Rural Electrification: GEF Experience in Renewables-based Microgrids

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Abstract

This paper discusses how the existing 1.2 billion poor people worldwide without access to electricity can be environment-friendly electrified with the implementation of the UN Sustainable Development Goal 7 (SDG7) on energy and the 2015 Paris Agreement on climate change. The objective of this paper is to demonstrate the experience of the Global Environment Facility (GEF) in rural electrification with renewable energy-based microgrids or mini-grids, and identify challenges and business opportunities in rural electrification in the least developed countries (LDCs). Several case studies are presented to show GEF's strategies of financing renewable energy-based microgrids. This paper concludes that (1) with the demonstrated evidence of the importance of new technologies for renewable energy-based microgrids, it is necessary to improve enabling environments for creating markets conducive to the new technologies; (2) project investment is a necessary first step, but for success to be fully realized, catalyzing follow-on investments should also be set as an important goal; and (3) investments need to include effective technology transfer components for renewable energy-based microgrid technologies.

1. Introduction

Ensuring all human beings to access to affordable, reliable, sustainable, and new renewable energy, Sustainable Development Goal 7 (SDG7) is one of the 17 SDGs in the 2030 Agenda for Sustainable Development adopted by world leaders at a UN Summit in 2015. In addition, signed in 2015 and effectuated in November, 2016, the Paris Agreement dealing with greenhouse gas (GHG) emission mitigation, climate adaptation and finance requires all UNFCCC Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. All Parties are asked to report regularly on their emissions and on their implementation efforts. According to the International Energy Agency (IEA, 2016a), fuel combustion accounts for approximately two-thirds of total greenhouse gas emissions and 80 percent of CO2. The SDG7 and the Paris Agreement require governments in all countries use low carbon or zero carbon technologies in their energy supply systems. Now, the question is how to make the low or zero carbon technologies affordable to the governments and people in developing countries, particularly in LDCs.

Asia and Africa are continents with most LDCs and home to largest rural population, accounting for 3 of the 3.4 billion rural dwellers in the world (UNDESA 2015). The IEA (2016b) shows that there were approximately 1.2 billion people without electricity worldwide in 2015 with 244 million (21 percent) in India alone and 632 million (53 percent) in Sub-Saharan Africa (SSA). The United Nations estimates rapid growth of rural population in the two continents in next few decades, reaching over 1.2 billion by

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2050. Electricity is expected to be provided to existing population without access electricity as well as all incremental population. Rural electrification will thus be an increasingly critical issue for Asia and Africa. With continued deterioration in global conditions of finance in energy for the poor, business as usual in the energy sector would not be able to achieve the goal of SDG7. Alternative technology systems, innovative business models, and new financial instruments for rural electrification must be applied to electrify the poor.

A renewable energy-based microgrid in this GEF paper is defined as a very small power grid system with a range of 20-500 kW that uses localized new renewable energy resources such as solar, wind, and biomass as primary energy input to provide electricity to local communities. It can be connected to and synchronous with the traditional centralized electrical grids; it can also be disconnected and function autonomously as physical and/or economic conditions dictate. The outstanding characteristics of a microgrid power system include (1) local availability of energy resources with low or zero impact on both local and global environment, (2) contributing to climate change mitigation and protecting natural capitals, (3) less vulnerable to the volatility of the fossil fuel markets, and (4) stimulating local employment and technological and economic development. Micro-scale renewable energy technologies such as micro-hydro, small biomass digesters, solar photovoltaics (PVs), and micro-wind power, offer rural households access to cleaner, and in some cases, most cost-effective energy resources (GEF 2013).

2. Challenges and Opportunities to the Renewable-based Microgrids

Technologies alone, however, are not sufficient; rural electrification for LDCs with renewable-based microgrid systems need support from policy, capacity building, finance, and institutional development. There are instances when electric companies and energy suppliers defer expanding access to economically disadvantaged areas because such expansion is not perceived as financially viable. In most LDCs, the public sector could be stymied by its inability to implement or finance rural electrification projects with microgrid systems, and is always under pressure to satisfy other urgent public financing needs. National planners may also hesitate to promote renewable energy-based microgrids because these grids are thought relatively more expensive than fossil fuel energy technologies and the systems are normally sourced from overseas suppliers. In addition, for a variety of social and political reasons, government agencies give higher priority for expanding access for urban, rather than rural areas.

