LEARNING PRODUCT

Reliable and Affordable Off-Grid Electricity Services for the Poor:

Lessons from the World Bank Group Experience

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An IEG Learning Product

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Abbreviations

CAS	country assistance strategy
CPS	country partnership strategy
IBRD	International Bank of Reconstruction and Development
IEA	International Energy Agency
IEG	Independent Evaluation Group
IDA	International Development Association
IFC	International Finance Corporation
SHS	solar home systems

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Overview

This learning product (study) draws upon existing IEG evaluations, project documents and analytical work relating to the World Bank Group's (WBG's) experience with supporting efforts towards the rapid scale up of off-grid electrification ("pico-solar" products, individual solar home systems [SHSs], and micro and mini-grids), in client countries. The focus is on experiences geared towards efficiently and effectively integrating off-grid electrification scale-up efforts with grid rollout – within a national roadmap for achieving universal access in a given time-frame. Relevant findings and lessons are framed as strategic considerations to inform the design, development and implementation of country engagements tailored to the prevailing sector conditions and readiness; through capacity building, technical assistance, and investment lending.

Background

In recent years, there has been renewed focus on the 1.1 billion people around the world without any access to electricity from either the conventional grid or any off-grid or stand-alone source. Most of these people are poor and are held back from their potential for human development and from the improved quality of life that can be enabled by access to electricity services.[1] In Sub-Saharan Africa alone there are over 600 million people without access, and this figure may rise to 935 million in 2030 if the population grows as projected and the pace of new electricity connections remains at the average annual rate of the last 10 years (IEG 2015).

Against this background, the World Bank Group and the United Nations have committed to the Sustainable Energy for All initiative[2], which is reinforced by Sustainable Development Goal 7 ("ensure access to affordable, reliable, sustainable and modern energy for all") and the World Bank Group's goals of ending extreme poverty and boosting shared prosperity.

The IEG report *World Bank Group's Support for Electricity Access, FY2000–2014* (IEG 2015) presented to the World Bank's Board of Executive Directors in 2015, was a strategic evaluation of the engagement, operations, and outcomes of the entire

[1] Another 1 billion people around the world who are connected to the grid still experience a highly unreliable and inadequate power supply, which triggers high welfare costs; they are not the focus of this study.

[2] http://www.se4all.org/

Bank Group portfolio in this sector for fiscal years (FY) 2000–14, related to the provision of adequate, reliable, and affordable electricity access. The report noted that the World Bank Group's support for off-grid electrification was a small proportion of its overall portfolio for the electricity sector during FY2000–14. However, the report also recognized a rapidly growing trend and scope in several countries in the adoption of portable solar products that can speedily bring, at a minimum, basic electricity services—lighting, fans, small television, and cell phone charging—to those who have little prospect of receiving grid-based electricity for several years or even decades.

An updated and in-depth examination of World Bank and International Finance Corporation (IFC) operations approved or closed during FY2000–16 identified 83 projects—71 Bank projects and 12 IFC operations—that were either dedicated to or had a component for off-grid electrification. The total commitment for World Bank Group projects for off-grid applications during this period was US$1.594 billion, estimated at about 2.5 percent of Bank Group lending for the electricity sector.

The World Bank's projects with off-grid components are concentrated in 10 countries (five low-, four high-, and one medium-access country). The countries received 78 percent of all World Bank assistance for off-grid electrification during FY2000–16. Bangladesh alone accounted for 32 percent of this lending, followed by Argentina (12 percent). The shares for Mali, Myanmar, Ethiopia, Uganda, India, Sri Lanka, Bolivia, and Liberia ranged between 7 percent and 2 percent. The predominant portion of the lending was for individual SHSs.

The Coming of Age of Off-Grid Access Delivery: World Bank Group's Catalyzing Role

From a near-standing start less than 10 years ago, more than 100 companies are now actively focusing on stand-alone solar lanterns and SHS kits targeted at those without modern energy access. They have sold over 14 million quality-certified pico-solar products (defined as having a photovoltaic panel smaller than 10 watts), mainly portable lights, as of mid-2015. These products provide basic electricity access for millions of people in Africa and Asia and have lifted 21 million individuals to the first rung of the energy ladder, according to our estimates. This rapid growth has been stimulated and supported by the World Bank and IFC's Lighting Africa program and its successor, the Lighting Global program, which pioneered well-designed and targeted technical assistance for improving quality assurance and service delivery. Though no firm estimates are available, the value of quality-certified pico-solar products is several orders of magnitude higher than the

relatively small outlay for technical assistance from the Lighting Africa and Lighting Global programs.

Despite some significant pilot examples of micro-grid and mini-grid project components supported by the World Bank Group and in the private sector, scaling up continues to pose a challenge – in terms of institutional arrangements and for commercially viable business models. This contrasts with the expectations from the International Energy Agency's (IEA) World Energy Outlook (WEO) 2014 New Policies Scenario of SSA for universal access by 2040, in which 315 million people in rural areas are expected to gain access to electricity, with around 80 million (25 percent) of them through stand-alone off-grid systems, and around 140 million (44 percent) through mini-grids requiring the development of between 100,000 and 200,000 mini-grids, depending on the number of households connected to each system (IEA 2014).

Implications from Good Practice Examples

This study highlights good practice country program experiences in supporting commercially viable and *rapidly scalable* off-grid access and services provision models and institutional frameworks. These encompass supply and service delivery chains for SHSs and microgrids as well as the technologically and commercially fast-evolving pico-solar products and their growing transformative record. These experiences have taken different routes in mainstreaming off-grid electrification according to their own needs and context. In Bangladesh, the scaled-up SHS program in grid-proximate areas took hold as an opportunistic market response to the then-stalled grid extension program; in Sri Lanka off-grid electrification (initially isolated village hydro mini-grid networks) grew out of an ex-ante strategy, anchored by an island-wide spatial electrification plan, and implemented as staged pre-electrification till such time as planned grid extensions arrived at those locations; in Rwanda and Kenya, off-grid electrification is proceeding in an ex ante planned manner; Morocco presents a case in which the cycle of planned pre-electrification has transitioned to mostly grid-based electrification; and most recently, Myanmar – drawing on preceding good practice experiences, has also embarked on a conscious strategy of ex-ante planned pre-electrification – designing an off-grid program that promotes solar products, SHS and isolated mini-grid networks coordinated with grid expansion.

This collective experience illuminates valuable insights and strategic considerations for low access countries that are looking to efficiently and rapidly achieve universal electricity access. From a strategic, nationwide perspective, realizing the full

potential of off-grid electrification in each country-specific context calls for a comprehensive approach that can leverage the dynamics of access expansion through both grid and off-grid means in a coordinated manner in space and time.

Findings and Lessons – Strategic considerations for scaling up off-grid electrification in low access countries.

The experience and good practices from countries—with Bank support or otherwise—yield the following insights:

PUTTING PEOPLE (BENEFICIARIES) FIRST, NOT TECHNOLOGY SOLUTIONS

- People want affordable, adequate, reliable access "yesterday." From a personal as well as a social and national perspective, the opportunity costs of delay in providing even basic access are very high—tantamount to depriving another generation of the benefits of modern services, including education and health care services. Time is of the essence.

- Access to even small quantities of modern electricity—sufficient to power basic modern lighting, cell phone charging, a small radio or television—can trigger a giant step for that are without any access. The United Nations Sustainable Energy for All Global Tracking Framework's tier 1 and tier 2 market segments typify this first hugely transformative step of demand for basic access.

- Significantly, over time, peoples' expectations tend to grow, and almost all aspire to electricity access comparable in adequacy, quality, and reliability that is typical of a well-managed utility-run grid system.

- A national roadmap for achieving universal access ("electricity for all"), irrespective of where people are located (for example, urban areas, including any slums; peri-urban; rural; or rural), can avoid or counter tendencies toward "cherry picking" geographical service areas or beneficiaries, whether for grid or off-grid rollout.

GRID VERSUS OFF-GRID: A FALSELY FRAMED BINARY CHOICE

- The "grid versus off-grid" trade-off needs to be framed in relation to complementarity and coordination geared toward universal access. Grid and off-grid technologies and access service delivery are not necessarily either-or options to be determined simply based on a narrow least-cost calculus. Rather, looking ahead, off-grid access provision is appropriately viewed as

playing a complementary and coordinated role alongside grid rollout in the process of achieving universal access.

- The manner in which the off-grid and grid combination plays out during implementation varies by country and is dynamic in space and over time, as for instance in the cases of Bangladesh, Sri Lanka, and Morocco. This may come about in response to progress—or lack thereof—in the respective grid rollout and off-grid rollout implementation in the field; to potential factors such as evolving customer expectations and aspirations for service standards and the sociopolitical policy responses to those; and possibly to other real-time triggers.

- Off-grid electrification can play a significant role in most low-access countries in the near future. In many countries, grid rollout has yet to get under way. In others, it has stalled or advanced in starts and stops and at an unpredictable pace on account of one or more factors in sector readiness conditions, such as governance, institutional framework, capacity, long-term vision, targets, commitment and sustained follow-through, lack of accountability, or on-and-off rather than programmatic finance, not taking into account the commercial viability for the qualified private sector agents engaging in access rollout.

PRIVATE AND PUBLIC SECTOR ENGAGEMENT: BOTH PLAY ROLES IN CATALYZING AND ENABLING SCALE-UP OF OFF-GRID ACCESS ROLLOUT FOR TIER 1 AND 2 MARKETS

In tracing the evolution of off-grid access delivery across the WBG portfolio (sections 2 and 3) two noteworthy features are: (i) the evolving scope and roles of the World Bank and International Finance Corporation (IFC) engagements in response to opportunity for maximizing the synergies resulting from their respective strengths and comparative advantages in enabling early stage ("pre-market") development, and (ii) assisting the client countries in designing the participation of the private and public sectors working in close partnership, bringing their respective natural roles and comparative strengths towards scale up delivery for realizing the national goal of universal access efficiently and rapidly

The complementary roles of the public and private sectors are to be seen in Bangladesh where the World Bank played a key role by supporting IDCOL, an autonomous government undertaking, in mentoring and promoting private sector operators, NGOs, and microfinance institutions for deploying SHS in a competitive business model. The WBG's Lighting Global Program has engaged in design and preparation of a substantial scale off-grid electrification program for Tier 1 and 2 segments, aided by the spatial information provided by the nationwide geospatial least cost plans funded by the World Bank and grid extension plan over time. The

instances of Kenya, Rwanda and Myanmar typify country cases where the World Bank assisted the Government with preparation of the national least cost geospatial electrification implementation plan for universal access by 2030 (grid and alongside coordinated in space-time the off grid program scale up), and syndication of the investment financing requirements orchestrated by the governments' within a sector wide organizing architecture and oversight process.

MULTIPLE ADVANTAGES OF A HIGH-LEVEL NETWORK PLANNING PLATFORM THAT IS ANCHORED IN A GEOSPATIAL AND COMPREHENSIVE PLAN COVERING GRID AND OFF-GRID MEANS

- Providing access (in some form) to all households, clinics, and trading centers—wherever they may be—requires identifying where the beneficiaries are located geospatially. This enables least-cost placement and expansion of existing electricity access infrastructure. Sound geospatial planning platforms that can be readily updated to reflect changes in key variables have been shown to provide a comprehensive analytical foundation for and a dynamically coordinated strategic-level rollout implementation of grid and off-grid growth in space and time. Such planning facilitates further detailing of design and rollout operationally.
- The national geospatial least-cost strategic rollout plan serves to further anchor and foster closer alignment of multiple and varied donor programs with national priorities and targets and to effect harmonization across donor programs. It also facilitates and directs financing support (called syndication) of the investment prospectus on-grid or off-grid and in space and time (more below).

SECTORWIDE ORGANIZING ARCHITECTURE AND PROGRAMMATIC FINANCING SHOW PROMISE

- Sector-wide organizing architecture and programmatic financing can be effective for rallying and orchestrating stakeholder participation in closer alignment with national priorities than otherwise; as well as syndication of program financing of an integrated grid and of-grid rollout, up to a medium-term horizon. Specifically, the sector wide investment prospectus for grid and off-grid expansion¬ would be anchored by the overall least cost geospatial rollout plan to achieve the time-bound targets set by Government; together with the enabling policy and institutional framework being in place.

1. Setting the Context

Introduction

1.1 In recent years, there has been renewed focus on the 1.1 billion people around the world who are without any access to electricity from either the conventional grid or any off-grid or stand-alone source. Most of these people are poor and are held back from their potential for human development and the improved quality of life that can be enabled by access to electricity services.[3] In Sub-Saharan Africa alone it is estimated that about 600 million people were without access in 2012 (IEA and World Bank 2015), and this figure may rise to 935 million in 2030 if the population grows at the projected rate and the pace of new electricity connections remains at the average annual rate of the last 10 years (IEG 2015).[4]

1.2 Against this background, the World Bank Group and the United Nations have committed to the Sustainable Energy for All initiative[5], which seeks to achieve universal access to energy by 2030 and improve energy efficiency and the use of renewable energy. This initiative is reinforced by Sustainable Development Goal 7 ("ensure access to affordable, reliable, sustainable and modern energy for all") and the World Bank Group's goals of ending extreme poverty and boosting shared prosperity.[6]

The Independent Evaluation Group's Strategic Evaluation of Electricity Access

1.3 The Bank Group's commitment to assist client countries in moving toward the Sustainable Energy for All goal together with other development partners was the backdrop for the comprehensive evaluation by the Independent Evaluation Group (IEG), *World Bank Group's Support for Electricity Access, FY2000–2014* (IEG 2015), which was presented to the World Bank's Board of Executive Directors in 2015. The report was a strategic evaluation of the engagement, operations, and

[3] Another 1 billion people around the world who are connected to the grid still experience a highly unreliable and inadequate power supply, which triggers high welfare costs; they are not the focus of this study.

[4] The Independent Evaluation Group's report's estimates are indicative and based on average growth of connections in last 10 years up 2014 along with projected population growth (IEG 2015).

[5] http://www.se4all.org/

[6] https://sustainabledevelopment.un.org/

outcomes of the entire Bank Group portfolio for fiscal years (FY) 2000–14 as they related to the provision of adequate, reliable, and affordable electricity access to all. These operations encompassed generation, transmission, and distribution and were differentiated across country groups by level of access.[7]

1.4 To achieve universal access by 2030, the report estimated that the pace of connections in low-access countries (those with less than 50 percent of the population connected—mostly low-income countries in Sub-Saharan Africa) needs to rise from the present average of 2 million per year[8] to about 15 million per year for the next 15 years. This translates to an increase of investments from US$3.6 billion per year to about US$37 billion per year, including for new generation capacity and rehabilitation of the electricity sector's physical assets. This huge increase in connections is unlikely to result solely or predominantly from grid expansion alone in the time frame set by global access goals.

1.5 The Bank Group's 2013 directions paper for the energy sector, "Toward a Sustainable Energy Future for All: Directions for the World Bank Group's Energy Sector," contains the Bank Group's approach to off-grid electrification (World Bank 2013b). In countries with low energy access, the World Bank Group's priority would be "to support affordable and reliable energy through all means, grid, minigrid, and off-grid." In rural, remote, or isolated areas, off-grid solutions based on renewable energy combined with energy-efficient technologies would be the most rapid means of providing cost-effective energy services. The paper notes that "grid, minigrid, and off-grid solutions are all needed, that they are not mutually exclusive, and can be implemented in parallel or, under specific conditions, in sequence." The strategies proposed in the directions paper are reflected only to a limited extent (less than one-third) in country partnership strategies (CPSs) effective 2014 or later for low-access countries where off-grid electrification is likely to be of relevance. A fuller analysis in this regard of CPSs for 50 low-access countries in the last 10 years is presented in appendix A.

1.6 IEG's 2015 electricity access report noted that the World Bank Group's investment support for off-grid electrification—mainly SHS, portable solar products for lighting and cell phone charging, and a small number of micro- and minigrids—was a small proportion of the World Bank Group's overall portfolio for the electricity sector during FY2000–14. The penetration of SHS is concentrated in a few

[7] Countries are classified in terms of the percentage of population having access to electricity: Low (up to 50 percent); Medium (>50 to 75 percent); High (>75 to 95 percent); Universal: (>95 percent). This is consistent with IEG's 2015 electricity access study.

[8] Predominantly household connections, though the breakup is not available.

countries, namely Bangladesh, Mongolia, Nepal, and Sri Lanka, and is in a nascent stage in several other countries.

1.7 At the same time, the report recognized a positive and growing trend and scope for the adoption of solar products that can speedily bring, at a minimum, basic electricity services—lighting, fan, television, and cell phone charging—to those who have little prospect of receiving grid-based electricity for several years or even decades. This is seen in the proliferation of quality-certified portable cash-and-carry pico-solar products for lighting and cell phone charging, enabled by the targeted support for starter and early markets by the joint IFC-World Bank Lighting Africa program, which has evolved into the present Lighting Global program.

1.8 These experiences are particularly relevant for low-access countries, many of which are in fragile situations, have significant shares of dispersed populations without prospect of electricity access, or do not have enabling sector conditions sufficiently in place for systematic and rapid access scale-up through grid extensions and supply.

Terminology: What Is Considered Off-Grid Electrification?

1.9 For the strategic evaluation purposes of this report, off-grid electrification is viewed in the following categories, which span a variety of products, services, and technologies and reflect recent and emerging trends in the provision of off-grid access (World Bank 2011).

- **Isolated network systems with generation plants (microgrids and minigrids).** Microgrids typically range from 30 kilowatts[9] to 500 kilowatts and use a range of technologies, from simple diesel generators to hydropower, biomass, photovoltaic, wind, or hybrid systems. Larger minigrids are typically above 1 megawatt capacity, and can provide sufficient power for activities such as water pumping, milling, grinding and other forms of processing.
- **Individual systems.** These include SHS, which range from household-sized systems of 30–100 watt peak[10] capable of powering a few bulbs, a fan, and

[9] A microgrid with a 30 kilowatt capacity can cater to about 200 households for lighting, television, and possibly small appliances.

[10] Watt peak stands for peak power. This value specifies the output power achieved by a solar module under full solar radiation

possibly a small television, to institutional sizes (100–500 watt peak) for use in small community centers, schools, or health centers.

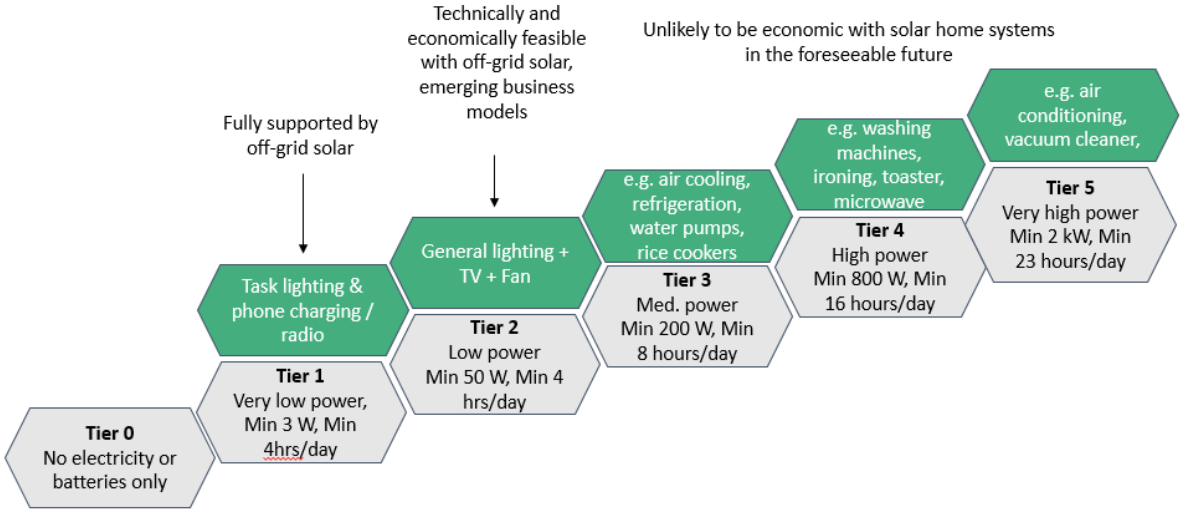
- **Pico-solar photovoltaic charging products.** (This term is used interchangeably in this report with the terms *solar products* and *pico-solar products*.) Such products are for modern lighting, cell phone charging, and so on, and are linked with solar or grid-based charging.

1.10 A multitier framework for defining and measuring the level of access to electricity was introduced through the Sustainable Energy for All initiative. In contrast to the binary measurement of electricity access undertaken historically, the Global Tracking Framework distinguishes five levels of access.[11] The schematic in figure 1.1 illustrates the corresponding service level tiers (tier 1 through tier 5). Each tier is differentiated by the typical electricity end uses that can be powered and the associated number of hours per day for which that access should be available. Specifically these range from simple task lighting, phone charging, and radio (tier 1) and general lighting, television, and fan (tier 2) at one end, to the use of the full range of modern appliances such as air conditioners at the other end (tier 5; World Bank 2015). Further, the expectations for duration and reliability of service increase with the tier level. Tier 1 and 2 services should be available for at least four hours a day, and tier 5 services should be available for 23 hours in a day.

1.11 Tier 1 services are fully supported by off-grid solar products, including pico-solar products. Tier 2 access is technically and economically feasible with off-grid solar, especially SHS, and increasingly so by pico-solar products, as more efficient lighting and gadgets become available. Isolated network systems (microgrids or minigrids)—if properly designed and maintained—are capable of providing tier 3 services (air cooling, refrigeration, water pumps, and rice cookers) or higher tier services in the case of larger minigrid systems (figure 1.2).

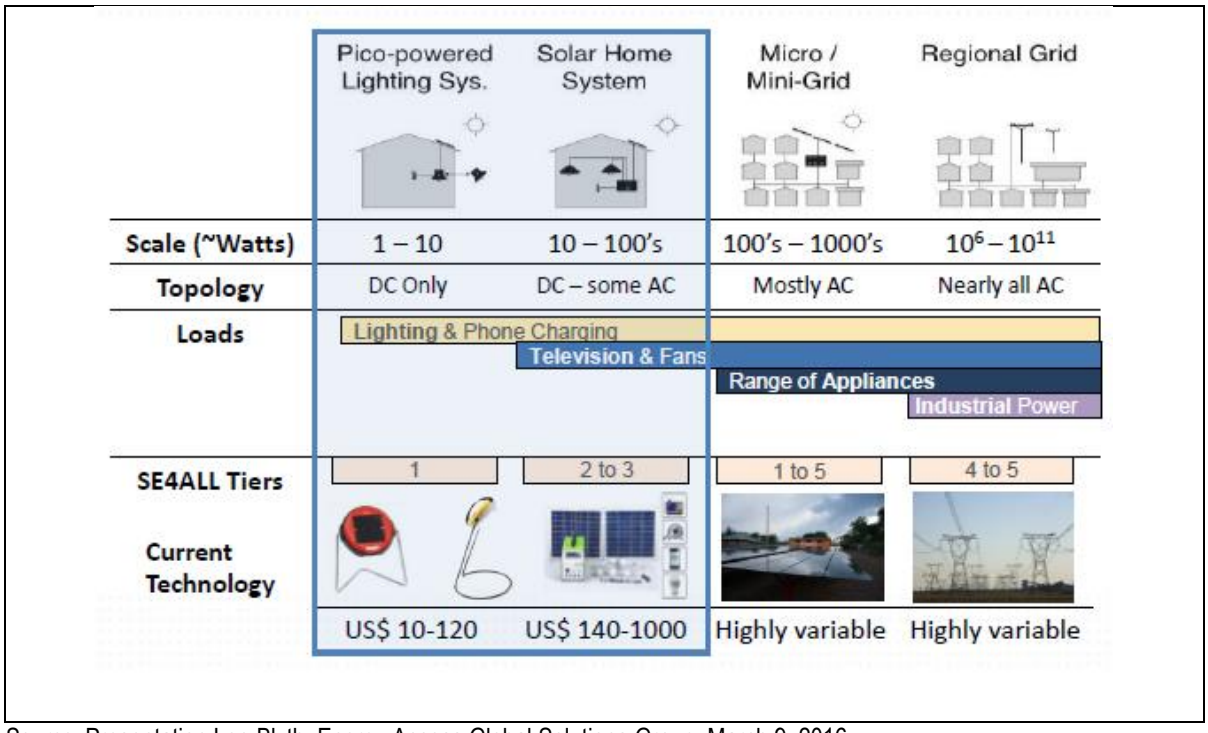
[11] Access to electricity is measured based on technology-neutral multitiered standards for which successive thresholds for supply attributes allow increased use of electricity appliances. The key attributes relevant for household electricity are (i) capacity; (ii) duration (including daily supply and evening supply); (iii) reliability; (iv) quality; (v) affordability; (vi) legality; and (vii) health and safety (World Bank 2015).

