 1991, the GEF has emerged as the largest multilateral funding organization for transfer of ESTs. The GEF has two outstanding characteristics in promoting technology transfer. First, the GEF uses its funds to directly finance projects that have technology transfer components. Second, the GEF has provided resources for Technology Needs Assessments (TNAs) and other enabling and capacity-building activities in more than 100 countries.

Among the ESTs that the GEF has supported over the past years, more than one third are energy efficient technologies, ranging from efficient lighting and appliances to chillers, boilers, motors, and brick kilns. Investments also address building designs and construction materials, district heating systems, power generation and distribution, combined heat and power (co-generation), and industrial energy efficiency. As of June 2010, total GEF funding for EST transfer was approximately US$1 billion.

All 49 of the completed energy efficiency projects analyzed have directly or indirectly addressed the issue of technology transfer, and eight of them include hardware technology transfer components. Capital expenditure on technology transfer in these projects forms part of capital expenditure for hardware acquisitions (**Figure 5**). There were also been a combined total of 49 energy efficiency technology patents transferred from OECD countries to developing countries and economies in transmission under these projects. For example, in China's industrial boiler efficiency project the investment in technology transfer supported by GEF was the largest national investment in combustion efficiency improvements in China's industrial boiler sector in the mid-1990s. The project transferred a total of nine technology patents from Japan and the US to China to boiler manufacturers which successfully built prototypes meeting energy efficiency and environmental performance criteria. Furthermore, eight transferred technologies were used for commercial boiler production and achieved initial sales success. After 15 years, some of the transferred technologies are still in use, yielding a significant increase in fuel efficiency of approximately five percent. The reported global environment benefit of this project at the design stage was estimated at 40 million $MTCO_2$.

7. Advancing National and Local Energy Efficiency Policies and Standards

To help developing countries and countries with economies in transmission, the GEF has provided funding to remove a large number of regulatory, policy, and market barriers to energy efficiency. Within the 49 GEF energy efficiency projects analyzed, participating governments created 17 energy efficiency policies, standards, and codes. Moreover, these projects promoted the establishment of 21 innovative financial instruments and 29 market-based mechanisms.

Enhanced national energy efficiency policies, codes and standards, and regulations have significant and long-lasting impacts on energy efficiency improvements. For example, a GEF lighting project in Mexico led to the development of national quality standards for high-efficiency lighting. In Thailand, after the completion of a GEF project, the Thai Consumer Protection Agency, in collaboration with other organizations, worked to achieve mandatory labeling for refrigerators. In China, national standards for refrigerators were established as a result of an energy efficiency project. In Senegal, the project Sustainable and Participatory Energy Management led to the development of building codes for the entire nation.

8. Capacity Building Investments Yield Dividends

Capacity building has become a major priority in global conventions and the international community. In May 1999, the GEF Council, aware of the growing importance the UNFCCC placed on capacity building, approved the 18-month Capacity Development Initiative (CDI) as a strategic partnership between GEF and the UNDP, for the preparation of a comprehensive approach to developing the capacities needed at the country level to meet the challenges of global environmental action. The CDI was undertaken to: 1) conduct a comprehensive assessment of capacity building needs of developing countries and countries with economies in transition; 2) take stock of earlier and ongoing efforts to assist national capacity building; and 3) prepare a strategy to strengthen the GEF portfolio. The CDI was undertaken in a highly consultative manner, based on national inputs, regional expertise, contributions by civil society organizations (CSOs) and bilateral/multilateral agencies, and the discussions with the UNFCCC [10].

Under the CDI, the GEF worked to strengthen capacity building efforts in developing countries that were already being undertaken with national resources. The GEF clearly recognizes the need to mobilize other resources and to assist countries in identifying complementary sources of financial and technical assistance, either multilateral or bilateral, to meet capacity building needs. Valuable opportunities to achieve this exist in countries that prepare an action plan for capacity building on the basis of National Self-Assessments of Capacity-Building Needs (NCSAs) and/or countries for which country programs will be developed.