For LDCs, the governments and people are facing severe challenges, including the need to:

1) Have feasible financing models to reduce the high initial construction cost for accessing renewable energy, particularly for installing equipment.
2) Improve living conditions and enhance economic opportunities for the 1.2 billion people without access to electricity; and supply clean fuels to about three billion people who rely on solid fuels for cooking.
3) Increase energy security for their own countries, regions, and communities, while at the same time reduce carbon emissions.
4) Reduce the adverse environmental effects and ancillary risks associated with current energy systems and increase prosperity.

Paralleling the abovementioned challenges, rural electrification for the 1.2 billion poor people also provides great business opportunities. Although these poor people earn about $2 a day per capita on average; their total income per day already amounts to $2.4 billion, or approximately $876 billion per annum. If 10 -15 percent of the income is spent in energy at homes including lighting, TV, rechargeable torches, and mobile phone charges, the energy market amounts to $88-176 billion per year. In addition, renewable energy-based microgrid technologies can play crucial roles in employment and economic growth for local poor communities. These technologies are more labor-intensive than conventional technologies for the same energy output—employing a mixture of local and decentralized workers. For an investment in decentralized renewable energy technologies of $1 million over 10 years, wind energy generates 5.7 person-years of employment; solar photovoltaic (PV) generates 5.7 person -years; but the coal industry only generates 4.0 person-years (Pachauri 2009).

3. The Role of the Global Environment Facility

While dealing with these challenges, developing countries, particularly LDCs, have been seeking financial resources. To address such need for financial assistance, the international community created the GEF in 1991 as a financial mechanism. Since then, the GEF has provided over $17 billion in grants and mobilized an additional $88 billion in financing for more than 4000 projects in 170 countries. Today, the GEF is an international partnership of 183 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues.

3.1 GEF's Renewable Energy Strategies

In managing these investments, the GEF pursues a set of strategies to boost the likelihood of success for its renewable energy portfolio. These include (1) supporting the development of functional markets, and (2) providing finance for critical investments.

Support for the development of functional markets includes efforts to enable appropriate policies and regulatory frameworks, more effective standards and certification, greater levels of awareness and know-how, and greater capacities of institutions, businesses, and workers. In supporting these activities, the GEF views national policies as a critical element in creating favorable conditions for renewable energy development. For example, many GEF decentralized renewable energy projects have contributed directly to the development of such policies by drafting or revising national strategies, or by developing roadmaps and national action plans for off-grid renewable energy development.

The GEF has also been successful in developing standards, testing, and certifying renewable energy technologies. This has proven to be an important success factor in sustaining market development as more effective standards and testing can significantly improve quality, reliability, and consumer acceptance. In parallel, most GEF renewable energy projects have supported awareness raising activities such as distribution of promotional material and production of audiovisual tools that help build community trust in renewable energy technologies. The GEF also helps recipient countries build technical and institutional capacity by organizing workshops and training opportunities for government officials, engineers and technicians, and other technical and business personnel.

The availability of affordable finance remains a key barrier for renewable energy investments, especially

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

One of the GEF's most effective strategies is to test innovative financing approaches in order to increase access to local funding. Such approaches differ according to the status of the local financial sector, the type of financial barriers to be overcome, and the type of business model employed. For example, in the case of small-scale power generation, sales-based business models may require a degree of financing for suppliers and dealers, but the main need is microfinance for consumers. Since 1991, the GEF, through its implementing agencies, has sought to:

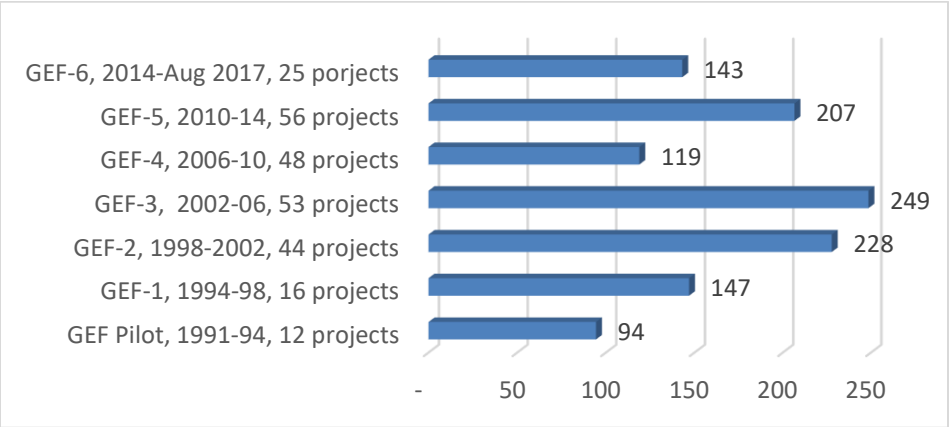
- Provide grants and contingent financing for project preparation and investment. The GEF offers contingent loans and grants to cover up-front project development capital costs. A contingent loan has an interest rate and payment schedule similar to a traditional loan, but the loan can be forgiven if certain conditions are met.
- Mitigate technology-specific project risks. For example, the highest risk during geothermal plant development occurs when the first well is drilled, even if there has been successful surface-based geophysical exploration. The GEF projects in South Asia, Africa, the Caribbean, and Eastern Europe are developing risk mitigation facilities to insure investors against the geological and technical risks during development of such projects.
- Initiate microfinance schemes. Extending financing to private consumers, such as households and small enterprises, for the purchase of renewable energy equipment is often considered a low priority by financial institutions (FIs), especially in the developing world. The GEF has supported existing FIs or developed new microfinance institutions to provide lending to such recipients, for example, for the purchase of solar home energy systems in India, Bangladesh and Uganda.

3.2 GEF's Renewable Energy Portfolio

From October 1991 to August 2017, the GEF has provided a total of $1.19 billion grant for 254 renewable energy projects worldwide, 43% of which are in the category of microgrids, mini-grids or decentralized renewable energy projects. The projects were undertaken in 160 countries, most of them are in Asia and Africa. With these projects, GEF funding has been supplemented with more than $11 billion in co-financing, and targeted GHG emission reductions amounted over 1.5 billion tonnes of CO2 (GEF 2017).

Figure 1 shows how GEF funding for these renewable energy projects has changed over time. Funding for the renewable energy projects increased from the pilot phase (1991-1994) through GEF-1, 2, 3, but declined in GEF- 4, 5 and the first three years of GEF-6. This is due to a variety of factors including the expansion of other climate change portfolios, especially energy efficiency; the high amount of funding directed to renewable energy projects, such as concentrating solar power (CSP) projects under GEF-3; and the decision not urgently to pursue the strategic objective of promoting off-grid renewable energy technologies in GEF-4 (2006-2010). In terms of co-financing for the decentralized renewable energy technologies, on average, whenever the GEF invests one dollar, other stakeholders invest in 9.3 dollars. In GEF 6, the co-financing ratio reached over 20.

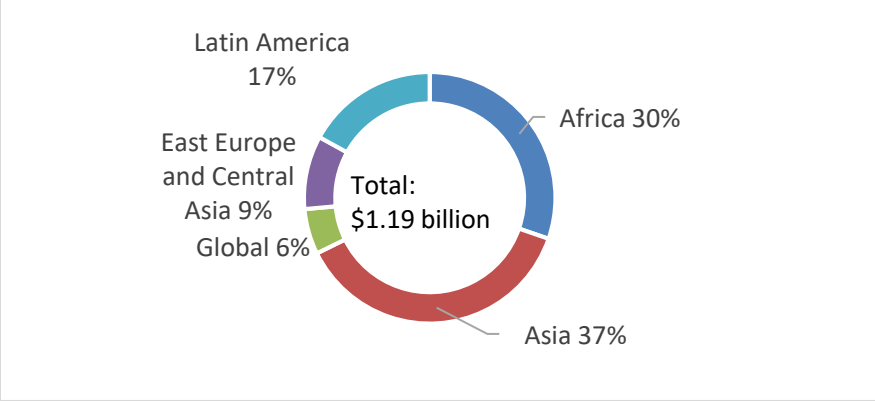
Figure 1 GEF Renewable Energy Investment by GEF Phases ($ Million)



Source: GEF CCM database, August 2017

Figure 2 shows the regional distribution of the GEF's renewable energy portfolio. Most of the GEF funding (67%) was invested in Asia and Africa. The rest (33%) was invested in Latin America, Central Asia, Eastern Europe and the Caribbean.