Figure 1.1 Levels of Electricity Access



Source: Bloomberg Energy Finance et al 2016
Note: The power supply also needs to cover at least two evening hours for tier 1, 2, and 3, four evening hours for tiers 4 and 5; be affordable from tier 3 to tier 5; and be assessed on reliability, quality, legality, and health and safety for tiers 4 and 5.

Figure 1.2. Off-Grid Solar Solutions Allow Consumers to Climb the Energy Access "Ladder"



Source: Presentation Leo Blyth, Energy Access Global Solutions Group, March 9, 2016.
Note: AC = alternating current; DC = direct current.

1.12 In the following sections, this report highlights the emergence of an expanded array of market-proven solar options, that is, products and service delivery for

effectively achieving tier 1 and tier 2 markets for access. They are now "market proven" and available for mainstreaming and rapid penetration within the context of an overall sector strategy for implementing universal access by 2030. These cover quality-certified solar products ranging from plug-and-play solar kits, which can provide sufficient power for the most basic services of essential lighting and cell phone charging, up to SHS kits rated 100 watt peak and beyond, and related services delivery. These products can potentially and rapidly provide access to basic electricity services to the billion people that make do today with far inferior and more expensive sources of energy such as kerosene, wood, or candles and get them to the first step of the energy access "ladder" (figure 1.2).

The Scope of This Report

1.13 This learning product study draws upon existing evaluations of the Independent Evaluation group (IEG), and a wide-ranging literature review to derive key principles and lessons from the World Bank Group's experience with supporting the rapid scale up of off-grid electrification on a sustainable basis in client countries. The purpose is to identify key strategic directions and essential building blocks of an enabling policy and institutional framework for planning, financing and orchestrating a planned and coordinated rollout - in space and time - of off-grid and grid electrification alongside. This study is not a toolkit for detailed project design, service delivery model specifications, technology, or payment mechanisms for off-grid electrification. It is not so much about identifying best practice answers or implications for one question per se: how or what to do in off-grid electrification operationally. Rather, the study gathers the findings and lessons of experience in the World Bank Group and from other actors to understand the context and mechanisms underlying experiences and instances where rapid and efficient scale up of off-grid electrification has been achieved in client countries. This with a view to putting forth key considerations as well as implications for the World Bank Group to assist in framing the right questions in a country-specific context with respect to strategic directions for operational strategy development and for engagement, technical assistance and lending; for scaling up off-grid implementation alongside the grid extension program.

Audience

1.14 The main audience for this report is staff and task team leaders of the Global Practice for Energy and Extractives, who are concerned with designing and operationalizing electricity access scale-up implementation under diverse country

contexts and levels of sector "readiness." The study is of particular relevance to task team leaders in Sub-Saharan Africa, where most of the low-access countries are situated with a wide diversity of sector readiness conditions and start-up challenges.[12] The messages from the study would also be of interest to policymakers and sector practitioners in client countries, other multilateral and bilateral lenders and donors, and nongovernmental organizations.

1.15 The rest of the report is organized as follows:

Section 2 traces how off-grid electrification has come of age in its ability to serve both tier 1 and 2 category access needs in several developing countries. The pivotal ways in which the World Bank Group has contributed to these developments is examined with respect to individual SHSs, scaling up the use of solar products with relatively small financial outlays, and micro- or minigrids.

Section 3 builds on the evidence for off-grid electrification as a mainstream component of broader national efforts to increase electricity access. It highlights several country examples that embody the "next generation" of off-grid electrification strategic planning and implementation staging.

Section 4 brings together the findings and lessons from the World Bank Group's experience for strategic considerations, operational directions, and implications, keeping the country-specific context in focus.

2. Off-Grid Electrification's Coming of Age: Pivotal Contributions by the World Bank Group

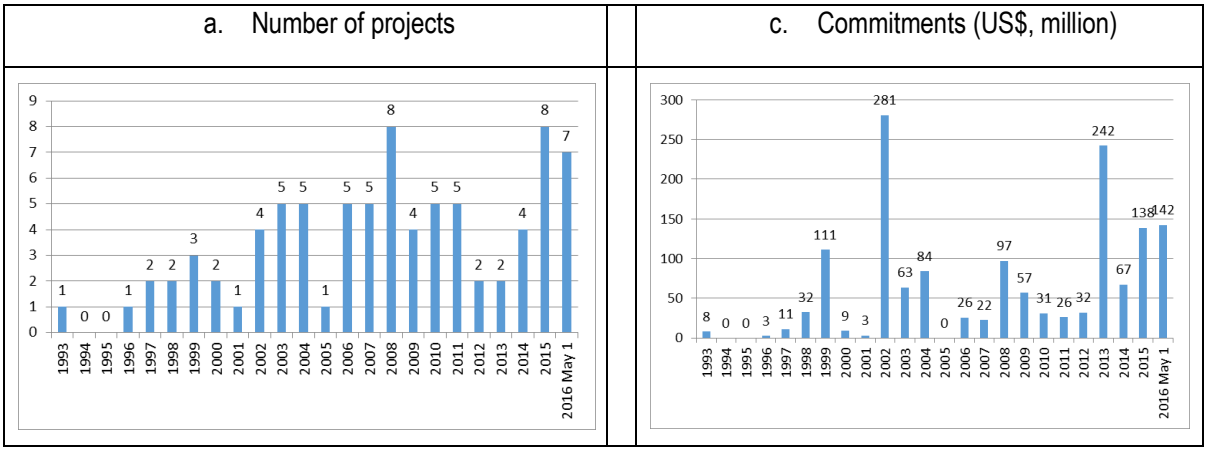
2.1 The World Bank Group's contribution to advancing commercially viable and readily scalable off-grid access delivery over the last decade, especially in the tier 1 and tier 2 access categories, has been transformative in several respects. Despite relatively low and sporadic lending for off-grid electrification (in comparison to overall electricity sector lending), the World Bank has supported sound service delivery mechanisms for solar home systems (SHSs) in South Asia, while the World Bank and the International Finance Corporation (IFC) have jump-started the market for pico-solar products in Sub-Saharan Africa and South Asia.

[12] This also applies to other countries that are advancing their electric access, such as Myanmar, Indonesia, Papua New Guinea, and other Pacific Island countries.

2.2 This section traces how off-grid electrification has come of age in its ability to serve both tier 1 and tier 2 category access needs in several developing countries. The pivotal ways in which the Bank Group has contributed to these developments is examined with respect to individual SHSs, scaling up the use of solar products (mainly with technical assistance and relatively small financial outlays), and micro- or minigrids.

2.3 The World Bank Group's assistance for off-grid electrification has averaged about US$87 million per year during a 17-year period covering fiscal years (FY)2000–16 (out of total US$1.594 billion), which is estimated to be about 2.5 percent of its overall lending for the electricity sector during the period. No discernible trend is found in these commitments over the observed time period. There was relatively low activity year after year, punctuated by large commitments especially in FY2002 and FY2013, and what appears to be a promising trend in 2015 and 2016 (Figure 2.1). An analysis of the World Bank Group lending portfolio for off-grid electrification during FY2000–16 is presented in appendix B.

Figure 2.1. World Bank Group Portfolio for Off-Grid Electrification: Projects Approved or Closed FY2000–16



Source: World Bank project appraisal documents, midterm review reports, Implementation Status and Result Reports, aid memoire, legal documents, Implementation Completion and Results Reports and other project documents, IFC project data websites, GEF project data websites, and IFC 2007, 2012.

Large-Scale Rollout of SHS Systems and Services: Bangladesh

2.4 Bangladesh's well-known experience with deploying SHSs in peri-urban and rural areas built on an earlier World Bank–supported model in Sri Lanka using a financial intermediary and private vendors.[13] In its ongoing effort, Bangladesh has

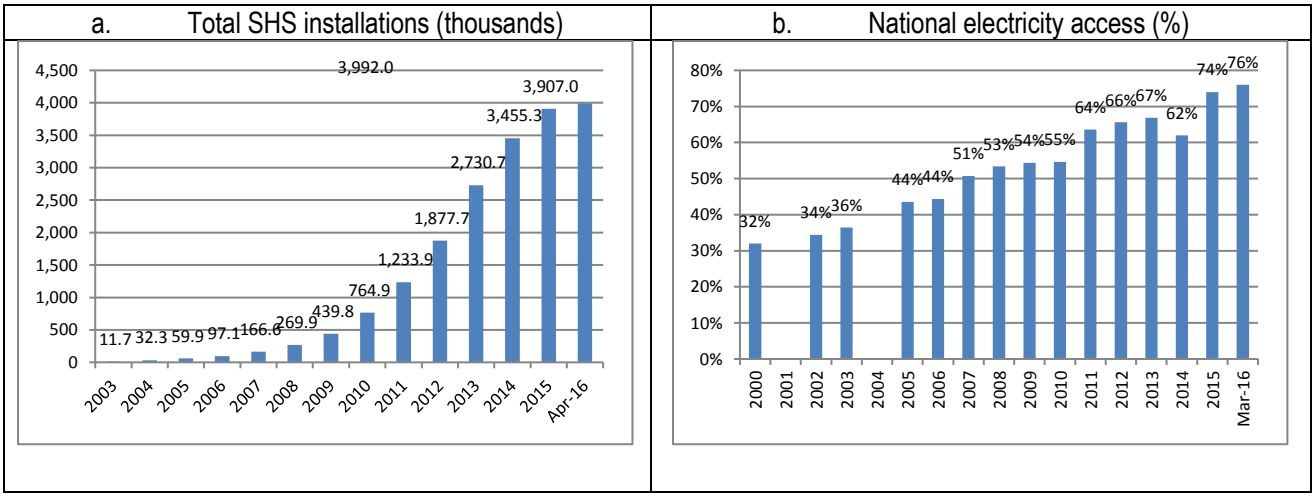
[13] Sri Lanka: Energy Services Delivery, and Second Power Distribution and Transmission Project (P010498) 1997-2003.

rolled out nearly 4 million SHSs since the early 2000s (Figure 2.2). These installations provide basic electricity services to about 12 percent of the country's population (Pavel 2016).

2.5 Bangladesh's rapidly scalable off-grid access expansion can be viewed as pre-electrification for areas that otherwise could be covered cost-effectively by centralized grids. The impetus for the Bangladesh SHS program originally came from a stalled extensions and connections program on the main grid, exacerbated by a severe shortfall in electricity generation in the country in the previous decade. A vendor-based program managed by the implementing agency and financial intermediary Industrial Development Company Limited (IDCOL) stepped into this breach and set the stage for the SHS market to take off in the country. The World Bank's Rural Electrification and Renewable Energy Development I and II projects have supported IDCOL in installing over 2.3 million systems from 2002 to March 2016. IDCOL has mentored over 49 partnership organizations—nongovernmental organizations, microfinance institutions, and private sector institutions—and engaged them in a competitive business model for SHS sales and servicing. A vital factor contributing to the success of IDCOL's SHS program is the availability of and access to finance from lenders and donors. By the deployment of these funds through a microcredit financing mechanism, supported by a combination of targeted consumer credit and (declining) subsidies (Khandker et al. 2014) poor households are enabled to access affordable energy services through SHS, because they do not have to come up with upfront costs or pay separately for operation and maintenance (Rai et al. 2015). Another vital factor contributing to the success of Bangladesh's SHS program is the attention to product quality standard through mechanisms set up by IDCOL.

2.6 However, since the peak installation pace of over 75,000 per month in Bangladesh during April and May, 2014, SHS sales have shown an overall declining trend, with a sharply lower 28,000 installations in October 2015. This slowdown is attributed to the rapid acceleration in grid connections (now more than 300,000 per month) in the push to achieve the government target of 90 percent geographic coverage by the grid by 2018. Given these developments, IDCOL is exploring various options, including promoting SHS as a back-up facility since reliability of grid supply continues to be uneven, and diversifying into product offerings such as solar pumps for drinking water for the partner organizations (to ensure that they remain in business to service the needs of existing SHS users in rural areas).

Figure 2.2. Bangladesh: Cumulative SHS Installations Financed by All Development Partners



Source: IDCOL SHS installation: Rahman 2016; Electricity Access Rate: BBS 2015; Bangladesh MPEMR 2014, 2015, and 2016; World Bank 2015e; IEA and World Bank 2015.

Note: The electrification rate decline of 62 percent in 2014 down from 67 percent in 2015 is due to the fact that the data for 2014–16 are from Bangladesh Ministry of Power, Energy, and Mineral Resources (MPEMR), whereas the Bangladesh Bureau of Statistics (BBS) provide time series of data from 2002–13. This underreporting by MPEMR could be because in India and Bangladesh, the SHSs are not considered in the rural electrification figures because they cater only to lighting needs (Palit and Chaurey 2011). BBS's data is for electricity for lighting, which could include SHS and also based on the sample survey. MPEMR's access rate may be based on the number of electricity connections and not a sample survey.

Deploying SHS in Remote Areas

2.7 Argentina and Peru employed a concession model for off-grid electrification in their remote, high-cost, isolated areas that are unlikely to be covered by the conventional grid in the foreseeable future. In both instances, the respective utilities servicing the area were responsible for the services, though procurement and installation could be undertaken by contractors. Mongolia established a reliable supply chain for SHS across the country, particularly benefiting over 85 percent of its herder population.

2.8 **Argentina:** The World Bank's Argentina Renewable Energy in Rural Markets Project (FY1999–2013) supported an early fee-for-service concession model to supply electricity to remote areas. The model delivered expected results, given Argentina's long experience with concessions in traditional electricity markets. The project developed eight concessionaires that installed off-grid facilities in nearly 30,000 households (about 0.3 percent of the population in a universal access country)—mainly with SHS but also with wind turbines and minigrids, in addition to installing more than 2,000 SHSs in schools, medical centers, and other public buildings (World Bank 2013e). The relatively large unit size of the institutional installation and mandated installation (as opposed to individual households that may not opt to sign up) greatly increased the attractiveness of the package to private sector bidders.

2.9 **Peru:** Similarly, under Peru's Rural Electrification Project (FY2006–13), electricity distribution companies installed and managed *as a utility service*, in excess of 100,000 SHSs in remote and isolated areas, representing about 1.6 percent of the national population, mostly living in remote areas. The World Bank's role was important in supplementing the financing plan, particularly in supporting capital investments and helping ensure transparency in awarding concessions.

2.10 **Mongolia:** The Mongolia Renewable Energy for Rural Areas Project relaunched the commercial solar home systems market by establishing a reliable supply chain and a country-wide system of sales and service centers for maintenance and repair; it also enabled underpinning of manufacturer warranties and partial subsidization of the sale of solar home systems. The project transformed the market for solar lighting from a subsidized to a fully commercial basis, accelerated its expansion from a baseline of 15 percent of the herder population in 2006 to 85 percent in 2014, and catalyzed its expansion beyond lighting products to supply all kinds of appliances, such as television sets and satellite receivers. By mid-2014, the market for solar home systems and appliances had become established over the entire country. (World Bank 2016).

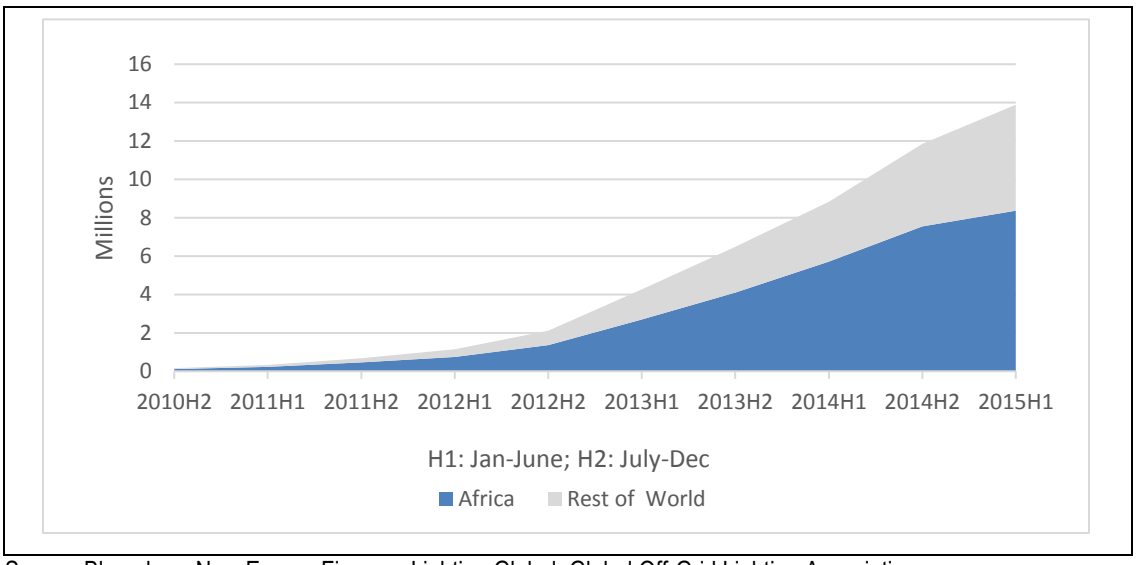
Rapid Market Penetration of Solar Products for access tiers 1 and 2: The Lighting Africa and Lighting Global Programs

2.11 In recent years, a vastly expanded array of market-proven off-grid solar products and service options have become available, and products are no longer confined to a piloting mode. These quality-certified products include cash-and-carry plug-and-play solar kits, which provide sufficient power for the most basic services of essential lighting and cell phone charging, as well as SHSs rated up to 100 watt peak (and beyond) and related service delivery

2.12 From a near-standing start less than 10 years ago, more than 100 companies are now actively focusing on stand-alone solar lanterns and SHS kits targeted at those without modern energy access. They have sold over 14 million quality-certified pico-solar products (defined as having a photovoltaic panel smaller than 10 watts), mainly in the form of portable lights, as of mid-2015 (Figure 2.3). These products improve energy access for millions of people in Africa and Asia and have lifted 21 million individuals to the first rung of the energy ladder, according to our estimates. These market developments signal a changing strategic paradigm for scaling up access efficiently and in a timely manner to enable access to basic electricity services. Deep and rapid-paced market penetration appears achievable for

off-grid access provision to tier 1 and tier 2 markets on a commercially viable sustainable basis (beyond possible need for start-up subsidies).

Figure 2.3. Pico-Photovoltaic Solar Products: Cumulative Quality Verified Product Sales



Source: Bloomberg New Energy Finance, Lighting Global, Global Off-Grid Lighting Association
Note: H = year half.

2.13 This rapid growth has been stimulated and supported by the World Bank and IFC's Lighting Africa and its successor, the Lighting Global program, which have pioneered well-designed and targeted technical assistance for improving quality assurance and service delivery. (Box 2.1).

Box 1.1 Lighting Africa; Lighting Global: Transformational Off-Grid Program for T1 and T2 access for the Poor

The World Bank and IFC piloted and scaled up Lighting Africa, an innovative program to address the lighting needs of a large segment of the population not served by the power grid. The program has been expanded successfully from its pilot phase within Kenya and replicated in other countries in Africa and Asia. Earlier efforts to provide solar lamps to poor families funded by donor grants and distributed free have had limited uptake.

The program design incorporated the entire supply chain and was informed by experience. The World Bank and IFC initiated Lighting Africa in 2007 to accelerate the development of a sustainable commercial market for quality, clean, and safe solar lighting products that are affordable to very-low-income households and small businesses. The collaborative effort was based on each institution's core competencies and has benefitted from frequent, regular communication between the two teams.

Lighting Africa enabled transformation at two levels. From a market development perspective, the project transformed the solar lamp market in Kenya by making modern, good quality, and affordable lighting products available to the very poor. It also demonstrated the commercial viability and sustainability of the approach to address the lighting needs of the base of the pyramid, in contrast to donor subsidized lending for the purchase of solar lamps. To achieve this, Lighting Africa considered constraints along the entire supply chain (such as high taxes on solar imports, lack of export financing, access to supplier credit, market analysis)—considering the entire system. At project start in 2009, only 2 percent of Kenya's population was using solar lamps for their lighting needs; this number had grown to nearly 10 percent in 2014 (although growth cannot be attributed solely to the project). About 850,000 solar lamps have been sold under the project from 2009 to 2014 (compared with an anticipated 300,000 units), benefitting an estimated 4.25 million people, mostly in poor areas of Nairobi and in rural areas. Household members using these lamps no longer inhale toxic fumes from kerosene lamps and paraffin. School children are able to study and do their homework at night. Households and small businesses had savings by drastically limiting their kerosene purchase.

Source: World Bank 2016

2.14 The success of Lighting Africa has inspired programs in India, Bangladesh, Papua New Guinea, Myanmar, Pakistan, and Afghanistan. Lighting Global is the World Bank Group's global platform supporting sustainable and rapid scale up of commercial market based off-grid access for the Tier 1&2 segments – encompassing (Figures 1.1 and 1.2) pico-solar lighting and charging devices *and* solar home systems (SHS) - to people not connected to grid electricity. Through Lighting Global, IFC and the World Bank work with the Global Off-Grid Lighting Association, manufacturers, distributors, and other development partners to develop the off-grid lighting market. The Lighting Global program's role is to provide market insights, steer development of quality assurance frameworks for modern, off-grid lighting devices and systems, facilitate product and systems

quality certification, and promote sustainability, in close partnership with industry *and* appropriately enabled and supported by Government policy. Lighting Global supports Lighting Africa, Lighting Asia and Lighting Pacific, which work along the supply chain of off-grid lighting products and systems to reduce market entry barriers and first mover risks.