In this paper, the effectiveness of support for NCSAs is assessed using both qualitative and quantitative indicators. The qualitative indicators for capacity building cover the following 11 dimensions (GEF, 2003): 1) awareness and knowledge; 2) national policy, legal and regulatory frameworks; 3) institutional mandates, coordination, and processes for interaction and cooperation among all stakeholders; 4) information management, monitoring and observation; 5) mobilization of science in support of decision making; 6) financial resources and technology transfer; 7) incentive systems and market instruments; 8) negotiation skills; 9) cooperation and networking within regions; 10) institutional management and performance; and 11) individual skills and motivation in key institutions. Other elements are related to specific projects. For example, a number of projects provided International Organization for Standardization (ISO) energy management standards training for local professionals. Quantitative indictors for capacity building include the number of people trained and the number of workshops or seminars conducted.

GEF investments in energy efficiency projects have strengthened the capacities of many developing countries and countries with economies in transition. Presented results show that the GEF has facilitated knowledge dissemination and capacity building in developing countries in at least three ways. First, the GEF has implemented a number of regional and global energy efficiency umbrella projects, addressing the shared challenges and needs of a number of countries with extended reach and outcomes. For example, in 2001, the GEF funded a project to promote energy efficiency in the West-African buildings sector. This project provided training in energy audit techniques to twenty audit engineers in Cote d'Ivoire and Senegal. Another global project implemented in China, the Czech Republic, Hungary, India, Slovakia, and Vietnam, has built a network for knowledge and technology information sharing across nation borders and regions. This project included components involving energy audits, project design and implementation planning, and training, and successfully raised the awareness of the economic and environmental benefits of energy efficiency improvements in these countries.

Second, some capacity building activities of the GEF projects not only involved the professionals in host countries, but also included the general public. For example, a project in Mongolia raised the awareness of energy efficient household stoves among tens of millions of residents through workshops and social media.

Third, GEF projects were sometimes implemented indifferent phases, and the completion of early phase projects often provided valuable experiences and lessons for the implementation of ongoing and future phase projects. For example, the second phase of GHG Emissions Reduction in Township and Village Enterprise Industries in China project benefited from the technical skills and educational materials which were developed during the first phase of the project.

A substantial proportion of GEF funding for energy efficiency projects has supported capacity building in host countries. Among the GEF financed US$313 million for the 49 energy efficiency projects from 1992 to June 30, 2010, US$100 million (32 percent) funded capacity building, such as developing policy, standards, codes, and institutional frameworks. For these projects, GEF mobilized US$327 million in co-finance from other project stakeholders. The combined funds used for capacity building (US$427 million) accounted for approximately 15 percent of the total funds (GEF resources and co-finance) for the 49 completed energy efficiency projects.

This investment has had significant impacts on energy efficiency capacity building in developing countries. These funds assisted with training more than 1.3 million professionals, and creating 17 energy efficiency standards and codes, 21 financial instruments, and 29 market-based mechanisms for energy efficiency development.

9. Case Study of an Energy Efficiency Project

GEF Experiences in Closing the Global Energy Efficiency Gap presents one of 49 GEF completed project case studies: Energy Efficient Industrial Boilers in China. The project was designed in the early 1990s, implemented from 1994 to 2004, closed in 2005, and post-evaluated in 2010. **Figure 6** shows the project timeline.