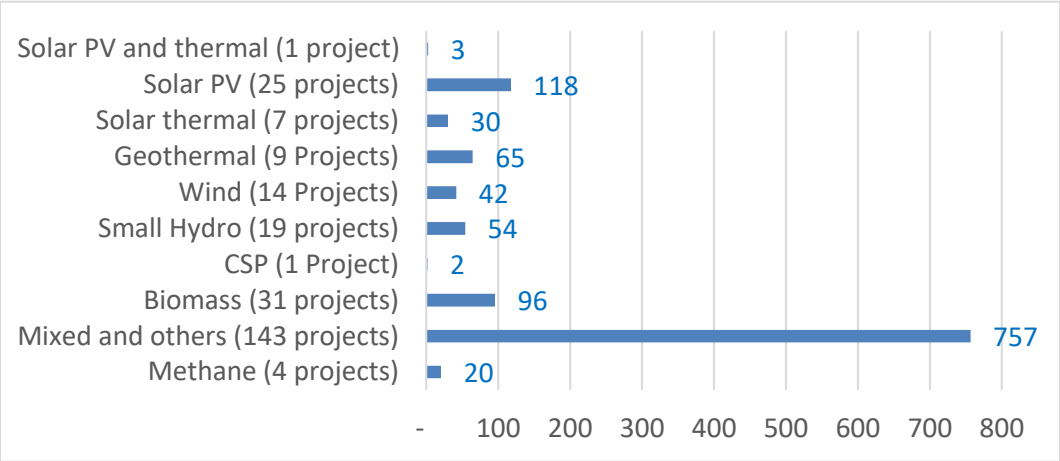
Figure 2. Regional distribution of the GEF renewable energy investment portfolio



Source: GEF CCM database, August 2017

Figure 3 presents the distribution of GEF investments in renewable energy technologies. Of the 254 projects, 106 were for microgrids, mini-grids and decentralized renewable energy technologies including those in biomass, small hydro, wind, geothermal, and solar. GEF funding has been invested in a variety of different technologies. The variety is broad because it is the GEF's role to address barriers to investments, and catalyze and transform energy markets generally, and not to single-out individual renewable energy technologies for support. In fact, GEF renewable energy investments have been targeted toward those technologies that are best-suited and most cost-effective as determined by the participating countries based on their local climate, market, and policy conditions.

Figure 3. GEF renewable energy investments by technologies ($ Million)



Source: GEF CCM database, August 2017

4. Selected Case Studies

As shown in the previous section, the GEF has financed a total of 106 microgrid, mini-grid, and decentralized renewable energy projects throughout the world over the past 26 years. This section presents only a few projects in Asia and Africa as case study examples. These projects cover the following two technologies: micro-hydro power and micro-solar PV grids.

4.1 Case Study 1: Congo DR — Promotion of Micro-Hydro Power Plants

In the Democratic Republic of Congo, only 9% of people had access to grid electricity as of May 2016. For the rest, the only power supply was from decentralized generators via microgrids and mini-grids running on imported oil and coal. The costs of imported fuels are exorbitant for both the country and consumers who operate under extremely difficult and unpredictable economic and political conditions. Thus, over 60 million Congolese rely predominantly on ligneous fuels such as wood, charcoal, plant residues, etc. for their basic energy needs, which was a major driver in destruction of the forests and rise of GHG emissions. In its Intended Nationally Determined Contributions to the UNFCCC, the government of DRC put rural and urban hydro-electrification as top priority to achieve its 2030 GHG emission reduction goal: reducing 17% below its business as usual scenario by 2030. Specifically, the country aims at installing 650 MW of power generation capacity through micro, mini, small, and medium scale hydro power plants, 8 to 10 sites with a budget of $1/W for power plants plus $ 1.35/W for electricity distribution grids. It was in this context, the government of Congo DR requested the GEF to finance a project with objective to promote investment in mini and micro hydropower (MHP)-based mini-grids for rural electrification in the country.