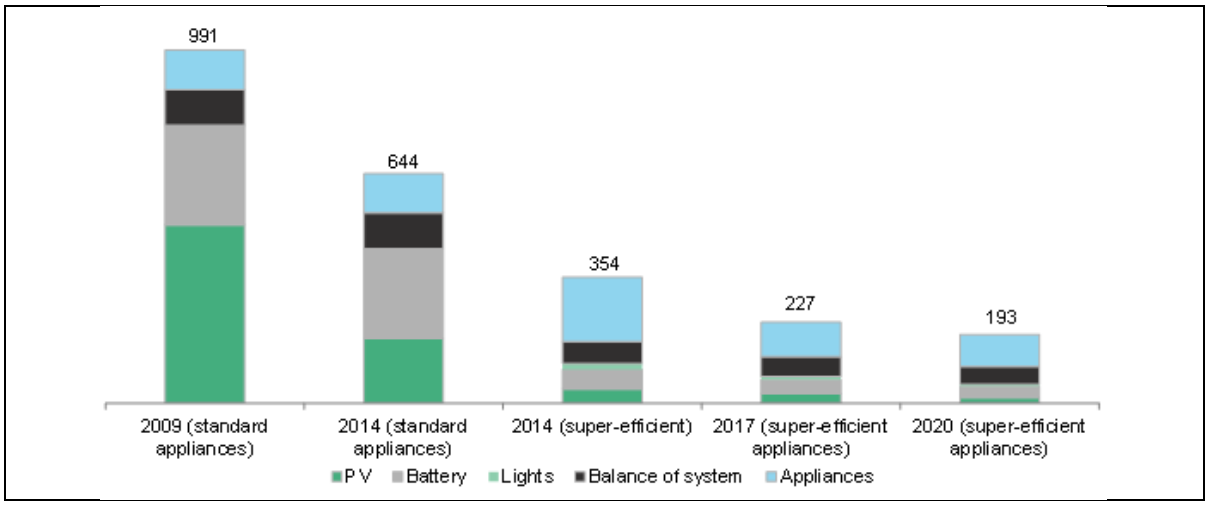
2.15 The well-established and sustained market record in a growing number of countries in Sub-Saharan Africa and in South and East Asia illuminates the foundations and principles for workably credible and scalable mechanism for bringing about a fast and initial transformational impact on those who otherwise make do with an inferior and higher unit cost means such as kerosene, candles, and wood, to meet their most basic lighting needs.

2.16 Evidence of a rapidly maturing industry can be witnessed firsthand and is shaped by the cycle dynamics of entrepreneurial energy, technological advances enabled by high-efficiency direct current appliances, and business model innovations. Between cost reductions, latent consumer demand, and a sales-driven push for higher-margin products, SHSs that are capable of powering appliances such as televisions and fans are projected to capture an increasing market share.[14] The cost of providing energy for basic lighting, radio, and a 19" television has gone down from US$991 in 2009 to US$354 with the use of super-efficient appliances and is slated to drop further to US$193 by 2020 (figure 2.4). With the sales-driven push for higher-margin products, SHSs capable of powering appliances such as televisions and fans are projected to capture an increasing market share.[15]

[14] Based on data from Bloomberg Finance, LTG Global, and the World Bank Group.

[15] Based on data from Bloomberg Finance, LTG Global, and the World Bank Group.

Figure 2.4. Solar Home System with 19" TV, Radio, and Lights
($US/unit)

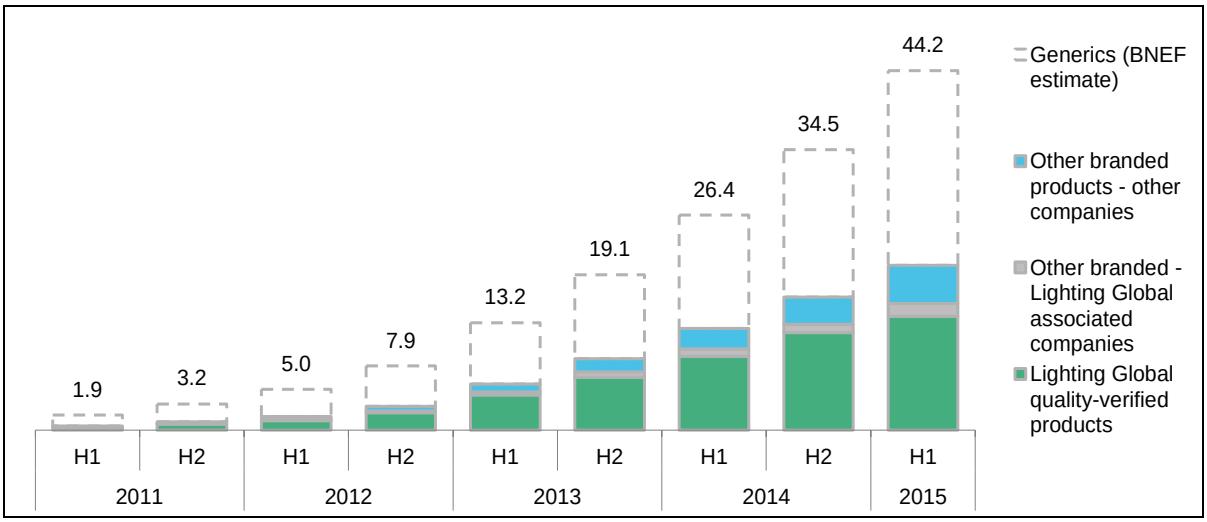


Source: Lawrence Berkeley National Laboratory, Office of Energy Efficiency and Renewable Energy Solid-State Lighting Program, Bloomberg New Energy Finance, and Dalberg Global LEAP Off-Grid Appliance Market Research.

2.17 The share of certified and branded solar products has been growing steadily over the years, as seen in figure 2.5. The products have been branded and certified by either Lighting Global or companies associated with it or by other companies producing their own branded products. Solar lights and SHSs have seen substantial cost reductions and performance improvements during 2010–15; for example, a low-cost light-emitting diode lantern was US$20 in 2010 and US$4 in 2015 (Bloomberg Energy Finance et al 2016). This low-cost pico-solar photovoltaic could provide the poor with their first pre-electrification experience and be available at local retail shops and kiosks where they would otherwise buy kerosene, dry-cell batteries, and candles, years before the utilities or electricity service companies offer SHSs or connection to the minigrid or main grid.

2.18 While firm estimates are not readily available, the market sales revenue of quality-certified pico-solar products (excluding SHS) are several orders of magnitude higher than the relatively modest dollar amounts funding the significantly well designed and targeted technical assistance facilitated from the WBG's Lighting Africa and Lighting Global Programs. For further perspective, the cumulative (2011-2015) market share of branded and Lighting Africa/Global quality-verified products sold by the first-half of 2015 was about a third of the total cumulative sales of all such products 44.2 million, and by comparison typically vastly inferior in performance, quality and life (Figure 6). The efforts of Lighting Africa/Global programs of the WBG have steadily made ever deeper inroads into this growing global market for pico-solar lighting and charging products.

Figure 2.5. Estimated Cumulative Sales of Pico-Solar Lighting Products in Sub-Saharan Africa and Asia, 2011–2015



Source: Bloomberg New Energy Finance et al 2016.
Note: Figures as reported to Lighting Global and Global Off-Grid Lighting Association with additional BNEF estimates for missing data points and other branded sales. Data are millions of units. BNEF = Bloomberg New Energy Finance; H = year half.

Micro- and Minigrids

2.19 Microgrids and minigrids are a big step up on the energy access ladder from pico-solar products and SHSs. Depending on the their capacity, microgrids and minigrids can provide the means for use of appliances such as refrigerators, rice cookers, and microwaves, and productive applications such as water pumping, milling, grinding, and other forms of processing (see figures 1.1 and 1.2) . As explained in section 1, microgrids and minigrids span a range of capacity and technologies. Broadly for the purposes of the is study, microgrids are characterized as ranging in capacity from 30 kilowatts to 500 kilowatts and can use a variety of technologies, from simple diesel generators to hydropower, biomass, photovoltaic, wind, or hybrid systems. Larger minigrids, typically from 500 kilowatts to 1 megawatt and above can provide sufficient power for a bundle of activities consisting of water pumping, milling, grinding, and other forms of electricity intensive process requirements.

2.20 The deployment of microgrids and minigrids comes in a variety of business and financing models, each with their own risk profiles and financing structures. While there are prominent examples of microgrid and minigrid project components supported by the World Bank Group and in the private sector, scaling up of the

micro- and minigrids is at an early stage.[16]. One overriding benefit of minigrids is that the cost to their customers is almost always lower than the monthly expenditures made by these same customers before the minigrid arrives. However, cost structures on a kWh basis are high, which in turn, requires high levels of government and donor subsidies. To date, there has been no systematic study of how the subsidies required by commercially viable minigrids compare with subsidies for connecting new rural customers through traditional main grid expansion.

2.21 Overall, the experience of the World Bank Group in the limited number of projects with minigrid components indicates that to date, minigrid programs are not yet scalable or replicable from country to country. Investors have been deterred as in the case of Bangladesh (World Bank 2014a) and other countries which were nonstarters in respect of micro- and minigrids because of the lack of a clear policy and regulatory framework, especially for remunerative tariffs[17]. At the same time, there are signs that some of the regulatory and policy impediments are now being addressed. For example, in Africa explicit regulatory and policy framework for mini- and microgrids have been adopted (Tanzania and Rwanda) or proposed (Nigeria and Kenya). In all four countries, there are provisions for compensation payments to minigrid owners when the main grid arrives.

2.22 The absence of or lack of clear communication about plans for grid expansion in the medium term makes it difficult for investors to plan ahead. Experience shows that off-grid electrification needs to be planned in coordination with the growth of the grid, with some assurance of compensation for stranded assets in case of faster grid expansion than anticipated. In addition, financing is a constraint: most minigrids are not yet straightforward deals for commercial investors or lenders (IFC 2012). However, IFC's review of business models for scaling up access concludes that this subsector holds real potential and merits greater attention of operating companies, policymakers and investors (IFC 2012). The World Bank / ESMAP in response to these issues initiated a Global Facility on Mini-Grids to provide ground level, "just in time" information for stakeholders and operational support to World

[16] Historically, China had tens of thousands of isolated minigrids before they were connected to the main grid or phased out. Similar minigrids, numbering 12,000 to 16,000 operate in Myanmar, providing electricity at relatively high prices of about 40 to 75 US cents per kWh.

[17] According to feedback provided by the World Bank's Energy and Extractives Global Practice, as of September 2016, a senior IDCOL official reported that 7 minigrids are in operation and that IDCOL expects to finance a total of 50 minigrids by the end of 2018. This seems to be attributable to a much clearer regulatory and subsidy policy framework.

Bank task teams. Since the Global Facility became operational only late 2015, it is still too early to know how it will perform.

2.23 Sri Lanka has used its micro- and small hydro potential to augment the supply situation in rural and isolated areas (Chowdhury et al. 2015) and has integrated it in a planned way with the grid as it gradually spread across most of the country. Between 1997 and 2011, 268 village hydro projects were created in Sri Lanka, an effort that was supported by the World Bank's Energy Service Delivery Project[18] and Renewable Energy for Rural Economic Development Project.[19] These are very small, microhydro installations with typical average installed generating capacities of 3–50 kilowatts, usually serving from 20 to 80 households. The facilities are owned and operated by community organizations known as Village Electricity Consumer Societies. The owner and operator of a Village Electricity Consumer Society is a community organization rather than a private business person. Rather than simply relying on villages to create village hydro projects on their own initiative, the government sought developers to promote the village hydro projects and advise the community organizations. About 20 private engineering consultants and nongovernmental organizations received payments of about US$8,000 for each successful village hydro project that they promoted (Tenenbaum et al. 2014). Many community-owned schemes have been taken over by entrepreneurial members, resulting in efficiency improvements (World Bank 2014c).

2.24 Over the past several years, the grid system of the national utility, Ceylon Electricity Board has reached about 70 of these previously isolated villages. In most instances, the households closest to these new grid facilities left the Village Electricity Consumer Society and chose to become Ceylon Electricity Board customers. Connecting to the Ceylon Electricity Board is more attractive because of better quality and reliability of electricity supply and comes with a subsidized national lifeline tariff (2.5–3.0 cents/kilowatt versus the typical 25 cents/kilowatt that they were paying as members of the Village Electricity Consumer Society; Tenenbaum et al. 2014). Several village systems have been connected to the Ceylon Electricity Board grid under a net-metering scheme.[20] Smaller systems connected to the grid can sell power to the utility at an agreed tariff that is higher than under net-metering. This is a win-win situation for the village-communities that have invested

[18] Sri Lanka Energy Service Delivery Project (ESD) (FY1997-FY2003; P010498).
[19] Renewable Energy for Rural Economic Development Project (RERED) (FY2002-2013; P076702.
[20] The Sri Lanka Energy Service Delivery Project created an enabling environment for private sector participation in grid-connected renewable energy projects by facilitating development of a Small Power Purchase Agreement (SPPA) (World Bank 2003).

money and sweat equity into their off-grid systems because they can now benefit from the reliability of the national grid while continuing to earn revenues from the sale of electricity generated by their village hydro schemes back to the utility at an agreed tariff. Hence the microgrids developed by the Village Electricity Consumer Societies provided a useful transitional supply of electricity to isolated villages before the arrival of the Ceylon Electricity Board grid.

2.25 The World Bank Group supported minigrids on a significant scale in a few countries (Nepal, Sri Lanka, Mali, and Cambodia). Other relatively smaller efforts were made in Bangladesh, Mongolia, and Vietnam. Efforts are underway or were recently completed in Tanzania for a larger-scale off-grid program, leveraging private sector resources and promoting small-scale power projects.[21]

2.26 A full list of World Bank and IFC projects and investments that that were approved or closed during FY2000–16 is presented in appendix C. A more detailed discussion of the World Bank Group's efforts in off-grid electrification is presented in appendix D.[22]

Productive Uses and Welfare Outcomes

2.27 The use of off-grid electrification is mostly dedicated to lighting, comfort, entertainment, and communication (IEG 2015). In principle, combining off-grid projects with interventions to promote local productive uses of electricity is expected to catalyze economic activity and improve incomes, especially from microgrids and minigrids, but there is little systematic evidence of this in the literature. Impact studies of World Bank projects and others are inconclusive in terms of degree and direction (positive or negative) of the welfare effects, although they identify a variety of benefits, such as income, health, education, gender equality and equity, communication, and environment (Pueyo et al. 2013; Pueyo and Hanna 2015; Rao, Agarwal, and Wood 2016; Wilcox et al. 2015).

2.28 A systematic review of the welfare impacts of electricity access carried out as part of the Independent Evaluation Group (IEG) 2015 study on electricity access covered 32 impact evaluations, including 8 for off-grid provision of electricity comprising six cases of SHSs and two with minihydro schemes (including five

[21] Tanzania Energy Development and Access Expansion Project (TEDAP) (P101645, P092154, FY2008-)

[22] Bolivia, Cambodia, China, India, Lao People's Democratic Republic, Mali, Nepal, and Tanzania.

associated with World Bank projects in Bangladesh, Nepal, India, and Vietnam). The results broadly showed that access to electricity, including from off-grid electrification sources, has a positive influence on school enrollment, years of schooling, and children's study time at home. Two studies show significant effect of electricity access on fertility reduction, whereas one other study found no effect. Very few studies measured the impact of electricity access on health. The evidence base for the impact of electricity access on microenterprise profits is also thin. Regarding household income, electricity access is found to have a positive effect on total income as well as nonfarm income. No overall impact on the number of hours worked was observed. The systematic review stressed that a bigger evidence base is needed to better understand the extent and magnitude of these links.

2.29 This study notes that 28 projects out of the 83 World Bank Group projects with off-grid electrification objectives or components planned to address productive uses or income-generating activities. Of these 28 projects, 20 actually implemented some of these planned activities, but there is no systematic evidence from these efforts. Out of the 82 project, 34 addressed cross-sectoral linkages by providing electricity access to schools, clinics, agricultural processing, mobile charging, and other livelihood activities, as well as to contribute to addressing climate change issues (see appendix C for further information).

3. Off-Grid Electrification Planning and Implementation: "The Next Generation"

3.1 Historically, off-grid electrification has been used for covering remote areas that were effectively out of reach of the grid, or for pre-electrification in areas where the grid was not likely to reach in the short or medium term. In instances and at points in time when and where grid rollout advance stalled or slowed, off-grid delivery has been scaled up opportunistically by market agents. However, over the years, with steady improvements in renewable technology performance and costs, off-grid electrification has shown the potential to be competitive for broader use in other areas well. The preceding sections 1 and 2 provide evidence of the potential for off-grid electrification to be implemented as a mainstream component of broader national efforts to increase electricity access.

3.2 In country situations where the grid rollout was or is advancing per scheduled plan but large segments of potential beneficiaries of grid access face extended wait times, there are instances of governments deploying a strategy (which may be termed *ex ante planned pre-electrification*) for efficiently and effectively

coordinating the advance of the grid geospatially and in time with off-grid electrification. This is backed by policy to effectively address the issues of retiring off-grid assets when grid service becomes a reality in those locations. This section highlights several country examples that embody the "next generation" of off-grid electrification strategic planning and implementation staging.

3.3 It is also noteworthy that good practice national electrification programs for achieving universal electricity access—even those well under way before launch of the Sustainable Energy for All initiative in 2013—reflect this strategy in their respective national geospatial least-cost access rollout program plans, capturing the synergies and dynamic complementarity between grid and off-grid rollout in space (geospatially) and time. They have strategically and systematically deployed off-grid access delivery, as circumstances warranted, across locations and time, both in a pre-electrification mode as well as otherwise.

3.4 A key takeaway from these experiences is that the starting point and sound basis for any off-grid access scale-up program staging and design is first preparing a comprehensive and analytically sound geospatial least-cost national electrification program plan, irrespective of staging of the grid rollout implementation, which depends on readiness along certain key dimensions.

Off-Grid Electrification and Implementation: "The Next Generation" of transformational programs

3.5 Space and time coordinated grid and off-grid rollout implementation (guided by a comprehensive least cost geospatial plan and roadmap for implementing universal access nationwide) enabled by sector viability – institutional and financial framework – are hallmarks of the next generation of national electrification programs to achieve universal access efficiently and fast. The following highlights of the ongoing experiences of Rwanda, Kenya, and Myanmar typify these features.

3.6 Rwanda and Kenya, both low-income countries, launched comprehensive, nationwide programs starting around 2008/2009, to achieve universal access by 2030. Both national electrification programs are grounded in a rollout strategy with a roadmap for achieving universal access. Implementation has progressed systematically and efficiently, and in a staged, and coordinated grid and off-grid rollout. Both countries are well ahead of the original plan targets in terms of monitored results on the ground.

3.7 Although both programs are naturally "home-grown" in their respective design features and supporting institutional framework, each program reflects the

core organizing principles and strategic drivers across the large and diverse spectrum of best practice country contexts and experiences highlighted in IEG's 2015 electricity access report; for example, Thailand, Tunisia, Lao People's Democratic Republic, Vietnam, and Morocco. In their own manner, the Rwanda and Kenya programs share with this diverse set of countries, the four key dimensions and characteristics that typify transformational programs for achieving universal access: developmental relevance, depth of change from the program as result, scale of change (large scale impact and widespread), and sustainability.[23]

3.8 The Kenya and Rwanda programs present a major break from their past modus operandi, which were typified by fragmentation, piecemeal electrification activities and initiatives, and scattered projects now and then. Rather than being aligned and contributing to national priority–set targets, many of these activities reflected donor priorities and interests; for example, rural electrification, slum electrification, intensification of connections in selected areas, and off-grid, small-scale new renewable energy for poverty alleviation. Coordination among these numerous well-intentioned if not always suitably designed initiatives was weak, and they do not add up for significant impact. The current approach of the two countries, with a comprehensive and programmatic institutional and investment financing framework shares the essential features of the good practice country programs worldwide in earlier years even before the Sustainable Energy for All initiative was launched.

3.9 Rwanda and Kenya, both low-income countries have mainstreamed planning, programmatic financing and implementation of comprehensive and coordinated grid and off-grid rollout programs to systematically scale up towards universal access, with aggressive intermediate targets. A key driver of the positive and encouraging experience and results from these programs was the government's ownership, early commitment, and persistent follow-through on the enabling actions established in Investment Financing Prospectuses. Each program is anchored by a least-cost geospatial national electrification rollout plan for grid and coordinated off-grid development for universal access by 2030; exemplifying best practice.

3.10 The World Bank's engagements began in 2007 for Kenya and 2008 for Rwanda. The first major step for each was preparation of a national geospatial access rollout plan that combined geographic, demographic, and technical parameters to scale up access in a least-cost and time-bound manner. Geographic information system (GIS)-based platforms have proved to be powerful planning

[23] World Bank. 2016.

tools for grid/off-grid national rollouts to meet time-bound targets. Experience confirms their easy understandability and appeal to effectively rally and shape broad consensus across the entire range of key sector institutions and stakeholders that such national programs need to mobilize for efficient, fast implementation. The geospatial plans have also been effectively used by the governments to syndicate large-scale financing on a programmatic basis and organize the diverse spectrum of stakeholders working together toward achieving universal access.

3.11 Spatial planning helps identify the "footprint" of the areas in which MV grid extensions that will enable downstream LV reticulation and achieving connection targets indicated in each planned state of the grid year by year as the country moves to universal access by 2030. All social institutions falling within the shaded planning cells are earmarked for grid connection. The remaining social institutions targeted for electricity supply are shown by distinct symbols in the box figure (Box 3.1) and will be equipped with solar PV units. These results can be achieved by progressively extending the medium voltage network and by concentrating initially on increasing the number of connections within the areas already reached by the MV network. Given the high population density in the country, the plan shows that most areas can expect to be connected to the national grid. However, in some areas, local mini-grids based on micro-hydro and solar PV systems will continue to be efficient for some time.

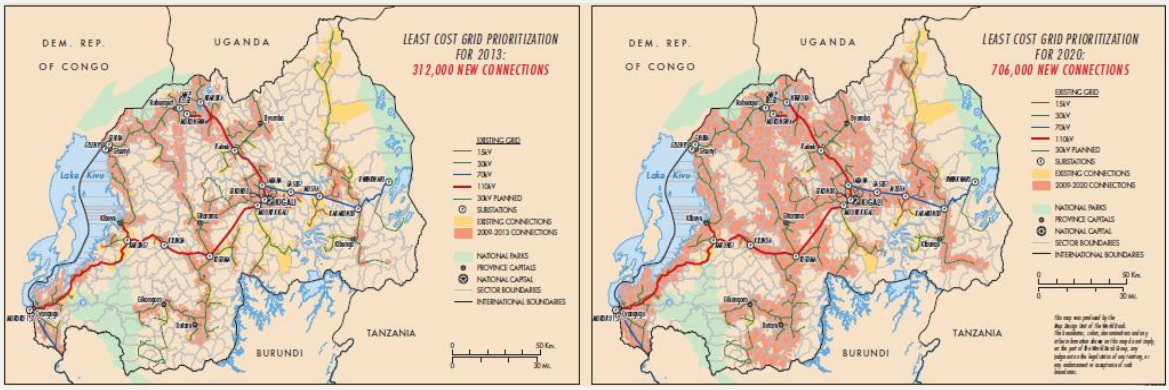
3.12 The geospatial planning platform captures a national development perspective across all sectors (health, education, administrative centers) and all households (urban, peri-urban, rural, and deep rural) and is not restricted to a "rural electrification project here and there" planning framework. The GIS data layers support the high level spatial network planning platform algorithm and postprocessor results processing of the least cost grid and off-grid plan; and can be updated readily.

3.13 The Bank's engagements began in 2008 for Kenya and 2009 for Rwanda. The first major step for each was preparation of a national geospatial access rollout plan that combined geographic, demographic, and technical parameters to scale up access in a least-cost and time-bound manner. The plan addressed equity and shared prosperity considerations through policies for keeping connections charges affordable for the poor. A substantial off-grid program gave priority to connecting public facilities (schools, clinics, primary health centers, and administrative centers) so that developmental effects could be spread out even ahead of the progress on household connections (box 3.1). The plans were funded by the Energy Sector Management Assistance Program as knowledge products that would be translated into operations.