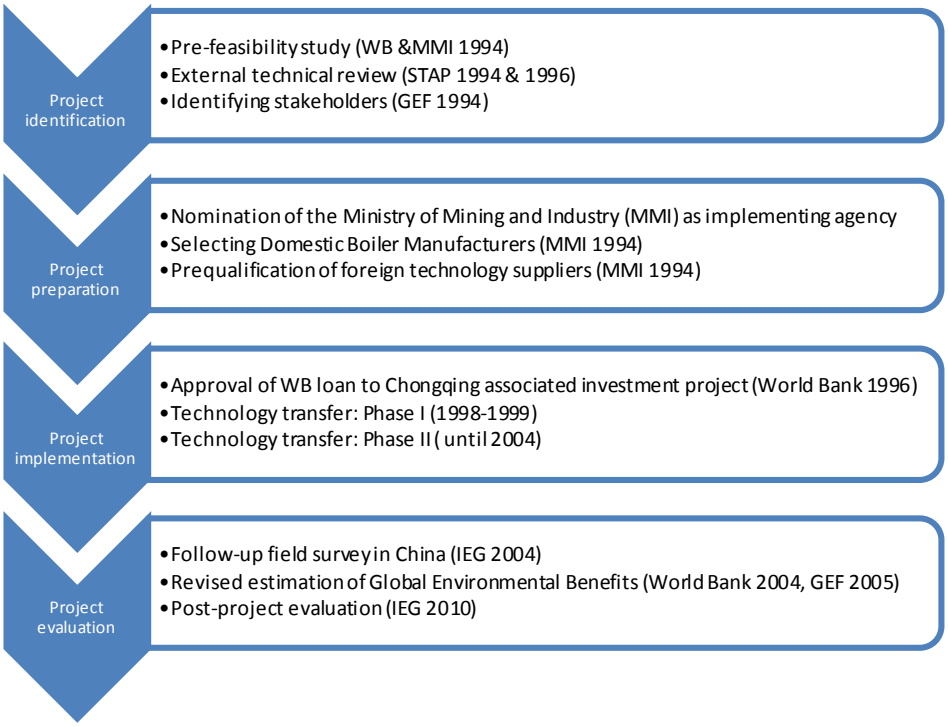

Figure 6. "Efficient industrial boilers in China" project timeline (1994-2010).

Project finance (US$121.1 million) consisted of the enterprises' own funds, commercial loans, and World Bank finance, and a GEF grant of US$31.85 million covering the incremental costs. The total project funds may appear minor when compared with the total capital costs that were needed to upgrade all industrial boilers in China. However, this project assisted the Chinese government in development of energy policy and boiler standards and regulations, which greatly facilitated the adoption of new energy efficient boiler technologies and investments from industrial users.

The major environmental benefits of the project are the reduction of GHG emissions as well as local pollutants such as SO_2. In total, tangible project benefits were 432,000 tons of steam production per hour (tph) of boiler production in nine beneficiary boiler manufacturers over a 20-year span. Most recent calculations by the Independent Evaluation Group (IEG) of the World Bank took this into account, suggesting that the project will likely achieve a total of 40 million $MTCO_2$ emissions reduction by 2019 [11].

10. Lessons and Experiences Learned

A number of lessons and experiences are learned from the analysis of the GEF's completed energy efficiency investment projects over the past two decades. These lessons and experiences include:

1) Involving and engaging governmental agencies at all levels is critical in identifying key stakeholders and obtaining their commitments to the projects. If a project is developed and implemented in a large country like China or India, it is particularly important to have the support from national governments. National government energy policies, standards, codes, and regulations have long term impact on energy efficiency investment.

2) National enforcement capabilities should be strengthened when it comes to energy efficiency improvements. In addition to encouraging manufacturers to adopt more efficient technologies, governments should enforce regulations to ensure that the appropriate national energy efficiency standards and codes are being set and met.

3) It is essential to ensure that sufficient finance is being provided from local organizations, including resources from lenders and the beneficiary enterprises themselves. In this way, local stakeholders have an ownership stake in the projects and the host countries are better able to realize project benefits.

4) Clear and consistent energy policies are needed for achieving sustainable impacts after the project is com-

plete. National energy efficiency standards should be higher than, or at least consistent with, the standards set by the manufacturers themselves. Otherwise, manufacturers may lack incentives for investing in research and development in energy efficient technologies. Take the efficient industrial boilers project in China as an example. When the government agencies set lower efficiency standards of boilers than the standards set by manufacturing companies, fewer industrial boilers which meet much higher efficiency standards but with higher prices will be sold. This eventually discourages the private sector to invest, resulting in fewer energy efficient technologies in the market.

5) Countries transitioning from planned to market economies should prioritize projects that emphasize market solutions. Before introducing new technologies, market-driven analysis should be conducted to evaluate the costs and benefits of such technologies. Without sufficient analysis in this area, it is difficult for project developers and project reviewers to estimate project benefits. For example, GHG emission reduction from the efficient industrial boilers in China project was estimated to be160 million $MTCO_2$ at the project preparation stage in 1993-1994. After sixteen years when the project was at its post-evaluation stage, this amount was estimated at 40 million $MTCO_2$. One of the reasons causing the estimation error is that the boiler market conditions have changed significantly over the 16 years, and the project developers did not project the changes. For example, many private companies which were initially involved in energy and boiler business moved to other businesses such as water and sanitations, and the project developer in the 1990s did not undertake any analysis including such changes.

6) Overly complicated procedures for project implementation should be avoided. For example, the bidding procedure for purchasing a patent to develop energy efficient technology locally should be transparent and simple. Simple procedures encourage participation and open competition and prevent delays in project implementation.