For the project, the GEF provided a total $3,187,669 grant and leveraged $14,150,000 co-financing to cover four areas: (1) Policies and a regulatory and institutional framework for private and community-based investments supplied by small scale hydropower; (2) Reinforcement of the technical capacities in the technological supply chain; (3) Pilot investments in selected mini- and micro-hydropower stations in rural areas; and (4) Communication, management, public relations and promotion of investment. The project is expected to lead the development and construction of 39 microgrids using hydro power technologies with a total installed capacity of 10MW. It will provide electricity for over 200,000 homes in

the poor communities of Congo DR. The project will likely avoid a total of 1.97 million tonnes of CO2 equivalent, including 0.69 million tonnes directly and 1.27 million tonnes consequentially.

4.2 Case Study 2: India—Microgrid Solar PV

During 1993 – 2002, the GEF provided $26 million and the World Bank released a loan of $424 million to "Alternate Energy" in India to promote off-grid PV applications. The objectives of the project were to (1) promote commercialization of renewable energy technologies by strengthening the Indian Renewable Energy Development Agency's (IREDA) capacity to promote and finance entrepreneurial investments in alternative energy; (2) create marketing and financing mechanisms for the sale and delivery of alternative 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.

The outcomes of the project include 2.1 megawatt-peak of off-grid PV power generation capacity for the local communities. Solar PV products from the project ranged from 5 W solar lanterns, 900 W PV irrigation pumps, 500–2500 W solar power packs, and 25 kW village power schemes to a 200 kW mini-grid system. The IREDA financed an additional 4 MW of PV irrigation pumps with assistance from the Ministry of Nonconventional Energy Sources. Evidence of positive development impacts from solar PV use among the 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 for children, under better lighting conditions.

5. Conclusion and Outlook

Providing sustainable energy to the poor in LDCs has been a global challenge for many decades. By the end of 2016, approximately 1.2 billion poor people in the world could not access electricity. Lack of information, scarcity of capital investment, insufficiency of policy and institutional supports, shortage of capacity, and inadequacy of technologies were major barriers to sustainable energy supplies to serve the needs of these people.

Since its inception in 1991, the GEF has provided assistance in rural economic development, rural electrification, and poverty reduction from investments in renewable energy projects in the context of mitigating climate change. As of August 2017, the GEF has invested approximately $1.2 billion, with an average of $4.9 million per project, for 254 renewable energy projects, including 109 microgrid, mini-grid, and other decentralized new renewable energy projects in 160 developing countries.

The GEF's experiences from these projects has shown that decentralized renewable energy can be a catalyst for change in rural areas including rural electrification and development of farm-based economies. Key lessons-learned from these experiences include:

- While demonstrating the importance of cost effectiveness and high performance of new technologies, it is also necessary to develop appropriate policies and best practices for creating markets conducive to renewable energy. As a result, the GEF has included technical assistance

for policies and regulatory frameworks, training and other efforts to build technical and institutional capacities, and innovative approaches to establishing financing mechanisms for investment in the deployment and diffusion of renewable energy technologies.

- Project investment is a necessary first step but for success to be fully realized catalyzing follow-on investments is also an important goal so the GEF has learned that investments need to include effective technology transfer components for renewable energy technologies. The GEF has invested in the transfer of commercially proven renewable energy technologies in rural areas and has emphasized market demonstration and commercialization of the most promising technologies, tools, and techniques. The GEF has focused its efforts to promote successful demonstrations of cost-effective applications with the aim of removing further barriers to commercialization and bringing the cost down over time.
- For successful implementation in rural areas and remote farming communities, promotion of access to modern energy services is paramount. Given the acute demand for energy access and services in rural areas in LDCs, GEF support has focused on bringing modern energy services to these areas by emphasizing decentralized production of electricity and thermal energy using local resources, businesses, and workers that suit local needs. Thus, GEF investments produced a track record of success, particularly in areas where needs are the greatest including Sub-Saharan Africa, South Asia, and Small Island Developing States.

Looking ahead, the GEF is planning to promote decentralized renewable energy in the forthcoming four years (2018-2022). In this period, the GEF will focus on grid modernization and integration of energy storages to facilitate the rapid growth of decentralized renewable energy in a cost-effective manner. It will resolve the issues of power backups for the decentralized renewable power systems. Energy storage technology has emerged as a new disruptor, changing market dynamics with rapidly improving technology capacity and declining costs, but the technology is not yet reaching many countries in LDCs. The GEF will support countries that have identified power sector transformation through mini-grids, off-grids, energy storage, and new business models in the period of 2018-2022.

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