Box 3.1. Rwanda Geospatial National Electrification Rollout Plan and Investment Financing

Rwanda is among the first countries to prepare and implement a nationwide electrification program combining grid and off-grid means based on a systematic and least-cost plan aided by geographic information system mapping techniques that combine technical, economic, demographic, and demand and supply data. The rollout plan can be updated with new information and offers several advantages over traditional electrification master plans.

Figure B3.1.1. Geographic Information System Mapping for Electrification Rollout in Rwanda



Source: World Bank maps unit.

- Geospatial planning is easier to visualize for all stakeholders and can rally financial participation. As experienced in Rwanda and Kenya, (and recently Myanmar), the geospatial plan effectively anchors a "prospectus" for large and diverse groups of national and international stakeholders to coordinate and commit to an adequate and sustainable financing package.
- The geospatial plan captures a comprehensive national development perspective across all sectors (health, education, administrative centers) and all households (urban, peri-urban, rural, and deep rural) and is not restricted to a 'rural electrification project here and there' planning framework. Geospatial planning helps identify the areas where off-grid access delivery options can potentially make the highest impact in the overall national plan for achieving universal access.

Note: Modest cost and ability to make frequent updates make geographic information systems a dynamic planning platform capable of undertaking rapid updates reflecting changes in key parameters. The comprehensive geospatial plans (coupled with a prospectus) for Rwanda and Kenya each cost about US$1 million and took one year to prepare. They better capture the ever-changing situation (growing grid extensions, changing demand and affordability, equipment costs) to inform the implementation process. By contrast, classic electrification master plan studies take two to three years, cost more than $2 million to prepare, and are based on a static framework that is not readily updated.

Source: World Bank 2011

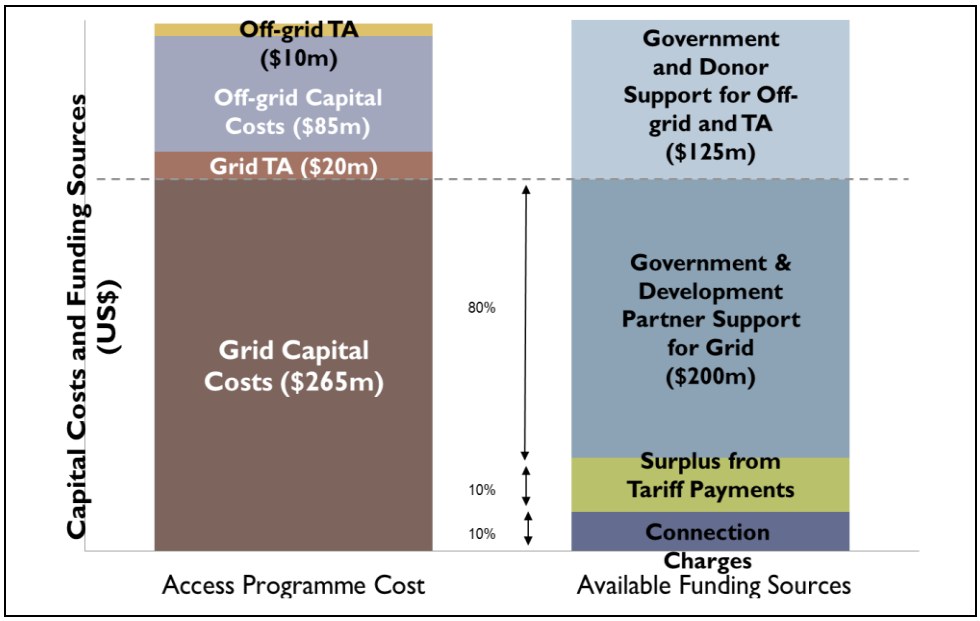
3.14 As part of the process, each country prepared a prospectus detailing the national electrification rollout plan. The prospectus stated the governments' commitments to sector policies and regulations for ensuring the financial viability of the sector and service providers. It also specified the financing requirements for each element of the program—generation, transmission and distribution, off-grid facilities, and others—in a phased manner for the next 15 years. These prospectuses were presented to donor groups in 2009 for Rwanda and 2010 for Kenya.

3.15 After the prospectus was prepared, the government of each country led a donor financing roundtable inviting all stakeholders and interested donors for syndication of the investment and technical assistance financing requirements of the comprehensive first five-year implementation program (2009–2014). The tables 3.1 and 3.2 below summarize the donor pledges, which are broadly allocated as follows:

- **Off-grid program co-financing.** These are financed 100 percent by the government and donors: capital cost (US$80 million) plus technical assistance (~US$10 million).

- **Grid program co-financing.** Financing is 10 percent each from utility and new customer connection charges, and the remaining 80 percent is split evenly between government and development partner contributions.

Table 3.1. Donor Financing Roundtable, Kigali, Rwanda, April 2009



Source: World Bank project documents.
Note: m = million, TA = technical assistance.

Table 3.2. Rwanda: Partner Pledges: Prospectus Donor Financing Round Table (2009–2014)

Development Partner	Financing amount (US$, million)
Programmed donor contribution	
World Bank and Global Environment Facility	78.3
Dutch government	45
Japan International Cooperation Agency	25
African Development Bank	50
Committed donor funding (off-grid)	
European Commission	35
New partners	
Arab Bank for Economic Development in Africa	10
OPEC Fund for International Development	10
Saudi fund	10
Government contribution ($10m/yr.)	50
ELGZ	27
Customers	27
Total financing	357.3

Source: World Bank project documents.

3.16 **Rwanda implementation track record (2009–2015).** Within a short time from program rollout initiation in 2009, Rwanda's national utility has displayed impressive growth for both grid and off-grid access in a coordinated manner guided at the strategic level by its comprehensive national geospatial least-cost rollout plan:

3.17 **Grid connections.** Grid connections showed impressive growth that has so far exceeded original targets.

- Year-end 2015 grid access was reported at 22 percent (563,000 national utility grid-connected customers, compared with about 6 percent access at program start in 2008 and 2009 (~110,000 customers).[24]

- In 2015, the marginal new connection rate on the grid established a new peak and *exceeded* 150,000 connections per year, compared with the program start

[24] Rwanda's population in 2015 is reported to be about 12 million. Intermediate access statistics in selected intervening years are as follows: 2012, access 14 percent (332,000 customer accounts) and a marginal connection rate of about 80,000 per year; 2014, access 22 percent (458,000 customer accounts) and a marginal connection rate of about 150,000 per year.

rate of about 30,000 per year (and a preprogram rate of less than 5,000 per year).[25]

- *Assuming* that the on-grid connection rates are maintained at 150,000 per year, with other conditions remaining the same, the projected national access rate would be as follows: year 2020 (>60 percent); year 2025 (>80 percent); and universal access by or before 2030 (assuming a population of about 15 million by then).

3.18 **Off-grid connections.** Under the national rollout plan, all schools, administrative centers, health centers and hospitals across the country were expected to be covered either by grid or off-grid means by 2016. This appears to have been achieved early, with off-grid access accounting for a significant share, which may decrease in the coming years as the grid catches up in these areas (table 3.3)

Table 3.3. Rwanda's Off-Grid Access Share in Providing Comprehensive Coverage of Public Facilities

	Access provided to public facilities (%)						
Institutions	**Baseline, April 2009**	**Sept 2012**	**Sept 2013**	**Sept 2014**	**Target 2016**	**Actual Dec 2015**	**Off-grid share**
Schools	21	35	37	37	80	100	54
Administrative centers	39	56	59	59	100	100	10
Health centers, hospitals	38	53	57	57	100	100	16

Source: World Bank project documents.
Note: Sept = September.

Micro- or minigrids: With respect to off-grid access, led mainly by the private sector, (coupled with capital subsidy in some instances), the recent developments are as follows:

- **Pico-solar lighting and cell phone charging products.** Over 11,000 products (one per household) were sold, (equivalent to about 17,000 watt peak) in only four months.

[25] Over this time, the national utility has substantially reduced unit connection costs to US$742 per connection in 2015, which is lower than the performance indicator target of approximately US$1,000 per connection agreed to at the start of the program with the government and donor financiers (and a preprogram costs of about US$3,000 per connection).

- M**icro- or minihydro projects.** There are two microhydro projects (in aggregate, about 700 kilowatts) and one minihydro project (3.9 megawatts) that are all bankable and advancing well toward implementation for power sale to the national utility grid.

- **Active pipeline.** Additionally, micro- and minihydro sites (in aggregate, about 5 megawatts total) are under various stages of feasibility study and advancing toward financial closure with technical assistance financed by a Bank project.

3.19 Kenya's experience parallels that of Rwanda, with and Energy Sector Management Assistance Program–funded technical assistance in 2008–09 supporting a comprehensive geospatial least-cost rollout plan to anchor a strategic roadmap for systematically staging a coordinated grid and off-grid program to achieve universal access. This involved intermediate targets differentiated for households, education and health sector facilities and priority administrative locations and centers. This plan anchored the first investment financing prospectus to rally all stakeholders and interested donors for funding the projected investment financing gap for both grid and off-grid electrification for the first five years of implementation (2010–2014).

3.20 **Grid connections:** Within a very short time from program rollout initiation (2009), Kenya's national utility, KPLC, has blazed a noteworthy and impressive record of overall progress in access scale-up implementation achieved in the field. This was guided at the strategic level by the comprehensive national geospatial least-cost rollout plan developed at the outset and since updated for the grid program:

- The national access rate based on-grid connections is about 32 percent in 2015.[26] Over the most recent five-year period (FY2009/10–FY2014/15), KPLC connected just under 2 million new customers, more than doubling the base of about 1.5 million customer accounts in FY2009/10. A further 1.5 million Kenyans gained access to basic power from the off-grid private market for T1 and T2 access highlighted earlier. (World Bank 2016)

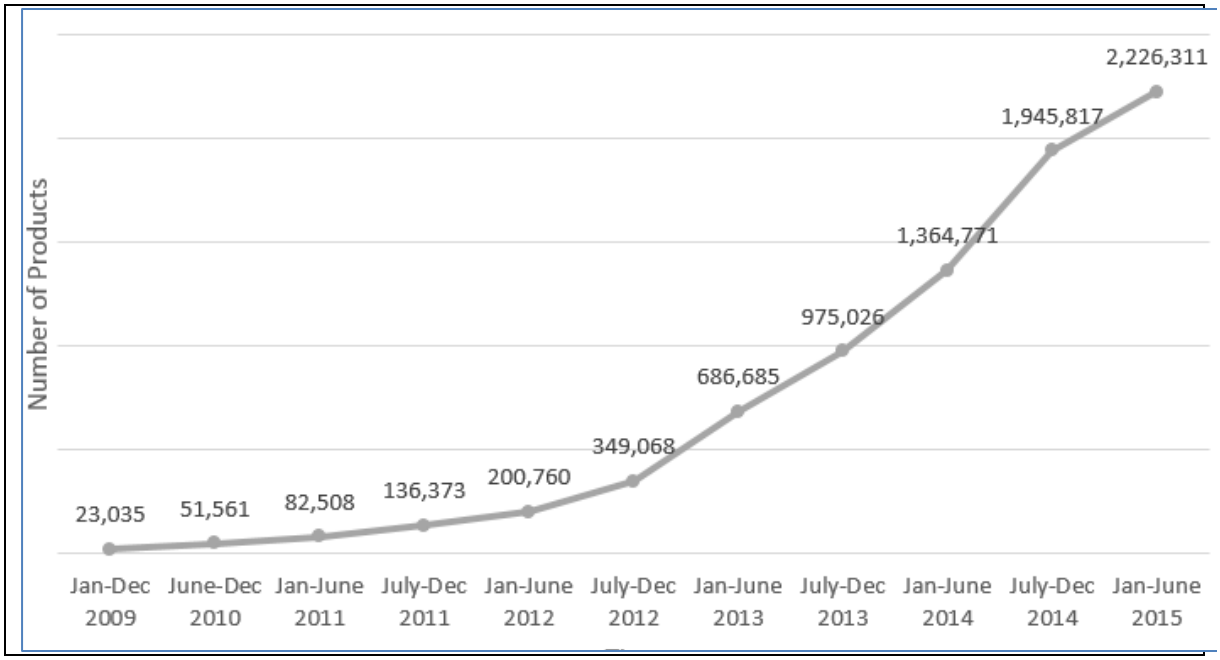
- Although the average annual implementation rate of new connections on-grid over the past five years is about 370,000 per year, the marginal rate in FY2014/15 was about 500,000 connections, and the rate is projected to rise well above that figure in the future.

[26] With an estimated national population of about 44 million in FY2013/14.

3.21 **Off-grid access:** Two broad demographic segments with very distinct characteristics and challenges can be identified in the country. The remote areas of the country have a population of about 7.3 million (out of the present national population of about 45 million) spread cross 13 counties in the northern areas. Here, access stands at 7 percent, or about 540,000 households. Aggressive and sustained efforts are under way to georeference map the population clusters across the entire northern region, as well their settlement patterns within, and systematically and comprehensively identify the effective options for scaling up access to the tier 1 and tier 2 segments as well as micro- and minigrid networks where appropriate.

3.22 In the rest of country, where the overwhelming majority of Kenya's population is concentrated, over 2 million quality-certified pico-solar products, and increasingly SHSs, have been sold since 2008, which represents over 25 percent of all quality-verified product sales in Sub-Saharan Africa (figure 3.1). In this segment, private sector players in Kenya have been successful in developing a robust, commercially self-standing market for solar products and services—the strongest in Africa. They have developed innovative business models and efficient supply channels for cash sales of portable lanterns and locally assembled SHSs. Furthermore, they have also pioneered the rollout of innovative technological approaches such as pay-as-you-go, which enables customers to pay for their solar products in affordable monthly increments, often paying via mobile money. Local financial institutions are actively supporting the sector by providing loans to actors across the value chain.

Figure 3.1. Pico-Solar Products: Cumulative Sales in Kenya



Source: BNEF et al 2016.

3.23 **Myanmar** recently (September 2015), launched its National Electrification Plan to achieve universal electricity access by 2030, supported by an International Development Association credit of US$400 million for implementation over the initial five years (FY2016–22). In the long run, systematic extension of the national grid system is expected to reach over 95 percent of the population as a least-cost solution. The off-grid component has an allocation of US$80 million investment for remote area communities of the country; identified under National Electrification Plan as those townships, villages, and households located farther than 11 miles from the national grid and unlikely to be reached by the grid for at least the next 10 years. These are targeted for pre-electrification by identifying the appropriate system(s) options: SHSs and minigrid systems. Additionally, the off-grid component of the National Electrification Plan targets public institutions (schools, rural health centers, and religious buildings). Private sector agents—suppliers, contractors, delivery chain management, and project developers—are expected to play a significant and varying role in providing the products, services, materials, construction activities, and operations.

3.24 The Ministry of Land, Fisheries, and Rural Development is vested with the overall responsibility for orchestrating the off-grid component. This covers the functions of detailed operational planning; technoeconomic financial assessment of options, standards, and procurement; and overall program management and regular coordination with counterparts responsible for grid rollout operationally. To this end, the International Development Association credit provides for US$10 million technical assistance to the ministry.

3.25 With respect to the off-grid market for pre-electrification, initial market assessments undertaken by Lighting Global indicate that the potential commercial off-grid market for solar photovoltaic products is approximately 8 million households in the central zone, which is home to 75 percent of the national population, with a commercial market economic potential of 4 to 5 million households. In addition, remote areas also represent potential for solar products and systems, but the market development costs and associated risks are judged to be much higher.

A National Roadmap for Universal Access Effectively Navigated: Morocco

3.26 **Morocco National Rural Electrification Program.** By 1995, most of the urban population of Morocco—representing about half of the national population of about 26 million at the time—had been electrified by the government-owned National Office of Electricity via the national vertically integrated utility, ONE. In rural areas,

the picture was not so bright, with only 18 percent access and over 80 percent of villages not electrified. In 1996, the government launched the Global Rural Electrification Program. In 15 years, over 42,000 rural villages and 2.1 million households (about 13 million people), representing about 99 percent of the rural area population, were provided electricity access, which was comparable in parity to overall national access.

3.27 Investment financing for this effort was shared across major stakeholder groups, with their share and responsibilities evolving over the years. The cumulative investment of the Global Rural Electrification Program from 1996 to 2009 is estimated at over €1.8 billion. Of this total investment amount, approximately 50 percent (US$ 1 billion) financing was syndicated across major international financiers: Agence Française de Développement (24 percent), European Investment Bank (18 percent), Islamic Development (15 percent), African Development Bank (12 percent), Japan Bank for International Cooperation (11.5 percent), European Bank for Reconstruction and Development (6 percent), Arab Fund for Economic and Social Development (5 percent), Kuwait Fund (4 percent), Oil for Development (4 percent), and KfW Development Bank (0.5 percent). Significantly, there was no World Bank Group engagement during this scale-up program. By 2009, consumers had provided about 25 percent of total investment, municipalities and communities provided about 20 percent (enabled by earmarked allocations sourced from value-added tax receipts and municipal development fund allocations), and ONE provided 55 percent. ONE's share of total investment financing was split approximately fifty-fifty with government borrowings, grants, and equity. These funds were raised in four tranches over the 15 year period from 1996 to 2009 (Ettaik 2013; IsDB 2013; Nygaard and Dafrallah 2016).[27]

3.28 Morocco's effort was from a home-grown plan, but it displayed international best practice principles for many partners, one plan, and one implementer, and was similar to earlier experiences in Tunisia, Thailand, Vietnam, and Lao PDR.

3.29 **Factors driving Morocco's access scale-up experience.** A single professionally competent implementation agent, the national utility ONE, systematically orchestrated and effectively managed the process. Morocco's access scale-up was informed at the outset by an analytically sound, comprehensive plan prepared by ONE that incorporated both grid and off-grid means in a least-cost

[27] Data are also from ONE annual reports 1990–2014; and IEG consultant field visit, personal discussions in Rabat with ONE, February 2016.

spatially optimized plan that was technologically neutral and took into account grid extensions, minigrids, and SHSs.

3.30 At one time, the minigrids were supplied by microhydro (63 villages), wind hybrids (2 villages), and diesel (12 villages). However, over time, these scattered systems were phased out as the grid extensions advanced geospatially. Additionally, in several instances, sociopolitical and regional balance and equity considerations—coupled with aspirations of the communities involved for grid service—resulted in grid extensions not identified as part of the least-cost plan.

3.31 At one time 105,000 SHSs, ranging in sizes from 50 watt peak up to 200 watt peak, were competitively procured and installed on a fee-for-service basis. Subsequently, consumers began to view SHSs a second-best solution because they were more expensive at that time and, in the final analysis, did not provide the same service as a grid connection. Under pressure, ONE expanded the grid extension program and scaled back the size of the SHS program.

4. Strategic Implications for Moving Forward

4.1 The current rate of new connections in low-access countries averages about 2 million per year, almost all through grid extensions. In stark contrast, an annual average implementation rate of about 15 million per year (about 100 million beneficiaries per year) is required to achieve the Sustainable Energy for All target of universal access by 2030. If low-access countries are to have an even chance of providing at least basic services (lighting, cell phone charging, fan, and television) to large sections of their population within a generation, off-grid electrification will need to be mainstreamed in a big way into the national access rollout effort.

4.2 The mainstreaming of off-grid electrification has taken different routes in the several countries where it has occurred on a significant scale. In Bangladesh, the scaled-up solar home system (SHS) program in grid-proximate areas took hold as an opportunistic market response to the then-stalled grid extension program. In Sri Lanka, off-grid electrification (initially in the form of isolated village hydro-minigrid networks) took place as staged pre-electrification on an ex ante spatial geography–based plan until planned grid extensions arrived at those locations. In Rwanda and Kenya, off-grid electrification is proceeding in an ex ante planned manner. In Morocco, the process occurred earlier in a spatially planned, staged manner, achieving 98.5 percent overall access, including in rural areas. Most recently, Myanmar has laid out a conscious strategy of ex ante planned pre-electrification utilizing an off-grid program promoting solar products, SHSs, and isolated minigrid

networks as appropriate, which is integral to the country's National Electrification Program Roadmap and Investment prospectus.

4.3 Looking ahead, the recent program experiences that have mainstreamed the scale up of off-grid access delivery, and related best practice developments highlighted in earlier sections signal that some off-grid access scale up modalities and market-based business models have come of age. No longer should a whole generation of the population be forced to wait in the dark with limited or no choice, forced to make do with grossly inferior and extremely high unit cost options to meet their most basic energy service needs until the grid reaches them. The era of modern electricity access services (pre-electrification) delivered by quality-certified solar-powered products—from pico sizes to upward of 100watt peak—is within reach in the short to medium term, to a very large portion of the 1 billion in the tier 1 and tier 2 market segments worldwide, and especially in low-access countries.

4.4 Fundamentally, this calls for seeing and thinking of off-grid electrification roles differently—no longer as pilot or small components in access projects, nor as the new answer to addressing the access scale-up challenge in entirety. From a strategic, nationwide perspective, realizing the full potential of off-grid electrification in each country-specific context calls for a comprehensive perspective that can leverage the synergies of access expansion through both grid and off-grid means in a coordinated manner in space and time.

4.5 The experience and good practices from countries—with World Bank support or otherwise—yield several findings and lessons that are outlined here as considerations to inform and tailor, for a given country context, potential modalities for mainstreaming off-grid electrification within the overall national electrification program. Such programs must take into account where, when, and in what modalities off-grid electrification can play its most effective role within the context of the institutional framework for achieving national goals of universal access in a country context and the country's "sector readiness" to do so.

Off-Grid Electrification: Framing the Key Strategic Questions Differently

PUT PEOPLE (BENEFICIARIES) FIRST, NOT TECHNOLOGY SOLUTIONS

4.6 The cumulative empirical evidence from worldwide best practice programs indicates to the following:

- People want affordable, adequate, reliable access "yesterday." From a personal as well as a social and national perspective, the costs of delay in providing even basic access are very high—tantamount to depriving another

generation of the benefits of modernized services, including education and health care services. Time is of the essence.

- Access to small quantities of modern electricity—sufficient to power basic modern lighting, cell phone charging, and a small radio or television—can trigger a giant step for those without access. The United Nations Sustainable Energy for All Global Tracking Framework tier 1 and tier 2 market segments typify this first, hugely transformative step of demand for basic access.
- Significantly, over time, peoples' expectations tend to grow, and almost all aspire to electricity access comparable in adequacy, quality, and reliability that is typical of a well-managed utility-run grid system.
- In light of the above, A National Roadmap for achieving universal access ("electricity for all"), irrespective of the area where they are located (for example, urban, including any slums; peri-urban; rural; or deep rural) needs to be based on spatially mapping where the people and settlements are located and identifying the best means to reach them in a staged manner based on techno-economic and equity considerations. This approach should also avoid or counter any tendencies toward "cherry picking" geographical service areas and/or beneficiaries, whether for grid or off-grid rollout, absent an effective plan to provide access to the excluded.

GRID VERSUS OFF-GRID: A FALSELY FRAMED BINARY CHOICE

4.7 **The "grid versus off-grid" trade-off is not so much about competing answers for the same question as about competing ways to frame the right question.** An important theme emerging from the good practice country experiences with achieving universal access effectively, efficiently, sustainably, and at a good speed (see section 3) is that grid and off-grid technologies and access service delivery are not necessarily either-or options to be determined based simply on a narrow least-cost calculus. Rather, looking ahead, off-grid access rollout provision is appropriately viewed as playing a complementary role to coordinated implementation alongside grid rollout in the process of achieving universal access.