7) In the least developed countries, GEF should mobilize co-finance agencies to invest more in capacity building. Although GEF has invested 32 percent of its funds in capacity building including training, policy, standards, and institutional development, the combination of GEF and co-finance funds invested in capacity building only represented 15 percent of the total funds. This implies that project stakeholders may have underestimated the impact of their own investments in capacity building. Project stakeholders might also expect that these investments should be more of GEF's burden. However, the historic lack of capacity building in countries to develop and manage GEF projects is one of the factors that caused some of the GEF projects to move too slowly. Strengthened capacities in host countries will help reduce the number of slowly moving projects.

8) Funding resources are generally invested in either hardware or software assets. First, resources geared towards hardware investments and tangible technological improvements generate substantial and almost immediate GHG emissions reductions. Hardware projects are often able to achieve cost-effectiveness and global environmental benefits in a short period. On the other hand, resources utilized for policy development, capacity building, and enabling activities tend to generate long-term global environmental benefits, which can be difficult to measure during project implementation periods. For example, projects that promote the policy making and consumer awareness efforts have high institutional and commercial value, but often result in few direct GHG emissions reduction impacts during the project period. When projects can help transform market environments, they usually stimulate associated economic growth and encourage environmentally-conscious decision-making. Successful projects often balance both tangible and intangible investments and create sustainable market transformations for energy efficiency technologies over both the short and long term. Investing in both tangible and intangible assets is one of the keys to success for the GEF in overcoming market barriers to energy efficiency improvements.

11. Conclusions

Much has been achieved over the past 20 plus years through world energy efficiency investment. But energy efficiency still offers a potential of reducing over 20 percent of energy consumption worldwide. To reach the global energy savings of 20 percent, US$35 billion of capital is needed to invest per year in energy efficiency in developing countries.

Over the past 20 years, the GEF has utilized US$313 million grants and directly mobilized US$2.6 billion from various stakeholders in global energy efficiency investments. The ratio of the GEF funds versus mobilized co-finance is 1:8.2. Of the co-finance for energy efficiency projects, 24.7 percent comes from the governments

of host countries, 30.7 percent from the private sector, and 44.6 percent from other resources, including multilateral banks, financial institutions, and non-governmental organizations (NGOs). The private sector in the developing countries has contributed a total of US$789.5 million in co-finance in the 49 completed energy efficiency projects. The total amount of GEF funds and mobilized co-financing funds is equivalent to approximately US$145.6 million per annum, which is approximately 0.42 percent of the amount estimated by the IEA that is required to close the global energy efficiency gap. Although this figure is miniscule, GEF project impact on national energy policy, institutional development, capacity building, and technology transfer and innovation in developing countries is significant, long-lasting, and beyond estimation.

GEF energy efficiency projects are cost-effective in mitigating GHG emissions. One dollar GEF investment in energy efficiency yields a direct reduction in GHG emissions of 1.89 $MtCO_2$, a mitigation cost of US$0.53 per $MTCO_2$. This abatement cost is the lowest among those of the average of all GEF sub-focal areas. For example, one dollar GEF investment in renewable energy, low-carbon transport, and land use, land-use change and forestry (LULUCF) yields a reduction in GHG emissions of 0.78 $MtCO_2$ on average.

GEF investments have catalyzed the transfer of climate-friendly ESTs from developed countries to developing countries. All of the 49 completed projects have directly or indirectly addressed the issue of technology transfer, with eight having formal technology transfer components. A total of 49 technology patents have been transferred from OECD countries to developing countries and countries with economies in transition.

The 49 completed GEF energy efficiency projects have helped remove a large number of regulatory and market barriers to energy efficiency in developing countries and countries with economies in transition. Governments participating in the 49 projects have created 17 energy efficiency policies and standards and codes, 21 innovative financial instruments, and 29 market-based mechanisms for energy efficiency development.

The GEF has dedicated a substantial portion of its funds in energy efficiency to support capacity building in host countries. Among the US$313 million GEF funds for the 49 completed projects from October 1991 to June 30, 2010, US$100 million (32 percent) was used for capacity building. In addition, the GEF has mobilized US$328 million co-finance for capacity building, policy, standards, codes, and institutional development for these projects. The combined funds for capacity building, policy, standards, codes, and institutional development (US$427 million) accounted for 15 percent of the total funds (GEF resources and co-finance) in energy efficiency. With the support of these funds, more than 1.3 million professionals have received professional capacity training.

For more information on the study, please visit http://www.springer.com/978-1-4471-4515-8.

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