PART I

Introduction: The Development Case for Rural Electrification

More than 1.6 billion people, roughly one third of the world's population, live without access to electricity. The vast majority of those without electricity live in rural areas. The World Bank estimates that 67 percent of the rural population in developing countries is without electricity. As a result, low-income households around the world spend billions of dollars every year on expensive and environmentally damaging energy sources such as charcoal, firewood, and disposable batteries, with an estimated $38 billion a year spent on kerosene alone. This is especially true in Africa, where roughly two thirds of households—more than 580 million people—depend on wood fuel for their daily cooking and heating needs. People in emerging markets who rely on these fuels use much of their labor to gather wood fuel and are exposed daily to indoor air pollution. The World Health Organization (WHO) estimates that the pollution caused by using indoor biomass cook stoves is responsible for 1.6 million deaths per year—mostly of young children and mothers.

Access to modern, reliable energy is important for rural development and improved livelihoods. Energy is a major tool for poverty alleviation, income generation, health, and other developmental agendas. The provision of clean electricity to low-income households allows for increased opportunities for studying in the evenings, as well as increased productivity of agricultural and micro-enterprise activities. Numerous studies have confirmed that the social benefits from electrification—the ability to power lights, radios, small appliances, and televisions—make a significant contribution to enhancing quality of life. This enhanced quality of life has, in turn, proved to be a key driver of increases in the demand for energy.

SOLAR PV: AN ATTRACTIVE TECHNOLOGY FOR RURAL ELECTRIFICATION

Inefficient energy infrastructure, rapidly growing demand, and a general lack of generating capacity mean that many developing countries are unable to meet their basic energy demands. The International Energy Agency (IEA) estimates under its reference scenario that developing countries require a $300 billion annual investment for the electricity sector alone.[3] In rural areas, where as many as four out of five people lack electricity, conventional grid-connected electricity schemes are often not feasible. Grid expansion can be extremely costly and has been demonstrated numerous times to be far less cost effective than supplying SHS.[4] Because of the high cost of extending electrical grid coverage in these areas, non-grid-tied renewable energy technologies, such as solar PV, may be a least-cost solution.

The availability of clean electricity not only helps households avoid the health risks associated with conventional forms of energy, such as kerosene, charcoal, and disposable batteries, but it also helps the global environment through the avoidance of greenhouse gas emissions and conventional air pollution associated with fossil-fuel-based forms of electricity. Renewable energy technologies also help governments gain energy independence and eliminate the need for costly grid expansion to remote villages.

Solar PV and SHS are attractive renewable energy technologies for many applications in off-grid areas. Most developing countries lie in areas with high solar insolation levels—a "must" for solar PV—and, with the added benefit of SHS being modular, SHS can be installed to provide energy for one house, groups of houses, or an entire village. Other renew-

[3] International Energy Agency (IEA), *World Energy Outlook 2004*, OECD and IEA, Paris.

[4] Foley, 1995, p. 41.

[5] Erickson, 1995, p. 1130.

[6] Cabraal et al., 1996.

[7] For more information on the WBG renewable energy strategy, visit www.worldbank.org/re.

[8] IFC's initiative with CEPALCO in the Philippines was the only grid-tied investment made.

able energy resources (e.g., hydro or biomass) are typically better suited for less dispersed populations, as they generally become economical only if they are able to provide energy to a more sizable population.[5]

Photovoltaic technologies already provide electricity in developing countries to an estimated 500,000 to 1 million rural households lacking access to electricity grids. SHS is one of the most common forms of solar PV application in rural areas. An SHS usually provides electricity for two or three fluorescent lights; a radio, cassette player, or television; and other small appliances. Electricity is drawn from rechargeable batteries charged through an electronic charge controller by solar PV modules mounted on a pole beside the house or on the rooftop. The total capacity of the unit is usually in the range of 30-100 peak watts (Wp), but can be less or greater.[6]

The direct economic benefits of SHS include increased convenience and safety, improved indoor air quality, a higher quality of light than kerosene for reading, and the displacement of CO_2 emissions. Improved lighting provides additional educational benefits, particularly for children, and can allow income-generating activities to occur beyond normal work hours. Solar PV systems can power lights and vaccine refrigerators in medical clinics, run low-lift water pumps, and allow for the operation of other vital systems.

THE WORLD BANK GROUP'S INVOLVEMENT IN SOLAR PV

When the Global Environment Facility (GEF) was established in 1994, it made available a new source of funds to support projects that generated global environmental benefits. One of GEF's operational programs supports renewable energy activities that are unable to secure commercial financing elsewhere. The WBG was at the time particularly interested in utilizing GEF funds to develop the renewable and energy efficiency potential in emerging markets and to gain experience in the solar PV market.[7]

IFC was particularly interested in exploring opportunities for the commercialization of solar PV. With its mandate to further economic development through the private sector, IFC had been active in the solar PV market since 1989, when it made a $3 million investment (debt and equity) in Shenzhen YK Solar PV Energy Co., Ltd., a solar PV manufacturer in China. Although the investment, made using regular IFC funds, did not meet its original expectations, it established an important precedent for investing in solar PV businesses in frontier markets.

IFC has since used its skill and experience in structuring projects that target the private sector to develop and implement a number of GEF-funded solar PV projects, many of which operated across country lines. Today IFC, together with the World Bank, is the largest financier of off-grid solar PV in the developing world, having supported the installation of over 1.3 million solar PV systems.[8] (See Table 1 below for details on the World Bank Group's solar PV–related projects.)

TABLE 1: WBG SOLAR PV INITITIATIVES

COUNTRY	NUMBER OF PROJECTS	NUMBER OF SYSTEMS INSTALLED*	SOLAR PV CAPACITY (kWp)	COST** ($ MILLIONS)
Argentina	1	30,000	2,843	36.0
Bangladesh	1	198,000	9,900	91.4
Bolivia	1	60,000	2,600	38.6
Burkina Faso	1	8,000	300	3.0
Cambodia	1	10,000	400	4.0
Cape Verde	1	4,500	129	2.5
China	1	400,000	10,000	144.9
Ecuador	1	2,200	110	1.5
Ethiopia	1	6,300	407	5.4
India	1	45,000	2,500	24.0
Indonesia	1	8,500	425	3.8
Laos	1	4,000	160	1.3
Madagascar	1	15,000	625	7.5
Mali	1	10,000	420	5.0
Mexico	2	37,000	704	12.9
Mongolia	1	50,000	520	5.2
Mozambique	2	9,800	1,096	13.5
Nicaragua	1	6,000	215	3.0
Pacific Islands	1	21,000	630	16.5
Papua New Guinea	1	2,500	100	2.2
Philippines	2	139,000	10,000	113.0
Senegal	1	10,000	420	5.0
Sri Lanka	2	104,400	4,176	36.1
Swaziland	1	2,000	100	1.3
Tanzania	1	40,000	2,500	30.0
Uganda	1	90,000	6,300	67.7
Multiple countries†	14	84,000+		25.3
Total	**44**	**1,300,000+**	**~58MW**	**~700.0**

Source: Anil Cabraal, 21st EU Solar PVSEC, 2006 (with update, January 2007).

* Figures include both the number of systems installed and the target installation for projects currently under implementation.

** Cost includes only total investment of solar PV components/applications.

† Includes projects of the SME Program in Bangladesh, Dominican Republic, Honduras, Tunisia, and Vietnam, and PVMTI in India, Kenya, and Morocco.