4.8 "Staging" in a particular country's context may constitute more than simply looking at time and, inevitably, may also entail considerations that go well beyond the techno-economic calculus of alternatives. The institutional framework and enabling policy framework put in place by the government, and what constitutes "electricity access" under its policy vision, is also crucial to take into account.

4.9 The scope and scale of off-grid electrification should be planned and designed as appropriate in the country context and be influenced by the need to act strategically from the outset in tailoring a country-specific program strategy design and operational engagements. To realize the full potential of off-grid electrification

in each country-specific context—taking into account scale, scope, geographic coverage, and time—can benefit from an expanded perspective in the process of designing country-specific roadmaps for access scale-up implementation.

4.10 This role of off-grid access rollout needs to be properly conceived and designed into the overall sector strategy for achieving universal access, with due consideration to least-cost and waiting time for access. There is a need to act strategically from the outset in tailoring country-specific program strategy design and operational engagements that are informed by a sound geospatial least-cost nationwide rollout program plan—grid and off-grid—to achieve universal access by the target year.

4.11 A key building block for anchoring the overall high-level roadmap plan for reaching universal access is preparation of a nationwide geospatial coverage least-cost plan for implementation that is periodically revised to reflect updated circumstances and changes in key parameters of the underlying analytical platform. It is not a central command and control tool or a "master plan." Furthermore, it is an essential frame of reference in terms of

- defining and monitoring target mandates and accountabilities of various agents and multisector institutions engaged in access rollout (such as departments of health and education, provincial and local government authorities, and water resources and supply)

- providing an essential and effective basis for coordinating implementation in space and time in the dynamically evolving grid-off-grid program; and

- signaling relevant and valuable information for private sector markets and agents interested in or engaged with some aspect of the electricity access business.

- Last but not least, as the country program examples in the preceding section highlight, a sound and comprehensive nationwide least-cost geospatial plan for implementation toward universal access (and the accompanying "bankable" investment financing prospectus it anchors) in effect serves as a fulcrum or central pivot point in an otherwise business-as-usual piecemeal jigsaw puzzle with many missing pieces. The plan rallies diverse stakeholder participation toward closer alignment to national time targets for access, crowding in new donors and guiding syndication of investment financing requirements on an ongoing and programmatically sustained basis.

4.12 The manner in which this combination plays out during implementation varies by country and is dynamic in space and over time. This may come about in response to progress, or lack thereof, in the respective grid rollout and off-grid rollout implementation in the field. Potential factors include evolving customer expectations and aspirations for service standards, the sociopolitical policy responses to those, and other real-time triggers. The specific circumstances and factors that trigger and shape the moving frontiers of grid and off-grid rollout advances—from the ex ante geospatial least-cost national electrification rollout plan—will vary but are broadly seen in the following country experiences:

Bangladesh: Grid rollout advance may slow down or in extreme cases stall at some point for an extended period of time and then restart later. Bangladesh's pace-setting and best practice–establishing SHS rollout program typifies an instance of "ex post opportunistic" pre-electrification facilitated by deploying standardized, quality-certified SHS–based access delivery and related services to beneficiaries.

Sri Lanka: Sri Lanka's national spatial rollout plan for scaling up envisaged ex ante at some point that village small hydro–based off-grid network access schemes would be phased out when grid reach was operational at that location, and this was achieved. This typifies an instance of "ex ante pre-electrification" facilitated by deploying isolated minigrids.

Morocco: SHS and isolated generation minigrid networks were identified ex ante under its nationwide comprehensive geospatial least-cost rollout plan for areas where grid extensions were not justifiable on technoeconomic calculus.

4.13 Off-grid can play a significant role in most low-access countries in the near term. In many countries, grid rollout has yet to get under way. In others, it has stalled or it advanced in starts and stops and at an unpredictable pace on account of the state of one or more sector readiness conditions, such as governance, institutional framework, weak capacity, long-term vision, targets, commitment and sustained follow-through, lack of accountability, on-and-off rather than programmatic finance, or not maintaining the commercial viability for the qualified private sector agents engaging in the rollout. And in country contexts where the main sector is functioning generally well and grid rollout implementation can be advanced efficiently (for example, Rwanda, Kenya, Morocco, and the recently launched project in Myanmar), off-grid electrification can make a major contribution as well via ex ante planned pre-electrification.

PRIVATE AND PUBLIC SECTOR ENGAGEMENT: BOTH MUST PLAY THEIR DUE ROLES IN ENABLING AND CATALYZING EFFICIENT AND RAPID SCALE-UP OF OFF-GRID ACCESS ROLLOUT FOR TIER 1 AND 2 MARKETS

4.14 In tracing the evolution of off-grid access delivery across the WBG portfolio (sections 2 and 3) two noteworthy features are: (i) the evolving scope and roles of the World Bank and International Finance Corporation (IFC) engagements in response to opportunity for maximizing the synergies resulting from their respective strengths and comparative advantages in enabling early stage ("pre-market") development, and (ii) assisting the client countries in designing the participation of the private and public sectors working in close partnership, bringing their respective natural roles and comparative strengths towards scaled-up delivery for realizing the national goal of universal access efficiently and rapidly

4.15 Notably in Bangladesh, the World Bank played a key role by supporting IDCOL, an autonomous government undertaking, in mentoring and promoting private sector operators, NGOs, and microfinance institutions, resulting in rapid scale-up of SHS penetration, based on a competitive business model. It has supported mechanisms for product quality assurance and starter market capital subsidies; typically towards financing the soft program costs, and directed towards lowering the high initial costs typical – such as extending service dealer chains, building capacity – costs not fully recoverable in market prices for the solar home systems, at early stage of development. Further, , Lighting Africa which over time focused on the Tier 1 starter market development, evolved into the Lighting Global umbrella program of the World Bank Group with broadened market focus. Specifically, the Lighting Global Program has engaged in design and preparation of a substantial scale off-grid electrification program for Tier 1 and 2 beneficiary segments; within the context of a national Road Map for achieving universal access; aided by the spatial information provided by the nationwide geospatial least cost plans funded by the World Bank and grid extension plan over time. The instances of Kenya, Rwanda and Myanmar typify country cases where the World Bank assisted the Government with preparation of the national least cost geospatial electrification implementation plan for universal access by 2030 (grid and alongside coordinated in space-time the off grid program scale up), and syndication of the investment financing requirements orchestrated by the governments' within a sector wide organizing architecture and oversight process.

MULTIPLE ADVANTAGES OF A HIGH-LEVEL NETWORK PLANNING PLATFORM THAT IS ANCHORED IN A GEOSPATIAL AND COMPREHENSIVE PLAN COVERING GRID AND OFF-GRID MEANS

4.16 Providing access (in some form) to all households, clinics, and trading centers—wherever they may be—requires identifying where the beneficiaries are geolocated. This enables least-cost placement and expansion of existing electricity

access infrastructure. Sound geospatial planning platforms that can be readily updated to changes in key variables have been shown to provide a sound and comprehensive analytical foundation for and dynamically coordinated strategic-level rollout implementation of grid and off-grid growth in space and time. Such planning therefore facilitates further detailing of design and rollout operationally.

4.17 The national geospatial least-cost strategic rollout plan serves to further anchor and foster closer alignment of multiple and varied donor programs with national priorities and targets, and to effect harmonization across donor programs. It also facilitates and directs their financing support (called syndication) of the investment prospectus on-grid or off-grid and in space and time (for further details, see the following section).

SECTORWIDE ORGANIZING ARCHITECTURE AND PROGRAMMATIC FINANCING SHOWS PROMISE

In their own home grown manner, the good practice transformational national programs for implementing electricity access scale (identified earlier), have adapted in essence a *sector-wide organizing architecture, comprehensive nationwide geospatial least cost rollout plan, and programmatic financing framewor*k. Their respective successes serve to highlight the effectiveness and multiple ranging benefits of such a framework for efficiently and rapidly advancing along a roadmap to achieve universal access in a timely manner. Specifically, the sector wide investment prospectus for grid and off-grid expansion would be anchored by the nationwide least cost geospatial rollout plan to achieve the time-bound targets set by Government on grid and off-grid, and updated regularly; and the enabling policy and institutional framework also in place. Such a framework and process, transparently and effectively facilitate: closer alignment of individual Donor program designs with national priorities than otherwise; syndication of the investment financing requirements (public sector portion) of an integrated grid and off grid rollout implementation, on a rolling five year horizon programmatic basis, and; facilitate timely and appropriate course corrections along the way should circumstances and implementation progress in meeting planned access targets on-grid and off-grid deviates significantly from expectations.

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Appendix A: Off-Grid Electrification Issues and Strategies in Country Partnership Strategy documents of Low-Access Countries

Country	Region	CPS Years	CPS time period begins FY2014 or later?	Were Off-grid electrification issues discussed significantly and/or had indicator?	Were any new operation/ TA or nonlending assistance planned?
Angola	AFR	FY2014–16	Yes	No	No
Benin	AFR	FY2013–17		No	Yes
Botswana	AFR	FY2016–20	Yes	No	No
Burkina Faso	AFR	FY2013–16		Yes	Yes
Burundi	AFR	FY2013–16		No	No
Cameroon	AFR	FY2010–13		No	Yes
Central African Republic	AFR	FY2009–12		No	No
Chad	AFR	FY2016–20	Yes	No	No
Comoros	AFR	FY2014–17	Yes	No	No
Congo, Dem. Rep.	AFR	FY2013–16		No	No
Congo, Rep.	AFR	FY2010–12		No	No
Djibouti	AFR	FY2014–17	Yes	No	No
Equatorial Guinea	AFR	None		None	None
Eritrea	AFR	FY2000		No	No
Ethiopia	AFR	FY2013–16		Yes	Yes
Gambia, The	AFR	FY2013–16		No	No
Guinea	AFR	FY2014–17	Yes	No	No
Kenya	AFR	FY2014–18	Yes	No	Yes
Lesotho	AFR	FY2016–20	Yes	No	No
Liberia	AFR	FY2013–17		No	Yes
Madagascar	AFR	FY2007–11		No	No
Malawi	AFR	FY2013–16		No	No
Mali	AFR	FY2016–19	Yes	Yes	Yes
Mauritania	AFR	FY2014–16	Yes	No	No
Mozambique	AFR	FY2012–15		Yes	Yes
Namibia	AFR	FY2014–17	Yes	No	No
Niger	AFR	FY2013–16		No	No
Nigeria	AFR	FY2014–17	Yes	Yes	Yes
Republic of South Sudan	AFR	FY2013–14		No	No
Rwanda	AFR	FY2014–18	Yes	No	No
Seychelles	AFR	FY2012–15		No	No
Sierra Leone	AFR	FY2010–13		No	No
Somalia	AFR	FY2014–16	Yes	No	No
Sudan	AFR	FY2009		No	
Swaziland	AFR	FY2015–18	Yes	No	No
Tanzania	AFR	FY2012–15		Yes	Yes
Togo	AFR	FY2012–13		No	No
Uganda	AFR	FY2016–21	Yes	No	Yes
Zambia	AFR	FY2013–16		No	Yes

Zimbabwe	AFR	FY2013–15		No	No
Cambodia	EAP	FY2005–08		No	No
Myanmar	EAP	FY2015–17	Yes	No	Yes
Papua New Guinea	EAP	FY2013–16		No	Yes
Solomon Islands	EAP	FY2013–17		No	No
Timor-Leste	EAP	FY2013–17		No	No
Tuvalu	EAP	FY2012–15		No	No
Vanuatu	EAP	None		None	None
Haiti	LAC	FY2016–2019	Yes	Yes	Yes
Yemen, Rep.	MNA	FY2010–13		No	Yes
Afghanistan	SAR	FY2012–14		No	No

Source: CPS, Country Partnership Framework (CPF), country assistance strategy (CAS), Interim Strategy Note (ISN), Interim Support Strategy and Country Economic Memorandum (CEM) from the World Bank imagebank websites, country websites or public websites.

Note: Includes Country partnership strategy, Country Partnership Framework (CPF), country assistance strategy (CAS), interim strategy note (ISN), interim support strategy, and country economic memorandum (CEM)

Appendix B: World Bank and IFC Portfolio Overview for Off-Grid Electrification

Table 1. World Bank Group: Commitments for Off-Grid Electrification: FY2000–2016 (May 1)

UNIT	No. of Projects/ operations	Off-grid commitment planned or final* (US$, million)	%
IFC	12	98	7
World Bank	71	1388	93
Total	**83**	**1486**	**16**

Source: World Bank project appraisal documents, Mid Term Review Reports, Implementation Status and Result Reports, Aid Memoire, Legal Documents, Implementation Completion and Results Reports and other project documents, IFC project data websites, GEF project data websites, IFC (2007 and 2012)

* Planned commitments for active projects and actual amounts for closed projects; in some cases, assumptions made where amounts for off-grid electrification were not explicitly disaggregated.

Table 2. Commitments for Off-Grid Electrification: FY2000–2016 (May 1) by Region

IFC

UNIT*	No. of Projects	Commitment (US$M)	%
SAR	4	57.0	58
Global	5	35.9	37
AFR	3	5.0	5
Total	12	97.9	100

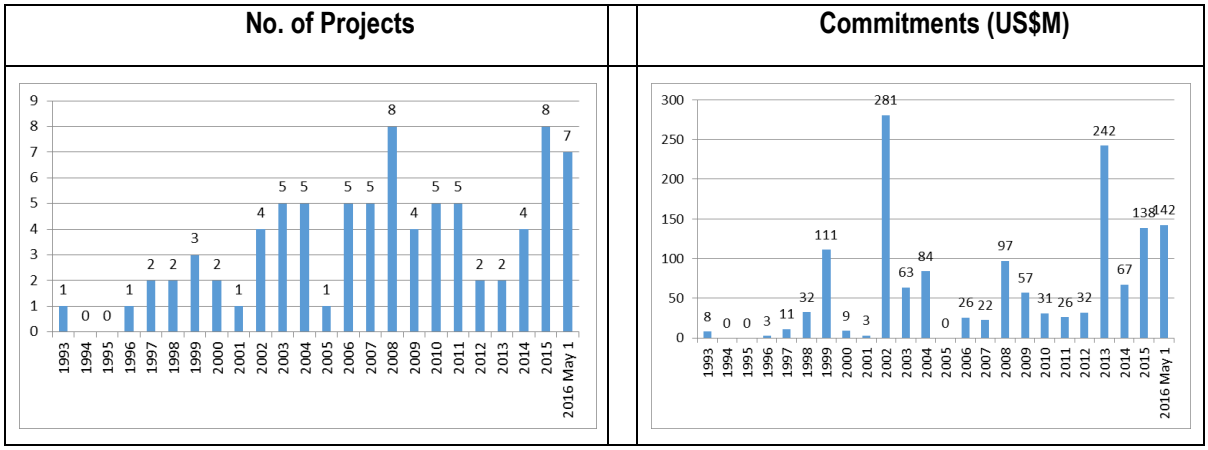
World Bank

UNIT*	No. of Projects	Commitment (US$M)	%
SAR	11	548.1	39
AFR	31	404.3	29
LAC	11	252.8	18
EAP	16	177.0	13
MNA	1	5.9	0
Total	70	1,388.1	100

Source: World Bank project appraisal documents, Mid Term Review Reports, Implementation Status and Result Reports, Aid Memoire, Legal Documents, Implementation Completion and Results Reports and other project documents, IFC project data websites, GEF project data websites, IFC (2007 and 2012)

* AFR (Sub-Saharan Africa); EAP (East Asia and Pacific); LAC (Latin America and the Caribbean); MNA (Middle East andNothern Africa); and SAR (South Asia)

Figure 1. World Bank Group Portfolio for Off-Grid Electrification: Approved or Closed during FY2000–16



Source: World Bank project appraisal documents, Mid Term Review Reports, Implementation Status and Result Reports, Aid Memoire, Legal Documents, Implementation Completion and Results Reports and other project documents, IFC project data websites, GEF project data websites, IFC (2007 and 2012)

Table 3. Top 10 recipients of World Bank Group Assistance for Off-Grid Electrification: FY1999–2016 (May 1)

Country	Number of operations		Commitments* for Off-grid Electrification (US$ million)	Share of total comm. (%)	Electricity Access Category
	Closed	Active			
Bangladesh	1	1	480.7	32	Medium
Argentina	1	1	181.6	12	High
Mali	1	1	103.1	7	Low
Myanmar		1	90.0	6	Low
Uganda	1	2	78.8	5	Low
Ethiopia	2	1	68.9	5	Low
India	3	3**	52.6	4	High
Sri Lanka	2	1**	45.0	3	High
Bolivia	2	1	31.4	2	High
Liberia	-	2	30.5	2	Low
Total for 10 countries	**13**	**14**	**1,163**	**78**	
Total for All 41 countries	**43**	**39**	**1,486**	**100**	

Source: World Bank and IFC databases
* Final disbursements in the case of closed projects.
** IFC operations status not available, and thus may have closed or still active.

Appendix C: World Bank Operations and IFC Projects with Off-Grid Electrification Objectives or Components, FY2000–16

No.	World Bank/ IFC	Region	Country	Access Level	Project ID	Project Name	Approval FY	Closed/Active	Closing FY	Electricity Sector Commitment (US$ M)	Off- grid lending US$M : Planned /Final*	Productive Uses	Cross-sectoral Issues	Components
1	World Bank	AFR	Benin	L	P079633	Energy Service Delivery Project	2005	C	2013	45.9	0			Strategy for off-grid electrification was one of the PDO indicators. At appraisal, this off-grid strategy was included in the IDA financing (USD 2.55 million) of Component 2 Engineering Studies. This target was partially achieved. The off-grid electrification strategy was completed by the government outside of the project (no IDA financing) and has been implemented.
2	World Bank	AFR	Burkina Faso	L	P078091	Energy Access Project	2008	C	2015	39.4	2		Yes	Increasing access in rural and remote areas: (i) Six diesel-powered plants in the Sahel region ; (ii) Twenty locations electrified through the provision of 4,366 solar PV kits of three lamps each, and 192 community service sites (village administration, health, education, and recreation facilities); c ross-sectoral activities initially in the health, education and water sector.
3	World Bank	AFR	Burkina Faso	L	P128768	Electricity Sector Support Project	2014	A	2020	50	1.1		Yes	Improving efficient use of energy in target area: Implement Lighting Africa activities including, inter alia: (i) provision of capacity training on off-grid lighting in rural electrification strategies; (ii) develop public service announcements and awareness campaigns to inform consumers of the benefits of solar lanterns and other good quality products; and (iii) deploy around 25,000 lanterns in public schools focusing on those in off-grid communities.
4	World Bank	AFR	Cabo Verde	M	P040990 P042054	Energy and Water Sector Reform	1999	C	2007	8	0			Renewable Energy Promotion and Development: Off-grid electrification services using photovoltaic and wind systems (largely superseded by on-grid electrification)

						and Development Project								
5	IFC	AFR	Cameroon	L	11579	IFC AES Sonel	2007	C	2009	0.4	0.4			IFC trust fund investment in AES Sonel's PV off-grid rural electrification to high density population centers, as a substitute to diesel gensets; pilot concluded in August 2008
6	World Bank	AFR	Cameroon	L	P104456	Energy Sector Development Project	2008	A	2017	65	20			Component I($45 million of which IDA $ 40 million): Rural Energy Fund (REF), including off-grid and on-grid. Assumed half of $ 40 million would be off-grid.
7	World Bank	AFR	Ethiopia	L	P049395 P077380	Energy Access Project	2003	C	2013	169.4	17		Yes	Off-grid rural electrification: electrified 21 villages with diesel generators (each village an average of 500 households); prepared five minihydro projects but these projects were not completed prior to the project's closing date; electrified 1,108 households with solar PV system, through cooperatives; electrified 200 rural health posts and 100 elementary schools with solar PV systems.
8	World Bank	AFR	Ethiopia	L	P101556	Second Electricity Access (Rural) Expansion Project	2008	C	2015	98.9	19.6			Given the lack of a clear institutional framework, capacity concerns in REF and time needed with the minigrids, dropped the minigrids and focused on capacity building of REF and implementation of GoE's SHS program to reach remote off-grid areas, installed 28,735 SHS in households. 683 local technicians trained.
9	World Bank	AFR	Ethiopia	L	P119893	Electricity Network Reinforcement and Expansion Project (ENREP)	2012	A	2019	405.4	32			Component 3: Market Development for Renewable Energy and Energy-Efficient Products: Development of stand-alone renewable energy programs such as solar home systems (SHSs), solar lanterns, especially in areas that are not yet connected to the grid.
10	World Bank	AFR	Gabon	H	P144135	Access to Basic Services in Rural Areas and Capacity Building Project	2016	A	2022	60	24.4		Yes	Installation of solar home systems (SHSs) and minigrid solutions;
11	World Bank	AFR	Ghana	M	P074191	Energy Development and	2008	A	2018	279.7	10		Yes	Mini-Grids and Grid-Connected Renewable Energy, including Solar-photovoltaic systems for public institutions such as schools and clinics; Capacity Building: Solar PV for public institutions; Improved Lighting & Solar

						Access Project								Systems for Basic Schools; Off-grid Community Lighting Project
12	World Bank	AFR	Ghana	M	P145765	Ghana Climate Innovation Center	2016	A	2020	N.A.	N.A.	Yes	Yes	Solar energy: Include companies developing promising– but unproven– business models in renewable energy (on-grid, off-grid, and home-based products such as solar lighting). Since supporting companies have not been decided, costs (lending commitment to energy sector and off-grid) are N.A.
13	World Bank	AFR	Guinea	L	P074288	Decentralized Rural Electrification Project	2003	C	2013	5.5	5.5			Financing Mechanism and Implementation of the Decentralized Rural Electrification (DRE) Program, through photovoltaic, picohydro, and diesel (or hybrid) systems. (However, At project closure, 35 applications had been processed, of which 32 resulted in signed agreements. 26 of the microgrids are currently operating and three are still under construction (including the picohydro project and all others a pico-diesel of 20–250kVA). No renewable energy subprojects were put in service. Because the project was demand-driven, the high upfront cost of renewable energy technologies discouraged local investors.)
14	World Bank	AFR	Kenya	L	P109683	Kenya Agricultural Productivity and Agribusiness Project	2009	C	2016	2	2	Yes	Yes	Linking rural agro-processing activities to off-grid energy sources: pilot energy facilities using local renewable energy sources (for example,minihydro, biomass, wind and solar). (Solar subproject delayed and some of them could be commissioned by the end of project on September 30, 2015 but commissioned in December 2015, resulted in at least 2,180 members, which is about 172 percent above the target set, linked feasible agri-business value chains to off-grid energy.)
15	World Bank	AFR	Kenya	L	P103037	Electricity Expansion Project	2010	A	2018	335.2	0.0			Design and implementation of off-grid electrification projects, including pilot programs. CancelationCancelation decided at the mid term review in Jun 2015 due to procurement delay and deletion of this sub component from the result framework noted in the amendment to the Financial Agreement in April 2016.
16	World Bank	AFR	Kenya	L	P120014 P145104	Electricity Modernization Project	2015	A	2020	457.5	10	Yes		Off-grid electrification (IDA US$2.5 million, SCF-SREP grant US$7.5 million) will be implemented through minigrids supplied preferably by hybrid generation systems, combining renewable resources (solar or wind) and thermal units This program would address the barriers for commercial dissemination of stand-alone PV and microgrid products and services for customers in remote areas. This subcomponent will help (i) increase

														income or productivity from promoting productive uses of electricity in agricultural, commercial, and industrial activities.
17	World Bank	AFR	Liberia	L	P120660 P129097	Electricity System Enhancement Project (LESEP)	2011	A	2017	45.5	3.5			Providing Modern Renewable Energy Services to Off-Grid Users, including Sub-component: Renewable energy pilot activities in rural areas: (i) both a Sustainable Solar Market Packages (SSMP) and "Lighting Africa" approach and (ii) a microhydropower plant rehabilitation, and Sub-component Technical Assistance: supporting the institutional framework in support of modern renewable off-grid options, developing policy foundations and strategy work necessary to underpin this sub-component.
18	World Bank	AFR	Liberia	L	P149683	Liberia Renewable Energy Access Project	2016	A	2021	27	27			Market development of stand-alone solar systems
19	World Bank	AFR	Madagascar	L	P151785	Electricity Sector Operations and Governance Improvement Project)	2016	A	2020	65	0.2			Consultancy services required for the definition of a strategy and action plans to increase electricity access in the whole Madagascar, both on-grid and off-grid.
20	World Bank	AFR	Mali	L	P073036 P076440	Household Energy and Universal Access Project	2004	C	2012	74.5	58.2	Yes	Yes	Energy Services Delivery, including about 83 private operators of mini or micro diesel (for example, AF RP 2011 indicates 45–450kilowatts), as of June 30, 2012, a cumulative number of about 74,787 connections had been made, exceeding the target of 68,896 connections. A cumulative number of 1295 public and community institutions and centers are connected including 218 schools and 168 health centers. Multifunctional platforms have been installed in 81 communities. Approximately 4,700 users are overall connected to the platforms. The original end target of installing 11,726 solar photovoltaic systems was partially achieved. A total of 8,141 systems were installed by the GEF grant closing date of June 30, 2009. The decision not to extend the GEF Grant was because at that time private operators were not interested in adopting as much as expected solar technologies and beneficiaries also wanted multiple

														uses of energy services that were difficult to be provided by solar home systems.
21	World Bank	AFR	Mali	L	P131084	Rural Electrification Hybrid System Project	2014	A	2021	44.9	44.9	Yes	Yes	Service Improvement and Extension of Existing Minigrids: Hybrid Generation about 96kilowattsp (total 4.8 megawattp) of solar PV to mini diesel systems (200–250kV) total about 50 diesel minigrids; Minigrid Extension and Densification, including SHS, Development of Off-grid Lighting Markets and Energy Efficiency, which will (i) expand off-grid lighting and solar lanterns in targeted rural areas through catalyzing the markets, and (ii) improve energy efficiency and promote a rational and efficient use of electricity on targeted minigrids. Aligned with the approach of the World Bank Group's Lighting. Africa program; Project Management Support and Capacity Building,
22	World Bank	AFR	Mozambique	L	P069183 P071942	Energy Reform and Access Project	2004	C	2011	46.3	6.7			Independent Grid Rural Electrification: No independent grid concession operational at completion of the project, Study to identify productive uses of electricity completed but no implementation of the recommendation. Renewable Energy and Cross-Sectoral Linkages (USD 6.65 million): Solar PV systems installed in clinics and schools, but the main issues (i) quality of the initial installations including components, (ii) difficult and costly maintenance due to the remoteness of the systems, and (iii) theft and vandalism. Also, residential solar PV systems
23	World Bank	AFR	Mozambique	L	P108444	Energy Development and Access Project 2	2010	A	2017	80	12.3	Yes	Yes	Investments on Rural and Renewable Energy Component, Sub-component 2.1: Solar Systems and Technologies (US $9.25 million) including Institutional Solar Systems (Rural Schools/Health Clinics), Community Solar Systems (including identifying productive uses that use electricity; Commercialization of energy equipment; search for new and Biomass Energy Systems only regarding (a) multifunctional energy service platforms (USD 2 million) which run on Direct Vegetable Oil (DVO) and/or Biodiesel in rural villages, innovative solutions for the most common maintenance jobs (such as weeding in gardens), as a way of involving the community and thus contributing to the creation of local employment), Promotion of Rural Electrification (assumed half of US $2.0 million), support the elaboration, consultation process and dissemination of a comprehensive national "Rural Electrification Strategy and Investment Program (RESIP)" including off-grid and on grids.

24	World Bank	AFR	Mozambique	L	P146398	Second Climate Change Development Policy Operation	2015	C	2015	N.A.	N.A.			This DPO supports "Improving the investment environment for private sector participation in both off and on-grid renewables"
25	World Bank	AFR	Niger	L	P153743	Electricity Access Expansion Project	2016	A	2022	65	0.7			Supporting government's efforts to increase electricity access in the country by financing a National Electrification Strategy and measures to expand access in rural areas. The strategy will consider both on-grid and off-grid solutions.
26	World Bank	AFR	Nigeria	L	P090104	National Energy Development Project	2006	C	2012	167.2	3.6	Yes	Yes	Off-grid electrification in Mfaminyen in Cross River State: installation of solar PV panels for electrification and battery charging, a public community space with an ICT business center and TV, solar streetlights and a solar-powered water borehole. (ii) Off-grid electrification in Ogun, Imo, and Kaduna: 45 solar home systems and 17 solar streetlights, including for community markets, and two solar water pumps to promote the commercial activities of Fadama user groups. (iii) Cross-sector energy applications developed two model agreements with telecommunication companies that require electricity for telecom towers in off-grid rural areas. (iv) Support drafting of renewable energy master plan
27	World Bank	AFR	Rwanda	L	P097818	Sustainable Energy Development Project	2010	C	2015	11.7	1.9			Sustainable development of micro hydro resources : (i) developing national installation and user guidelines for institutional PV applications, (ii) building capacity and conducive frameworks to allow local private firms to participate in international tendering for the Rwandan market, and (iii) supporting the development of a commercial SHS (Solar Home System) market for rural areas. (By project closing, about 45 enterprises were involved in the RE business (solar and pico/micro hydro) and 69 were in businesses related to biomass-efficient utilization (improved cook stoves, biogas and efficient charcoaling), according to results of surveys conducted in December 2013. Survey results also indicated that these enterprises employed about 1,460 personnel, which is significantly above the original project target of 75. The project has facilitated about 9.5 megawatt of micro hydro sites, representing annual energy savings of about 400 megawatth from the installed solar water heaters)
28	IFC	AFR	Senegal	M	30094	IFC Comasel Louga	2012		N.A.	0.8	0.1			Provide electricity 1,852 rural users with individual solar kits.

Appendix C: World Bank Operations and IFC Projects with Off-Grid Electrification Objectives or Components, FY2000–16

29	World Bank	AFR	Tanzania	L	P101645 P092154	Energy Development and Access Expansion Project	2008	A	2017	167	17.1	Yes	Yes	Green mini/micro grid; Sustainable Solar Market Development
30	IFC	AFR	Tanzania	L	34292	IFC GEF Off-Grid Electric	2014		N.A.	4.5	4.5			Support the deployment of approximately 100K solar home systems across Tanzania
31	World Bank	AFR	Uganda	L	P069996 P070222	Energy for Rural Transformation Project	2002	C	2009	67.5	6.3	Yes	Yes	Solar PV systems in homes, community institutions, Component 4: Cross-sectoral linkages ; 512 solar systems in health centers, 20 solar water pumping systems, 94 of the 129 Educational institutions using solar systems. Costs were estimated from PAD using the proportional changes at the ICR.
32	World Bank	AFR	Uganda	L	P112334	Energy for Rural Transformation Project II	2009	A	2016	101.5	49		Yes	Rural Energy Infrastructure, Off-grid Renewable Energy Investments; Technical Assistance and Training ; Impact Monitoring, finance solar PV energy packages for remote health, education, and water facilities
33	World Bank	AFR	Uganda	L	P133312 P146876	Uganda Energy for Rural Transformation III	2015	A	2021	143.2	23.5		Yes	Off-grid Energy Access Solar PV systems for public institutions in rural areas; business development support; provision of credit facilities to enhance electricity access; and quality standards enforcement support. Consultancy services, capacity building activities, and operations costs. Implemented by several IAs—Ministry of Health (MoH), Ministry of Water and Environment (MoWE), Ministry of Education, Science, Technology and Sports (MoESTS), the Private Sector Foundation Uganda (PSFU), and UECCC—under the coordination of the Project Coordination Unit (PCU) within the MEMD. Component 3: Institutional Strengthening and Impacts Monitoring (Assumed USD 1 million for off-grid from US$4.5 million IDA).
34	World Bank	AFR	Zambia	L	P077452 P076320	Increased Access to Electricity Services Project	2008	C	2015	55.9	5.7		Yes	Solar PV (households, Schools, Hospitals), Mini Grids (dropped)
35	World Bank	EAP	Cambodia	L	P064844 P071591	Rural Electrification and Transmission Project	2004	C	2912	40.6	3.5	Yes		Rural Electrification Fund, including SHS and off grids but since some of REEs became SPDs assumed half the cost of Component C, mini/village hydro found unfeasible Institutional development and sector reform - income generation, off-grid, regulations, REF, etc.

36	World Bank	EAP	China	U	P046829 P038121	Renewable Energy Development Project	1999	C	2008	39.8	25.5			PV Component: More than two million people in western China have been provided with access to modern electricity services through PV systems. Sales are concentrated in Tibet, Qinghai. Sichuan and Xinjiang. Total PV systems sales reported by the PV companies exceeded 500,000 with REDP-verified sales exceeding 400,000 units with an aggregate capacity of 11.1 megawattp compared with a goal of 350,000 units with a capacity of 10 megawattp. The TI component, consisting of an investment subcomponent only for PV manufacturers and the institutional strengthening. The ex post analysis covers the full amount of the grant allocated to the PV and TI components, totaling $25.5 million. All TI expenditures were allocated against the verified PV systems sold under the project.
37	World Bank	EAP	Indonesia	H	P035544 P003700	Solar Home Systems Project	1997	C	2001	5.3	4.8			Provision of credit through participating local commercial banks (PBs) to private Solar Homes Systems (SHS) dealers for the sale and installation of solar PV systems for homes and commercial establishments such as small shops, and (2) TA for a Renewable Energy for Rural Transformation Study and Action Plan, establish a Project Support Group (PSG) to provide assistance to SHS dealers and end-users, to monitor and evaluate project progress, and to conduct limited SHS related training to government officials and private sector organizations; and assist GOI in building Indonesia's institutional capabilities for the dissemination of solar PV technology.
38	World Bank	EAP	Indonesia	H	P154805	Power Distribution Development Program-for-Results	2016	A	2020	500	N.A.			Island based minigrid systems are included although not mentioned in the Program Document
39	World Bank	EAP	Lao PDR	M	P044973	Southern Provinces Rural Electrification Project	1998	C	2005	35.11	2.1			Off-Grid Rural Electrification, which piloted the use of small-scale, stand-alone generation systems such as microhydro and diesel minigrids as well as solar battery charging stations in remote rural communities on a financially sustainable basis.
40	World Bank	EAP	Lao PDR	M	P075531 P080054 P119715	Rural Electrification Phase I Project	2006	C	2012	23.7	6.7			Off-grid Investment Program SHS. Institutional Strengthening: MEM outsourced the overall coordination, implementation and monitoring of the off-grid component to a contractor known as Village Off-grid Promotion and Support or VOPS. Alternative RE Delivery

														Models: Fifteen village hydro projects were identified but not implemented. Income generation linkage assessment completed. An RE master plan and a geo-referenced RE database were developed and related staff in MEM were trained to maintain and update the geographic information system database. An assessment of mini/micro hydro resources and rehabilitation of existing mini/micro hydro plants was completed.
41	World Bank	EAP	Lao PDR	M	P110978 P117177	Rural Electrification Phase II Project	2010	C	2015	34.3	3.5			Off-Grid Investment Program: SHSInstitutional Strengthening: consultancy services to manage the village off-grid program and to monitor debt collection performance, Alternative Rural Electrification Delivery Models: design, supply, install, and supervise pilot projects for village hydropower to be developed under public-private partnership schemes, insufficient income-generating activity at village hydro sites.
42	World Bank	EAP	Mongolia	H	P099321 P084766	Renewable Energy and Rural Electrification Access Project	2007	C	2012	12.3	12.3			Herders' Electricity Access -SHSs; Soum Center Electricity Service – to develop the institutional and technical capacity of off-grid SC electricity services; and to invest in minigrid rehabilitation and R/RDHSs.; Institutional Capacity Building – to strengthen national renewable energy policy development and to support institutional development of the National Renewable Energy Center (NREC) training.
43	World Bank	EAP	Myanmar	L	P152936	National Electrification Project	2016	A	2022	400	90		Yes	Off-grid electrification: (i) solar photovoltaic devices or systems for a target of 456,500 households; (ii) minigrids to serve some 35,500 households; (iii) electricity connections for 11,400 health clinics, schools and other community buildings; and (iv) installation of 19,000 public street lights. IDA off-grid component is designed to complement and coordinate with IFC's proposed Lighting Myanmar program; develop an integrated framework to plan electrification, monitor result and evaluate impacts; secure technical advice and consulting services, including on standards, technology assessment and technical design, economic and financial analysis, environmental and social impact management, procurement and financial management; and (v) improve Project management.
44	World Bank	EAP	Pacific Islands	L	P098423	Sustainable Energy Finance Project	2007	A	2018	8.4	4.2	Yes	Yes	This project covers or solar PV, picohydro.

45	World Bank	EAP	Papua New Guinea	L	P088940	Teacher's Solar Lighting Project	2006	C	Closed date N.A.	1	1	Yes	Yes	Provide an affordable financing package which will make the purchase of solar lighting kits affordable for teachers, health workers, and eventually the general public; Build capacity within the PNG renewable energy industry, by requiring retailers to obtain PV-Gap certification (which include ISO 9000) and by regularly producing a catalog with certified solar PV components; and Build consumer awareness and confidence in the use of solar lighting, by requiring extensive outreach and support to Solar House Lighting Kit (SHLK) purchasers;
46	World Bank	EAP	Philippines	H	P066397 P113159 P072096	Rural Power Project	2004	C	2013	31.1	15.6			Rural Electrification (2) decentralized electrification supported investments in small power generation, decentralized grids and stand -alone RET systems, most notably photovoltaic (PV) systems (About 10 new productive applications initiated in pilot areas, Not achieved: During implementation of the GEF Grant, efforts for developing productive applications were not pursued, due to the prioritization of other activities.)
47	World Bank	EAP	Timor Leste	L	P092055	Gas Seep Harvesting Project	2007	C	2012	0.3	0.3			The investment components included three main subcomponents: (i) construction of a dual-fuel power plant using the gas from the seeps and diesel oil for power generation (150kilowatts*3); (ii) building of 20 kV distribution lines to connect the proposed power plant to the existing isolated EDTL systems and to new consumers in the rural communities near the proposed power plant; and (iii) introducing a system of revenue collection using cost-effectivecost-effective metering system. (Project dropped because seepage gas was much lower than that at the feasibility study. Also grid expanded.)
48	World Bank	EAP	Tuvalu	L	P144573	Energy Sector Development Project	2015	A	2019	7	0.2			Renewable Energy Investment included a satellite-based communications system on Funafuti and three of the seven outer islands to remotely monitor, control, and improve the operation and maintenance of its hybrid power system and enhance customer service.
49	World Bank	EAP	Vanuatu	L	P150908	Rural Electrification Project	2015	A	2020	4.7	4.7			Electrification of off-grid households, aid posts and community halls, focus on solar PV systems of between 5 to 30 Watts peak capacity that are of "plug-an- play" type, Component Two: Technical assistance and project management, including Vendor and product registration arrangements, communications and microfinance products and Project management and support
50	World Bank	EAP	Vietnam	U	P066396 P073778	System Efficiency Improvement,	2002	C	2013	301.9	2.5			Community-based hybrid renewable energy grids.

Appendix C: World Bank Operations and IFC Projects with Off-Grid Electrification Objectives or Components, FY2000–16

						Equitization and Renewables								
51	IFC	Global	Global	L	7735	IFC GEF Renewable Energy and Energy Efficiency Fund (REEF)	2000	C	2007	30	N.A.			Up to 20–30 percent of the money has also been set aside for smaller, off-grid sector loans (Millioner and Hope 2000). CanceledCanceled in 2007. REEF made only one investment during its first two years of operations, due to challenging market conditions and changes in investor expectations. The private equity fund was closed down in 2003 at the request of the fund's private investors.
52	IFC	Global	Global	L	504446	IFC GEF Environmental Business Finance Program (EBFP)	2004	C	2014	20	N.A.			Absorbed the IFC GEF SME Program as a successor to, and based on, the experiences of the SME Program (IFC 2007).
53	IFC	Global	Global	L	7327	IFC GEF Small and Medium Scale Enterprise Program	1996	C	2007	19.8	2.7			Increase access to finance, build capacity, and increase markets for SMEs active in the areas of climate change mitigation (energy efficiency and renewable energy) and biodiversity conservation through the provision of concessional loan financing. Solar PV projects included Grameen Shakti, Bangladesh; Environmental Enterprise Assistance Fund (EEAF) Soluz Dominicana, Dominican Republic; Soluz Honduras, Honduras; E + Co Rex Investment, Tanzania; Cogener, Tunisia; Selco Vietnam, Vietnam. (Source IFC 2007).
54	IFC	Global	Global (India, Kenya, Morocco)	H	502223	IFC GEF Photovoltaic Market Transformation Initiative	1998	C	2010	30.4	30.4			Accelerate the sustainable commercialization and financial viability of energy services based on solar PV technology in India, Kenya, and Morocco. Selco India, India; Eskom-Shell Solar Home Systems, India; Shri Shakti, India; SREI Infrastructure Finance, Ltd. India; Barclays Bank, Kenya, Kenya; Equity Building Society (EBS) Kenya; Muramati District Tea Growers SACCO, Kenya; Salafin S.A. Morocco; Sunlight Power Maroc, Morocco. (source IFC 2007)
55	IFC	Global	Global	L	N.A.	IFC GEF Solar Development Group (consists of for profit	2001			2.9	2.9			

						private equity fund Solar Development Corporation (SDC) and nonprofit Solar Development Foundation) [6]								
56	World Bank	LAC	Argentina	H	P006043 P045048	Renewable Energy in the Rural Market Project	1999	C	2013	89.3	85.5	Yes	Yes	Electricity Generating Equipment for Rural Markets: (a) SHS (b) small off-grids (with output range of 3 kilowatts to 10 kilowatts each, including photovoltaic, minihydropower plants, small wind turbines, diesel plants or hybrid plants) and (c) some 1,100 RES in provincial public service institutions (schools, medical centers, etc.), solar-powered water pumps and two biomass generation projects; Pilot Wind Home System (WHS);
57	World Bank	LAC	Argentina	H	P133288	Argentina Renewable Energy for Rural Areas Project	2015	A	2021	200	96.1	Yes	Yes	Renewable electricity service provision (US$183.40 million IBRD). (a) the acquisition and installation of stand-alone solar systems, stand-alone wind systems, Pico-photovoltaic (PV) for isolated individual households and public facilities in rural areas (b) the construction and/or upgrade of minigrids ranging 100kilowatts-4megawatt (including minihydro, as applicable) (c) the acquisition and installation of water pumping systems (d) the acquisition and installation of equipment to microenterprises for the development of individual or collective productive uses activities.
58	World Bank	LAC	Bolivia	H	P073367	Decentralized Infrastructure for Rural Transformation	2003	C	2011	21.3	9.6	Yes	Yes	Promulgation of Supreme Decree 28567 and Bolivian norms for SHS, together with Supreme Decree 29365 for Financing mechanisms; Solar PV System Installation and Market Development, SHS in households, schools, and clinics,Productive and Social Uses, 240 users of PV systems for wool shearing, 14 users of PV systems for poultry industry, two users of PV systems for store lighting, Over 100 PV users for powering machine tools,
59	World Bank	LAC	Bolivia	H	P102479	Bolivia Decentralized	2007	C	2013	5.2	5.2		Yes	New Solar Home Systems (SHS) service contracts; Pico-Photo Voltaic Pilot; Transaction Support TA (a) External audits and Output Monitoring and Verification (M&E)

						Electricity For Universal Access								
60	World Bank	LAC	Bolivia	H	P127837	Access and Renewable Energy Project	2014	A	2022	50	16.7		Yes	Electricity services for Unserved Areas: Individual Solar Photovoltaic Systems; Solar Photovoltaic Systems in Public Institutions; Provision of support to Bolivia's strategies on energy access and clean energy through, inter alia: (i) design, installation and evaluation of pilot energy access systems in unserved areas through new technologies, including Pico-PV systems.
61	World Bank	LAC	Haiti	L	P127203	Rebuilding Energy Infrastructure and Access Project	2013	A	2018	90	7.8		Yes	Component 1.2. Improving off-grid electricity access (IDA $ 7.8 million): This sub-component would seek to establish new nonpublic utility Electricité d'Haïti (EDH) connections to electricity services, including off-grid public lights, including SHS, systems for collective uses (street lighting, hospitals and health units, schools, community services, etc) and/or minigrid, and solutions for rapid responses to disasters. Synergies with other World Bank Group -financed operations (for example, Job Creation and Sector Growth Project).
62	World Bank	LAC	Hondura s	H	P086775	Rural Infrastructure Project	2006	A	2016	62.6	7.6		Yes	Off-grid electricity service delivery: Investments in village microgrids using hydro and other renewable energy technologies (50–100kilowatts each); Off-grid MHP technical assistance; Solar Photovoltaic Market Development Program for households, commercial users (retail stores, rural restaurants, microenterprises, etc) and institutional users (schools, clinics, community centers, etc) in dispersed off-grid areas; Local Capacity Building and Policy Development TA; improving access, quality and sustainability of electricity services through the development of off-grid electrification model projects for the rural poor in Honduras, and developing capacities and enabling environment for off-grid electrification in a decentralized setting in Honduras.
63	World Bank	LAC	Mexico	L	P060718	Renewable Energy for Agriculture Project	2000	C	2006	8.9	8.9	Yes	Yes	The project consisted of a set of interrelated and mutually supporting activities which were implemented concurrently: a campaign promoting the use of renewable energy (solar PV, wind and hybrid) by farmers; studies to identify the potential market for renewable energy systems in the agricultural sector; installation and demonstration of renewable energy systems; technical assistance in the maintenance and operation of these systems; establishment of specifications and certification systems; a pilot program to test vendor financing of

														energy systems and components in four states; technical assistance for agricultural extension personnel advising farmers on the proper operation of renewable energy systems;
64	World Bank	LAC	Mexico	U	P088996 P095038	Integrated Energy Services Project	2008	C	2016	23.9	0	Yes	Yes	Focus would be solely on simpler, more reliable photovoltaic (PV) technology in the form of centralized "solar farms (CSF) Farms (about 40–195kilowatts each)", feeding distribution lines to supply electricity to households and the productive and institutional sectors (community services, churches and health posts) (other renewable energy technologies in the original Project, including biomass gasifiers, micro hydropower and micro-wind generators would not be included as they have proved more complex to organize install and maintain, compared to PV technology (The limited capacity provided for individual households in the original plan is considered a major cause of the generally lukewarm social acceptance for the Project)
65	World Bank	LAC	Nicaragua	M	P073246 P075194	Off-grid Rural Electrification Project (PERZA)	2003	C	2012	17.4	8.7	Yes	Yes	Rural Electrification and Renewable Energy Policies and Strategies - A national rural electrification strategy integrates off-grid electrification and the use of renewable energy technologies (RETs); Rural Electrification sub-projects - Off-grid pilot projects (households, schools, clinics, etc.) demonstrate viability and the delivery mechanism for public/private investments; Microfinance services for rural subprojects- Provision of microfinance services by sustainable MFIs is available to increase affordability of off-grid systems for households and hookups and productive plans for micro and small businesses; Business Development Services (BDS) for rural subprojects - support the increase in social and economic benefits of rural electrification;
66	World Bank	LAC	Peru	H	P090116 , P090110	Rural Electrification Project	2006	C	2013	52.6	6.9	Yes	Yes	Investment in Rural Electrification Sub-projects, based on economic analysis and project cost in annexes, estimated SHS financed by IBRD based on the proportional shares of on-grid and off-grid (SHS). Assumed half the cost of Technical Assistance for Rural Electrification because it included the national PV tariff for regulated service with PV systems, prefeasibility studies to assist the development of subprojects using 7,000 PV systems , assumed half the cost of Pilot Program for Promotion of Productive Uses of Electricity (to adopt electricity and use equipment to process rice, cereals, coffee, cocoa, baked goods, meat products, wood and metal products and handicrafts, and to pump water for expanded

														agricultural production and processing. It is estimated that the program has benefited directly more than 100,000 people) and Component 5 Project Management.
67	World Bank	MNA	Yemen	L	P092211	RY-Rural Energy Access Project	2009	A	2017	25	5.9			This component would provide electricity service to off-grid areas based on SHS. The areas of focus will be the fringe areas of the 12 selected service territories that are on-grid extensions and areas outside the service territories in the seven governorates which have been defined as off-grid areas.
68	World Bank	SAR	Bangladesh	M	P071794 P074040	Rural Electrification and Renewable Energy Development Project	2002	C	2013	485	246.3			REB Solar Technical Assistance, IDCOL Technical Assistance, REB Solar Program, C1: IDCOL Renewable Energy Sub-loans, Scale up the renewable energy component; Technical assistance This component aimed to increase technical assistance specifically for a) Quality Assurance of SHS though PV and SHS lab and field testing / inspection, support to Technical Standard Committee for quality improvement, and collection efficiency inspections b) training and consumer outreach and environmental improvement through battery and CFL recycling support
69	World Bank	SAR	Bangladesh	M	P131263 P150001	Rural Electrification and Renewable Energy Development II (RERED II) Project	2013	A	2019	264.4	234.4		Yes	A. Access to Electricity (SHS and Remote Areas Supply System (RASS) for example, solar minigrids about 103 kilowattsp, Solar irrigation water pump with 6.5 kilowattsp solar, 200 kilowatts biomass gasifier/generator system, etc.
70	World Bank	SAR	India	H	P010410	Renewable Resources Development Project	1993	C	2002	185	8.2			PV capacity financed was 2.145 megawattp in 78 projects, slightly below the target of 2.5 megawattp. Products financed ranged from 5 watt peak solar lanterns, 900 watt peak PV irrigation pumps, 500–2500 watt peak solar power packs, and 25 kilowattsp village power schemes to a 200 kilowattsp grid tied system. Included solar PV minigrids in Sagar Islands.
71	IFC	SAR	India	H	25017	IFC Moser Baer India Ltd. (MBIL)	2008		N.A.	22.5	22.5			Moser Baer Photo Voltaic Limited (MBPV), a recently incorporated entity, is setting up an export oriented solar photovoltaic (PV) cell and module manufacturing facility with an installed capacity of 80 megawatt.
72	World Bank	SAR	India	H	P102331	Second Madhya Pradesh District	2009	C	2015	N.A.	N.A.	Yes	Yes	Solar microgrids, mobile stations and lanterns as a solution for the problem of erratic electricity supply in rural areas that affects livelihoods and education, and

						Poverty Initiatives Project							complemented other wide-ranging integrated livelihood development activities in the project.
73	IFC	SAR	India	H	29024	IFC Husk Power Systems	2011		N.A.	0.4	0.4			Husk Power Systems Inc. install and operate 35–100 kilowatts "mini power plants" that delivers electricity as a "pay-for-use" service using a point-to-point system that connects each household or business directly to the HPS power station. HPS sets up these plants in consultation with villagers at no fee to the village and procures rice husk/feedstock at negotiated rates. The firm sets up village-wide distribution systems that wire each household, irrigation station, and commercial enterprise with electricity
74	IFC	SAR	India	H	29501	IFC Applied Solar Technologies	2011		N.A.	21	21			Applied Solar Technologies (AST) is a solar PV based off-grid power solution company that provides off-grid solar power currently to telecom towers which often rely on diesel based generation for 50–100 percent of their power requirements. AST builds and operates these solar installations and takes over the power supply management of each site. It uses a combination of solar PV, battery back-up and diesel generator making it a hybrid energy solution that optimizes the usage of various sources through a controller.
75	World Bank	SAR	India	H	P119894	Scaling up Deployment of Renewable Energy Technology for Promoting Business Models	2011	C	2016	1.1	0.6			Detailed feasibility studies and preparing projects for setting up renewable energy based off-grid electrification under PPP mode. Short-term residential training programs were also organized for State Nodal Agencies (SNA), NGOs, and Entrepreneurs on Model RE based Micro Grid Power Projects in Remote Areas. This TA project has off-grid focus but to be conservative, half of the cost is assumed.
76	World Bank	SAR	Nepal	L	P043311 P116190	Power Development Project	2003	C	2014	115.6	22.1	Yes	Yes	Part B. Micro Hydro Village Electrification Program (MHVEP) with average 20kilowatts per system, including Community Energy Fund for income-generating activities, Grant for power connections for schools and health posts, etc.
77	World Bank	SAR	Nepal	L	P112893	Kabeli Transmission Project	2011	A	2017	38	0.7		Yes	: Rural Enhanced Energy Services Component: Microhydro 250kilowatts of new micro hydro generation capacity to be installed to benefit 2000 households, 300 SHS, Solar PV in 10 school and 5 health posts and Improved cooking fuel Biogas 200 households.

Appendix C: World Bank Operations and IFC Projects with Off-Grid Electrification Objectives or Components, FY2000–16

78	World Bank	SAR	Nepal	H	P131592	SREP-Supported Extended Biogas Project	2015	A	2020	7.9	4			Technical Assistance (a) Identification and Prefeasibility Studies,(b) Detailed Feasibility Studies, (c) Post Construction Third Party Verification, Financing of Investments.
79	World Bank	SAR	Nepal	H	P146344	Grid Solar and Energy Efficiency Project	2015	A	2021	130	N.A.			Distribution System Planning and Loss Reduction Component 2. (d) capacity building for distribution system planning, included development of a geographic information system database with information/data of locations and details regarding the NEA's existing generation, transmission, and distribution facilities; grid-connected customers; potential customers in grid-covered areas; potential demands in areas not covered by national grid; among others, for distribution system planning. The geographic information system database is critical for on- and off-grid rural electrification planning, loss reduction, planning, and distribution system and customer management.
80	World Bank		Philippines		P153268	Access to Sustainable Energy Programme	2016	A	2020	34.9	N.A.			Under ASEP, PV mainstreaming (PVM) entails rural electrification via solar home systems (SHS) of an estimated 40,500 households within the coverage areas of the participating Electric Cooperatives (ECs). Private sector entities will supply and install the systems. Through the contributions of the EU and also the Global Partnership for Output Based Aid, PVM will target ECs seeking to receive grants in the form of a competitively allocated capital subsidy for SHS distribution and installation. Notably, PVM will subsidize only SHS and appliances that are quality-certified by Lighting Global (LG). Three "must-haves" for the SHS kits were identified in order to achieve successful implementation of ASEP: (i) plug-and-play features of the packages delivered; (ii) the use of lithium-ion batteries for powering the kits; and (iii) the use of light-emitting diodes (LEDs) to meet the lighting needs of the targeted households. The Project has now entered its supply chain-building phase, which entails market soundings with interested private sector entities and an in-country Expo to bring suppliers, ECs and other relevant stakeholders together.
81	World Bank	SAR	Sri Lanka	H	P010498	Energy Services Delivery Project	1997	C	2003	28.1	6.4			Estimated with proportional changes in project costs in ICR from PAD, ESD Credit Program Village Hydro, SHS, Business Development and Off-grid support

82	World Bank	SAR	Sri Lanka	H	P076702 P077761	Renewable Energy for Rural Economic Development	2002	C	2012	135.3	25.6			Solar PV Investments, of the 110,575 SHS sold; an estimated 20,000 were repossessed by the PCIs due to defaults by households on their loans and Component 3. Independent Grid Systems 173 community-based micro hydro systems and two community-based biomass electricity systems. The average capacity of the village systems was 10 kilowatts
83	IFC	SAR	Sri Lanka	H	28662	IFC GEF Portfolio Approach to Distributed Generation Opportunity (PADGO) (Phase 1)	2010		N.A	13.1	13.1			The financial mechanism used by the Program is a portfolio risk-sharing facility to encourage local commercial banks to increase their exposure to small-scale renewable energy projects. Under this mechanism, IFC pledges to cover 50 percent losses that may arise from renewable energy loans that are advanced by partner banks. Funds from the GEF are used to provide first loss coverage. (source: IFC http://ifcext.ifc.org/ifcext/spiwebsite1.nsf/651aeb16abd09c1f8525797d006976ba/03fd07b0dd75cfb2852576ba000e2df2?opendocument)

Source: World Bank Group project documents and databases

Appendix D: Off-Grid Electrification: Summaries of World Bank Group Experiences in Selected Countries; and Other Private Sector Efforts

1. **Bolivia**

The World Bank has been supporting off grids electricity access with the solar home system (SHS) and pico-solar photovoltaic (PV) through the Decentralized Infrastructure for Rural Transformation Project (IDTR, P073367, FY2003–11)[28], Decentralized Electricity for Universal Access Project (EDAU, P102479, FY2008–13) and ongoing IDTR2 which was renamed Access and Renewable Energy Project (IDTR2, P127837, FY2014-). The IDTR and EADU achieved the total number of both project' combined installation of SHS and pivo-PV equivalent of about 2.7 percent of rural households in 2012.[29] If the IDTR2 achieves the target number of SHS and pico-photovoltaic installation set at the project appraisal, the total of the IDTR and IDTR2 and EADU's SHS and pico-photovoltaic installation would be an equivalent of 4.5 percent of total rural households in 2012.[30] In Bolivia, 72.5 percent of the rural population had access to electricity, whereas 90.5 percent of the total population and 99.2 percent of the urban population had access to electricity in 2012 (IEA and World Bank 2015).

The IDTR and EDAU used the output-based approach (OBA) with the medium-term service contracts (MSC).[31] However, under IDTR , the upfront payment required for the SHS users was not able to reach to the poorest of the poor and additional financial support was required. The EADU introduced a pilot pico-PV delivery to the very poor population who could not afford to the subsidized SHS and demonstrated the pilot success. Sustainability of the SHS and pico-PV was a challenge in ensuring the long-term after-sales service, maintenance and

[28] The IDTR originally was multisectoal nature including the information and communication technologies (ICT) (i.e., cellular phones) and electrification, but the ICT was mostly dropped due to the procurement issues, and the multisectoral approach including two ministries were complicated (although at the time of preparation, multisectoral projects were being supported by the Bank) (World Bank 2011).
[29] Based on the 2012 data of IEA and World Bank 2015.
[30] Based on the 2012 data of IEA and World Bank 2015.
[31] Under this hybrid approach combining the fee for service approach and the dealer approach, known as Medium Term Service Contracts (MCS), subsidies were provided in return for obligations extending over a number of years to provide service and spare parts.

replacement after the end of the MSC the contracts were found to be too short for the project period to have sufficient maintenance and service period. SHS supply under IDTR was combined with improved cookstoves implemented by another development agency. This collaboration was not designed at the project appraisal, but resulted in improved incentive for households to adopt SHS and cookstoves benefiting women (World Bank 2011b). The IDTR 2 was designed based on the experiences of IDTR1 and EDAU, with much longer project period of seven years than IDTR1 and EADU, which required closing date extensions for 3.5 years and three years, respectively partly due to procurement delay and the learning experience that the contractors would need to be familiar with the local situations.

2. **Cambodia**

World Bank was a major player in supporting Cambodia in grid integration and capacity building of private off-grid rural electricity enterprises (REEs) and solar home systems (SHS) in off-grid rural areas with rural electrification fund (REF) that was introduced by World Bank Cambodia Rural Electrification and Transmission Project (RETP, P064844, FY2004–12). These REEs emerged with their own private funding due to the very limited grid extension after the civil war (1971–75) and the Pol Pot regime (1975–79). RETP's total off-grid connections included 62,093 households, of which 50,000 by REEs and 12,093 SHS. However, since 155 REEs had been connected to the grid by the end of the project in January 2012 (World Bank 2012a), some of these 50,000 households with REEs connections might not be off-grid anymore and grid connected. Around the time that the RETP started, licensed rural consumers were 26,099 or 11 percent of total licensed consumers[32]. Around the closing of the RETP, in 2011, the number of customers in isolated system was 100,832 or 12.4 percent of total licensed customers (EAC 2012), of which 62,093 (62 percent) could be attributed to the RETP. In 2014, this customer number was reduced to 28,475 or 2 percent of total licensed customers, which was much less than RETP's off-grid household connections of total 62,093 (EAC 2015). Therefore, it was not clear if this number include SHS because the RETP has installed 12,093 SHS and the after the RETP, the REF installed another 4,000 SHS in 2014. This meant out of 28,475 household connections in isolated grid areas, 57 percent of households were using SHS. Otherwise, many of the customers of isolated grid moved to on-grid from 2011 to 2014.

REEs' daily service hours rose from four hours at the project appraisal to 12 hours by the project closing, exceeded the RETP target of eight hours with 54 percent of

[32] The 2003 Electricity Authority of Cambodia (EAC) annual report (EAC 2003) did not have a category of isolated system customer, but the rural consumer category appeared to be relevant to isolate system customer.

REEs provided 24 hour service at the project closing (World Bank 2012a). Minigrids system loss was 31 percent in 2003 (rural areas) (EAC 2004), and 19 percent in both 2011 and 2014 (EAC 2012 and 2015). An attractive tariff system by the Electricity Authority of Cambodia (EAC) helped the development of the licensed REE model. However REEs provided rather poor quality service (IED 2013). However, these REEs' services quality has improved and many of them provided power 24 hours daily as of 2014 (EAC 2015).

The original design of SHS delivery mechanism of RETP was OBA subsidy but similar to Bolivia IDTR experience, it was not affordable for the consumers to pay that upfront cash. Therefore, it was changed to use the hire-purchase delivery mechanism based on the World Bank Lao PDR Rural Electrification Project (REP) 1 and 2 and the RETP achieved SHS installation target accordingly. While the REEs needed funding to upgrade the technical standards and revenue management system that were consistent with those of the national grid that REEs could interconnect and get integrated, the RETP's REF did not provide this kind of funding. After the RETP closure, the REF moved on to include additional programs such as guarantee and loan for REEs to improve their infrastructure so that they could upgrade their technical standards and revenue management and improve other aspects of REEs, and a Power to Poor program similar to that supported by the World Bank Lao REP 1 and 2.

As of February 2016, about 56 percent of households had access to electricity (Cambodia Daily 2016). But neither the government-owned Electricité du Cambodge (EDC) nor REEs had funding and capacity to electrify the rest of households to achieve the national target of 70 percent electrification by 2030. Almost all off-grid were diesel based generation and there was no specific government support and enabling environment to promote renewable energy based off grids except SHS. The decision to reduce grid supply tariff rates in 2015 further weakened the green minigrid potential as renewable energy based minigrid could not compete with the prevailing grid supply tariff. The government stopped approval of diesel minigrids due to the increased disparity between the off-grid diesel tariff and the grid supply tariff. Therefore, going forward, in addition to the existing renewable energy policy, more specific legal, regulatory and institutional framework to promote renewable energy would be needed.

3. **China**

The World Bank China Renewable Energy Development Project (REDP) (P046829, FY1999–08) was successful in promoting the rapid growth of a sustainable off-grid PV market in China, which focused on supply side quality and product development with innovative performance- and output-based subsides and grants that were cost shared by the subsidy recipients thereby ensured ownership. The

project could have achieved even higher sales volumes had there not been any market inroads by highly subsidized government and donor PV projects (IEG 2010 and World Bank 2010a). More than 2 million people in western China were provided electricity service through the project. The REDP installed PV capacity of 11.1megawattp, exceeded the target of 10megawatt. The total installed capacity of PV in China was estimated to be 80megawattp at that time. Although the PV systems could have turned over during the project years (that is, some users abandoned or by new SHS, etc.), The REDP contributed an equivalent of 13.8 percent of the PV installed in China. The REDP provided some technical assistance (TA) for the Chinese government's renewable energy based off-grid electrification programs, such as Brightness Program, etc. The Golden Sun Program was started under the REDP and it supported the adoption of the Photovoltaic Global Approval Program (PVGAP) program in China and its implementation. The REDP's Golden Sun Quality Mark was awarded to qualifying products and it continued beyond the REDP until the market for off-grid solar declined due to market saturation. The importance of solar quality and setting up quality standards and testing protocols was initiated through the REDP. The REDP PV specifications for off-grid PV components were eventually adopted as their national standards. Beneficiary surveys of REDP PV users in selected provinces were positive in general but energy stacking remained as they continues to use other fuels (for example, kerosene, candle, ghee light and dry cells) as well as solar home system.

However, the REDP was not the only one that led to the leadership position that China had in large-scale PV as of 2016.[33] For example, some financing was available even without the REDP support. At the mid term of the REDP implantation, technology improvement (TI) companies under the REDP invested at least $187 million (from their own resources or bank loans), which was over 12 times the amount originally targeted by the REDP to finance (World Bank 2009). The PV companies also succeeded in accessing private financing to support sales growth and investments. After improvements in management, business skills and financial systems, some companies received access to commercial bank credits and financial support of other institutions. However, consumer financing remained difficult, which was out of the scope of the REDP. While the overall Chinese both off- and on-grid electrification was very successful, some studies on the government's off-grid electrification programs in western China found that the general top-down approach lacked attention to users' needs, quality of services, operation and maintenance, which would affect the sustainability (Zhang and Kumar 2011, Shyu 2013 and Niez 2010).

[33] This paragraph was based on emails by a former Bank staff Anil Cabraal.

4. India

The major World Bank Group's support to off grids in India were Renewable Energy Resources Development Project (P010410, FY1993–01); Second Madhya Pradesh District Poverty Initiatives Project (P102331, MDPDPI2, FY2009–15), and International Finance Corporation's support to Husk Power Systems (HPS) which is a microgrids company and a solar company Moser Baer India Ltd. (MBIL) (2007), IFC/GEF Photovoltaic Market Transformation Initiative (PVMTI) (1998–2010) supported solar companies Selco India, Eskom-Shell Solar Home Systems, Shri Shakti, SREI Infrastructure Finance, Ltd, Total and others, and Applied Solar Technologies. There was also a technical assistance (TA) for Scaling up Deployment of Renewable Energy Technology for Promoting Business Models (P119894, FY2011–16). Integrated Coastal Zone Management Project (P097985, FY2010-) does not promote off-grid but extends main grid to off-grid areas in Sagar Islands, where Renewable Energy Resources Development Project financed off-grid solar PV village electrification. Decentralized Energy Systems, India (DESI Power) won a grant the World Bank Global Development Marketplace Competition 2006[34].

The Renewable Energy Resources Development Project's examples of off-grid sub projects were Solar Lantern Leasing Program by a Savings Cooperatives, Sagar Island Solar PV Village Electrification, and Solar PV Irrigation Pumps Leasing (World Bank 2002a). At the completion of the project, all these off grids sub components had positive economic internal rate of return (EIRR) and financial internal rate of return (FIRR) except the isolated solar PV power station in village, which was negative EIRR unless the global environmental benefits were included.

The Renewable Energy Resources Development Project contributed to the development of renewable energy both on-grid and off-grid and capacity building of IREDA. Commercial market development in solar PV was evidenced by : (i) the large private sector-led manufacturing base; (ii) a competitive market where product costs were among the lowest in the world; (iii) retail sales and service networks; and (iv) emerging participation of financial intermediaries. IREDA became a mature financing institution for renewable energy and energy efficiency. IREDA encouraged other lenders to support renewable energy projects, including bank and nonbank institutions -- in 1993, there was no funding for this type of project. The government has changed its approach to renewable energy development from state - administered to market-driven. India started to export wind and PV technology. International joint ventures were fostered by the project requirement for competition in procurement. Marketing and service delivery business models that IREDA helped

[34] Source: DESI Power website: http://www.desipower.com/downloads/2015/DESI-Power-Company-Profile.pdf

launch included renewable energy service companies; consumer retails of renewable energy products and services; private power developers selling to captive consumers, third parties and to State Electricity Boards (SEBs); consumer financing by rural banks, saving and trading cooperatives, etc. The project helped identify innovative approaches to addressing rural credit risks faced by PV energy entrepreneurs thus opening avenues for renewable energy supply to penetrate the rural market. Participation of cooperatives or micro/rural financing entities was a key to making the systems accessible to rural/poor consumers (World Bank 2002a and 2002b).

IREDA promoted businesses owned by women and scheduled tribes and castes as evidenced by several women-owned businesses (for example, Dastkar Society for Crafts and Craftpeople (Gujarat), solar lantern leasing by self-help groups (Andhra Pradesh), Sagar Solar Shop (Vadodara), and Prakritik Lighting & Urja Systems Ltd., perhaps the first woman-owned PV module manufacturer) (World Bank 2002a).

The off-grid experience of this Renewable Energy Resources Development Project found the following (World Bank 2002a and 2002b). Adequate time was requried to develop innovative projects and the market for renewable energy. A specialized financial institution such as IREDA was essential at the beginning as new technologies were commercialized, but for market growth, broader participation by the financial sector was essential. Affordable financing accessible to rural consumers was essential for selling PV products in rural areas. Delivering rural PV services needed a partnership between key actors: rural financing institutions, product/service suppliers and organized consumer groups. Assessment of land acquisition as well as payment of compensation needed be completed prior to commencement of civil works to avoid delays in project implementation. The renewable energy program needed to be consistent with and embedded into the plan for power sector reform and restructuring. Supportive and predictable policies and regulatory framework were essential for market development. Tariffs and power sales rules needed to be fair to all parties for sustainable development of the sector. Careful attention needed to be paid to maximizing energy output rather than installed capacity. Regular review and rationalization of subsidy policy was necessary (World Bank 2002b).

The PVMTI added value to the emerging Indian PV market through incubating innovative firms and business models. As an example, PVMTI directly supported a start-up entrepreneur through an investment in SREI, a nonbank financial intermediary to address two key issues facing the Indian solar PV industry, namely, the lack of after-sales services and maintenance activities, and the lack of rural credit mechanisms. SREI became one of the world's largest rural electrification entrepreneurs as of 2010. The entrepreneur, Enviro Energy India Ltd. (EEIL),

received support from SREI to establish to establish a PV installation and service business, eventually acquiring Shell Renewables India when it divested from rural electrification projects in India and Sri Lanka. From the original hub in West Bengal, EEIL expanded operations to Karnataka, Bihar, Jharkand and Orissa. As of 2010, the business installed and serviced approximately 45,000 SHS (IFC 2010). Its experience highlights the need for patience, particularly in a challenging solar PV market (IFC 2007). Selco, the first PV rural electricity installation and service provider in India, was also supported by the PVMTI. With its focus on poorer segments of society and quasi-commercial approach, Selco initially experienced many challenges relating primarily to shortage of working capital, fluctuating market and PV equipment supply constraints. The PVMTI helped the company through this tough phase by restructuring and partially writing down the PVMTI loan and helped sort out bigger corporate issues. The business attracted new equity to support its future business growth of 2010.

The modest success of the PVMTI in India came from firms that had a preexisting PV/renewable energy business dedicated to this line of business or one that creates such a line rather than financial or other institutions who might have been offered incentives to introduce PV financing or systems as a product or service (IFC 2010). This success could be attributed, in large part, to the high population density in off-grid areas, the existence of established solar PV companies, and the relatively widespread knowledge about solar PV technology (IFC 2007).

Solar energy was one solution for the problem of erratic electricity supply in rural areas that affected livelihood and education. The MPDPIP2 promoted the use of solar energy for meeting household electricity needs through microgrids and multi-utility centers in 81 and 42 villages respectively. Solar lanterns and solar mobile stations were initiated in project districts. Solar lanterns were being used in 249 villages. (World Bank 2015g). A common solar charging station was developed and a community member was trained to recharge the solar lamps provided to villagers.[35]

IFC provided financing and advisoryadvisory support to HPS, that quickly scaled up to serve 30,000 households, or about 200,000 people in four years with innovative business model. Some highlights of HPS and DESI Power were discussed in the sub-section 10. The microgrid and minigrid experiences in the private sector (with or without any involvement of the World Bank Group) at the end of this appendix C). Despite the policy support especially the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) since 2014, the off-grid electrification, the coordination between off grids

[35] An email from Raman Wadhwa Dy. Commissioner,(RD) Dy. CEO MPSRLM , Bhopal on April 14, 2016.

and on grids process and the enabling environment for the private sector, are still much to be improved. The inconsistent subsidy systems between the on-grid and off-grid, which unfairly lower the on-grid electricity tariff with lower quality and reliability, distort the market and consumer choice.

5. Lao People's Democratic Republic

The World Bank played a major role in supporting the Lao government to promote off-grid, especially SHS under the public-private partnership (PPP) and developing and ensuring regular updates of the rural electrification master plan to include both off-grid and on-grid. As of December 2013, 87 percent of the total households were electrified in Lao PDR (Pillai, 2014). Out of these electrified households, about 2 percent or 18,872 households were electrified by renewable energy based / hybrid off-grid systems, of which 13,000 were SHSs (Pillai, 2014). The World Bank installed total 22,763 SHSs[36] excluding the withdrawn SHSs under the World Bank Lao PDR Southern Provinces Rural Electrification Project (SPRE) (P044973, FY1998–05), Rural Electrification Phase I Project (REP1) of the Rural Electrification (APL) Program (P075531, P080054, P119715, FY2006–12) and REP2 APL (P110978, P117177, FY2010–15). Since some of these SHSs might have already been out of use, the estimated total 13,000 SHSs in Lao PDR in 2014 does not match the three projects' contribution of total 22,763 SHSs. The projects' support to rural electrification master plan and updates of the plan, which included both on-grid and off-grid had limited impacts because actual electrification did not necessary follow the plan and some local authorities were not aware of or followed the plan, which resulted in uncoordinated off-grid and on-grid electrification that expanded more rapidly than expected. Cream skimming and principal agent problems were experienced with the SHS contractor Provincial Energy Service Companies (PESCOs). Going forward, following would be needed: (i) improved incentives to PESCOs to target only poor and other vulnerable people where the grid would not reach for the next 10 years or so and improve the after-sales services and availability of spare and replacement parts, (ii) buyback of withdrawal of reusable SHSs only; (iii) coordinated efforts with other private players such as Sunlabob and other development partners to ensure level playing fields and complementarity; (iv) improved sustainability of REF, (v)

[36] The Implementation Completion and Result Report (ICR) of REP1 noted that 5,000 SHS purchased with Australian Government's cofinancing under REP1 were being installed under REP2 (World Bank 2013). REP2 ICR reported that the total number of SHSs to 11,758 but considering the funding from the Australian Agency for International Development for 5,000 SHSs from REP I, the effective prorated target achievement for IDA and local contributions was 9,601 units or 96 percent (World Bank 2015). Hence, this reports included 11,758 SHS for REP2 since neither REP1 nor REP2 reported the SHS co-financed by Australia.

ensuriing the regular updates of rural electrification master plan and the central and local authorities follow the updates in planning and implementing off-grid and on-grid access and (vi) development or improvement of the favorable policy, legal, regulatory and institutional framework for off-grid promotion. These World Bank projects hire-purchase scheme for SHS and Power to People scheme for grid electrification were both adapted in the World Bank Rural Electrification and Transmission Project in Cambodia.

6. Nepal

The World Bank Nepal Power Development Project (PDP) (P043311, P116190, FY2003–14) was successful in Micro-Hydro Village Electrification (MHVE) that 66,174 households had electricity access under MHVE, slightly less the final revised target of 74,000 but exceeded the original target of 30,000 (World Bank 2003a and 2014b). This meant within the total of about 1 million households with off-grid access as of 2015, seven (7) percent of these households with off-grid access would be the equivalent number of households under MHVE (World Bank 2003a, 2014b and 2015; Government of Nepal 2012). The project's restructurings and additional financing allowed MHVE to scale up. This scaling up was not only due to the successful implementation of MHVE itself, but also the PDP's largest component Power Development Fund (PDF) to provide long-term financing for private sector small and medium-sized hydropower developments was scaled down and eventually canceledcanceled. This was because (i) the long lead time was needed for the PDP to facilitate private sector led development of Nepal's hydropower potential, (ii) the Kabeli-A hydropower plant, which was originally envisaged as the first private sector small hydropower project financed by the PDF was supported by the World Bank as a stand-alone intervention (World Bank 2008 and 2012), and (iii) the political unrest -Maoist insurgency attacked large size commercial hydro projects suitable for PDF and not microhydro suitable for MHVE (Sovacool et al. 2011).

MHVE's success factors included (i) community involvement, (ii) capacity building, (iii) special attention to women, (iii) income generation activities, (iii) simple technology, (iv) de-politicization, (v) maintenance and after-sales service and (vi) flexibility. Community-based microhydro projects required lots of capacity building, as estimated MHVE's 56 percent was spent on capacity development and institutional strengthening, only 44 percent was spent on hardware (Sovacool et al. 2011).

However, communities did not fully use available electricity and used only for lighting and energy stacking continued even for lighting by using kerosene, candle, etc. and their priorities were not electricity. Social culture could exacerbate

inequalities, with in some cases those contributing labor during construction not given access or an electricity connection (Sovacool et al. 2011).
Still market penetration is likely to be difficult in these areas due to low industrial activity. The power plants located in remote locations in Nepal run at low plant factor because of low demand for productive end uses. Lack of transport infrastructure is one of the reasons why productive end uses are not so well developed (Mainali and Silveira 2011; Sovacool et al. 2011; Rao, Agarwal, and Wood 2016).

Limited people were available for maintenance, after services and delivery of the units, resulted in a large back log. MHVE suffered financially with no cost recovery, uneven and unequal tariff, no meters, nonpayment, noncollections, etc. There was a problem of donor dependency and lack of domestic financing, different donor priorities – competition with other alternative energies such as solar, biogas, etc. (Sovacool et al. 2011).

While Nepal achieved remarkable progress in off-grid electrification, coordination with grid extension needs to be enhanced through planning future rural electrification to avoid stranded off-grid assets when the grid is extended to the off-grid areas (World Bank 2015a and 2015b). Energy crisis as a major constraint to growth. The lack of grid-supplied electricity is a major barrier for Nepal to expand access to quality electricity services, improve living standards, raise agriculture productivity and incomes, and help its youth transit from farming to nonfarm employment (World Bank 2015a and 2015b).

Subsidy policy 2000 promoted more installation of SHS and micro hydro. The community contribution also increased. But there was a lack of credit and those very few financial institutions that finance renewable energy suffered from bad debt and nonperforming assets. Subsidy was also not efficient and effective due to high transaction costs and did not really meet the needs. SHS was rather for the better off people (Mainali and Silveira. 2011).

7. Tanzania

Tanzania Energy Development and Access Expansion Project (TEDAP) (P101645, P092154, FY2008-) is one of the World Bank's flagship projects in Tanzania and included support to the first attempt in Tanzania for a larger-scale off-grid electrification program, mobilizing and leveraging private sector resources and promoting small-scale power projects. TEDAP scaled up its support to small power producer component which included both off grids and on-grid with additional financing in 2010. With combinations of its support to simplified regulations for small power producers (SPPs), cost-sharing grants, credit lines (CL) and technical

assistance, the TEDAP promoted SPPs provide power to the isolated grid and main grids of Tanzania Electric Supply Company (TANESCO) and Rural Electrification Agency's capacity has also improved. Sustainable Solar Market Packages (SSMP) was also a part of the World Bank/International Finance Corporation (IFC) Lighting Africa Initiative (World Bank 2007). However, cream skimming and principal agent problems were experienced due to the apparent lack of interest by the contractor on the households solar PV sales as the potential profits for the base load business of public facilities PV was sufficient. The contractor was qualified for the task of designing and installing relatively large-scale PV systems (the project developer or builder type) but had little competence or experience in the business of marketing SHS (the vendor type). Unlike in the World Bank Philippines Rural Power Project (RPP) (P066397, P113159, P072096, FY2004–13), the contractor did not partner with established vendors. The products were unaffordable on cash-only basis to majority of households. The contractor initially presented a consumer financing plan for their products that would enable payments over time but never implemented it. Also, the matching grant program allowed some of the inexperienced developers to initiate the projects that have never been completed to the required standards to move ahead to financial close.

The Bank is preparing a follow up project entitled Tanzania Rural Electrification Expansion Project under the Program for Results (PforR) operation. In the off-grid subsector, among the donor communities, the World Bank plays a leading role in helping the Rural Energy Agency (REA) support private sector initiatives along with support from Swedish International Development Cooperation Agency (Sida) and UK Department for International Development (DfID). The proposed PforR will provide funding through a window in an existing CL developed under TEDAP for the SPP development. A new, second window under the CL will be directed at providing financing to vendors for the delivery of quality-certified solar products to consumers in rural areas. A Payment Security Mechanism (PSM) will be set up to ensure that the SPPs in operation and the ones expected to sign SPPAs with TANESCO are paid on time (World Bank 2016a). IFC launched a $5 million program to increase access to energy in Tanzania by developing a market for minigrids in October 2015 (IFC 2015).

8. Timor-Leste

The World Bank Timor Leste Gas Seep Harvesting Project (GSHP) (P092055, FY2007–12) was to demonstrate the technical and economic viability of harvesting seep gas from natural gas seeps to produce reliable and affordable power for isolated rural communities in the southeastern part of Timor-Leste. Replication potential of demonstration project was perceived high as at least 30 gas seeps spread throughout the country. However, during the implementation, the gas test revealed an inadequate quantity of gas, which led to the project's closure. The project

preparation did not have sufficient funding to conduct comprehensive feasibility study and took a risk as this was a pilot. Even before this reveal, the government ownership and interest in this project was declined due to the power development and grid expansion as well as problems of conflict of jurisdiction between ministries and state secretaries.

This GSHP demonstrated that even with a pilot project, technical risk and cost estimates needed to be properly assessed and even if the probability of risk was low, the magnitude of impacts if the risk materialized needed to be examined and decision needed to be made accordingly. In pilots without lessons learned for a specific type of project like this GSHP, lessons learned and the risk mitigation measures should have been rigorously sought from the relevant industry. Otherwise, there would be a waste of public resources of tax payers' money of donor countries. Establishing and maintaining effective communications with the client country was extremely important to ensure (i) timely decision to change the course of project when the client made a decision to expand the grids to the isolated areas and (ii) justification of the donor finance. The GSHP was justified given the (underestimated) low cost of pilot project and the cost to the rural poor without sufficient electricity services was overwhelming. In fact, the GSHP was high risk and high cost and some of the project deigns were premature, although the GSHP was well intended to support the country.

9. Mali

The World Bank Mali Household Energy and Universal Access Project (HEUAP) (P073036, P076440, FY2004–12)promoted isolated minigrids at the project closing on June 30, 2012 with a cumulative number of about 74,787 connections exceeding the target of 68,896 connections. As a result, Mali was perceived to the most successful in promoting minigrids in Africa (RECP/EUEI PDF 2014). The Agency for the Development of Domestic Energy and Rural Electrification (AMADER) is the central authority for rural electrification. AMADER has incorporated a variety of regulatory and policy reforms and measures, concessions and capital cost grants to support successful deployment of over 160 stand-alone minigrids (70,000–80,000 customers), serving an average of 500 connections each —perhaps the most of any Sub-Saharan African country (Rai et al. 2015). In the early 2000s, a market for minigrids did not yet exist in Mali (Rai et al. 2015). Mali's Energy Sector Organization Law in 2000 set the stage for minigrid market by: allowing private operators to supply electricity; launching a rural electrification program; and eliminating the nationwide monopoly of (Énergie de Mali (EDM) (Rai et al. 2015).

AMADER works with local governments and companies to submit proposals for minigrids concessions and manage Rural Electrification Fund established in 2005

under HEUAP. The country has a coordinated program of support across Mali agencies with World Bank and KfW, the World Bank projects included HEUAP and Mali Rural Electrification Hybrid System Project (FY2014-; P131084) which has been promoting a renewable-diesel hybrid minigrids (World Bank 2003c, 2013h, 2013i). The primary driver behind the creation of AMADER was the World Bank, which, based on its experience in other countries, recognized that creating a so-called one stop government agency to regulate and grant funds to the rural electrification sector was a "cleaner" and "easier to implement" approach than "assigning regulatory responsibilities over isolated minigrids to the national electricity regulator" (Tenenbaum et al. 2014).

HEUAP emphasized the cost recovery of operation and maintenance of minigrid, Information, Education, and Communication (IEC) and helped strengthen technical and managerial capacity building (World Bank 2003c and 2013i). The Mali government has taken both a top-down and a bottom-up approach (bidirectional approach) to encouraging private developers to build minigrids by providing two separate routes to approval. Although the government has designated clear areas for concessions, nearly all the developers chose the route of submitting unsolicited proposals as that provided fewer administrative burdens than competitive concessions. The program has been successful in attracting a wide range of minigrid developments and providing increased energy services. The simplified institutional framework, given full authority to AMADER, attracted the private sector interests (Rai et al. 2015). Malian society is very entrepreneurial. The success of the bottom-up approach was due to local private entrepreneurs' interests in rural minigrids and the local market (World Bank 2014). The decentralization of decision-making, financial resources, and budgetary autonomy to local authorities changed the mind-set from one of waiting for national-level action to one of stimulating local-level initiatives (World Bank 2003c).

However, the electricity tariff in minigrids for households is higher than the tariff for grid-connected customers, which caused "tariff envy," leading to the rapid extension of the national grid to seven minigrids sites located close to the national utility's concession area (Tenenbaum et al., 2014).

Mali's privately run minigrid case highlights (i) Opening multiple avenues to solicit projects from minigrid developers can jumpstart private investment; (ii) Partial capital cost grants can support financial viability and sustainability of minigrid projects; (iii) Designating a "one stop" agency to regulate and provide minigrid grants can increase efficiency and make private sector engagement more attractive; (iv) Allowing minigrid developers to set their own tariffs can support minigrid deployment; and (v) Including support for hybridization of diesel-powered minigrids can reduce their operating costs and thus lower their tariffs, which has

been supported by Mali Rural Electrification Hybrid System Project (FY2014-; P131084).

Mali's approach of allowing minigrid developers to set their own tariffs has enabled the creative use of technology through several business models. For example, 'Shared Solar' has developed a pay-as-you-go model that allows customers to purchase small amounts of electricity "on demand" by purchasing scratch cards from local vendors and sending a text message with a single-use code to the network operator. These minigrids have led to new local small businesses, a new local radio station, and improved hospital services in some of the pilot villages (Harper 2013). Columbia University's Earth Institute has constructed a series of minigrids that deploy prepaid meters and "smart controls" that limit overuse at the customer and minigrid level to ensure a stable supply (CEM 2013).

Under HEUAP's SHS promotion, private operators were not interested in adopting as much as expected solar technologies and beneficiaries also wanted multiple uses of energy services that were difficult to be provided by solar home systems. Hence some of the allocated funding for SHS was canceledcanceled. Instead, this HEUAP had a greater success in minigrids, which contributed to Mali to be most successful in minigrids in Africa (World Bank. 2013i; RECP/EUEI PDF. 2014; Rai et al 2015)

HEUAP also supported multifunctional platforms, composed of a small 10 kilowatts diesel engine coupled to a generator, that could be connected to income-generating equipment, such as cereal grinding mills, battery charger, de-huskers, and water pumps, or to generates electricity that can be distributed through a microgrid to households (World Bank 2013i; Sovacool et al. 2013). A multifunctional platform is installed in 81 communities, just shy of the target of 86 communities, covering approximately 4,700 users. Women's associations played an important role in remote communities as providers of energy services (World Bank 2013i). The communal model for managing the platforms, with active involvement of women's associations was not found workable, and the management of 61 platforms was transferred to the private sector (World Bank 2013i).

10. Microgrid and minigrid experiences in the private sector and communities (with or without any involvement of the World Bank Group)

Following examples of Indian private biomass minigrids IFC-financed HPS and a World Bank Group grant recipient Decentralized Energy Systems (DESI Power) and non-World Bank Group supported solar minigrids Gham Power, illustrate the private sector's strong focus on performance and financial viability.

The private sector is serious in market development, for example, by employing market development specialist, and in payment collection, for example, by sending a tariff collector daily. They are very strenuous in reducing theft but even with the use of modern technology, theft and overuse are very difficult to capture and person-to-person detection is still needed, a similar experience in Haiti by EarthPark International, active in minigrid with smart prepaid meter, which still requires a person to tackle theft (EarthPark International 2015). To scaling up minigrid business, HPS uses franchising, which also could help the franchised agencies get financing given the established brand (Bhattacharyya 2014 and Schnitzer et al 2014).

The private sector strives for using the resource efficiently. In some cases, the biomass minigrid operator integrated the rice mill business to ensure business viability and to internalize the symbiotic relationship with the power plant. Further, the char obtained from burning the husk is used for incense stick making by women, thereby monetizing the waste. Silica precipitation is sold for mixing with cement (Bhattacharyya 2014). To meet investor expectations on the level of return on a project, Gham Power has expanded its product offering more than just selling electricity, selling basic services needed in that community, such as rice milling, a dairy chilling center and telemedicine. Gham Power put an Internet connection on all our systems for remote monitoring. Gham Power's role often shifts into business incubation where their staff is going to the community and sitting down with community leaders, and asking things that have nothing to do with solar (IRENA 2015).

They employ women operators and conducting women empowerment and business development activities to complement the arrival of electricity. They develop income-generating activities, which requires significant time and resources as an example of DESI Power giving loans to existing industries to convert their diesel engine-driven loads to motor-driven loads, and employing a staff position that is dedicated to assisting commercial customers to develop businesses and increase electrical load. In most areas, however, especially village markets, electricity is not necessarily linked in the minds of villagers to productive activities – just lighting (Bhattacharyya 2014 and Schnitzer et al 2014).

Many private minigrid operators are still partially dependent on some form of subsidy or grant, yet cannot serve the poorest of the poor for them to be commercially viable.

Both public and private sector experience in minigrids in many countries (for example, India, Sri Lanka, Malaysia, Mali, Kenya, China, etc.) showed that the community involvement was important but could interfere commercial practices, independent regulation, and transparency due to adverse politicization, social network, etc. (Schnitzer, et al. 2014; Ulsrud et al. 2011; Yadoo 2012; World Bank

2014a). A case study in Orissa in India found villagers did not want to dedicate the time needed to collectively maintain the system that could never facilitate power for income-generating activities (Schnitzer et al 2014).

In some cases, community-based minigrids were able to finance most of the working capital. Non-Bank Mpeketoni Electricity Project (MEP), a community-based diesel-powered microgrid system in rural Kenya during 1994–2007 demonstrated the potential to cover a substantial proportion of the operating costs from internal revenue derived from sales of electricity and other charges and a grain mill as an income-generating activity to cover the operating deficit. At the time of the Kenya Power and Lighting Company (KPLC) takeover of the microgrid in September 2007, MEP had attained 94 percent cost recovery, nearly five times that realized by the diesel-powered microgrids operated by the KPLC, the national utility. Through the Rural Electrification Program (REP), KPLC installed a new and larger (250 megawatt) diesel-distributed generation system to supply power to Mpeketoni and surrounding villages. Aside from receiving a 24-hour/ day power supply, the government's takeover resulted in considerable consumer surplus. This was because, under REP, Mpeketoni customers obtained service at a highly cross-subsidized rate of Ksh8/kilowattsh (US$0.11/kilowattsh) compared to Ksh37/kilowattsh (US$0.53/kilowattsh), the rate MEP customers were willing to pay at the time of the takeover. Conversely, this arrangement yielded a negative producer surplus because the cost of diesel-powered supply by the KPLC (Ksh39/kilowattsh or US$0.56) (Kirubi et al. 2007), which reduced the scarce public funds and sustainability. Despite the extremely unreliable electricity supply, the use of electric equipment by small and micro enterprises resulted in significant improvement in productivity per worker ranging 100–200 percent depending on the task and in a corresponding growth in income levels in the order of 20–70 percent, depending on the product made. Access to electricity enabled and improved the delivery of social and business services. It demonstrated that when local electricity users had an ability to charge and enforce cost-reflective tariffs and when electricity consumption was closely linked to productive uses that generate incomes, cost recovery could be feasible (Kirubi et al. 2007).

In non-World Bank community-owned minigrids in Indonesian Borneo, three NGOs with complementary roles collaborated to develop renewable energy minigrid projects. Two international NGOs helped channel the financing for installing the minigrids and offered technical expertise and community organizing skills. The third NGO, a community association, focused on training people in the skills to maintain the systems. After one year of operation, the NGOs handed over ownership to the community. A village-level committee was then created to operate and regulate the minigrid. The tariffs, decided by the community, were directed toward a fund for operations and maintenance. Because these minigrids were not

registered with the government, the only source of funding for repairs was what the community pays in tariffs. When repair costs were too high, repairs were not made (IRENA 2015). This issue was a common issue elsewhere, such as Malaysia (Schnitzer et al. 2014)

Community PV systems in two primary schools and three health posts in rural areas under the non-World Bank Malawi Community Rural Electrification and Development (CRED) 2008–2011, in Chikwawa district in Malawi also demonstrated its ability to cover working capital by providing mobile phone charging and cold drink sales to communities as their supplementary income generation activities. Selected and trained community energy committee encouraged community access, regular maintenance, security, income generation and a logbook record of all activities. A local fieldworker was hired and trained to support the energy committees with further technical support in the main town (Frame et al. 2011). Frame et al (2011) who examined the systems operations for the first 18 months, noted that technically the systems trouble free expect one faulty charge controller, which the energy committee reported to the fieldworker who in turn contacted the supplier to replace this item, financed by the revenue generated by the committee via the system. Funding of systems operations supported from income generation activities on mobile phone charging and cold drink sales and well accounted maintenance funds growing, income generation on track to allow battery replacement for after four years. This project gained institutional support for the community energy approach from the health and education authorities, and local government's formal support to the energy committee activities (Frame et al. 2011).

Appendix E: References for Appendix D

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