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SYNTHESIS REPORT

DECENTRALIZED ENERGY PORTFOLIO REVIEW

NOVEMBER 2016

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Cover Photos

Top left: Belo Horizonte, Brazil: Enalter, a Brazilian commercial firm, received a loan backed by a USAID credit guarantee in 2007 to expand its operations in the solar water heating market. Since then it has steadily increased its services to low-income households through partnerships with national and state actors in Brazil. Photo by: Andrea Marques.

Top right: Pará State, Brazil: Young residents of Cachoeira do Aruã, a remote community in Brazil's Amazonian north that received USAID support to install a micro-hydro system that has served the community since 2007. Photo by: Andrea Marques.

Middle left: Tanzania: Inside a household solar system's battery charging cabinet. Photo by: Ryan Thomas.

Center: Adhouli Village, Uttar Pradesh, India: An entrepreneur and her husband pose in front of their solar lantern charging station. As part of Humana People to People-India's USAID supported efforts, entrepreneurs in western Uttar Pradesh run approximately 100 lantern rental businesses providing basic lighting services for rural communities. Photo by: Sam Hargadine.

Middle right: Narrow Village, Uttar Pradesh, India: Rooftop solar panels used to power a lantern charging hub; part of Humana People to People-India's activities. Photo by: Sam Hargadine.

Far left: Pará State, Brazil: View from the Aruã River, host to a number of off grid communities in northern Brazil. Photo by: Andrea Marques.

Bottom: Belo Horizonte, Brazil: Enalter's roof-top solar powered water heating unit supported by a USAID credit guarantee. Photo by: Andreia Marques.

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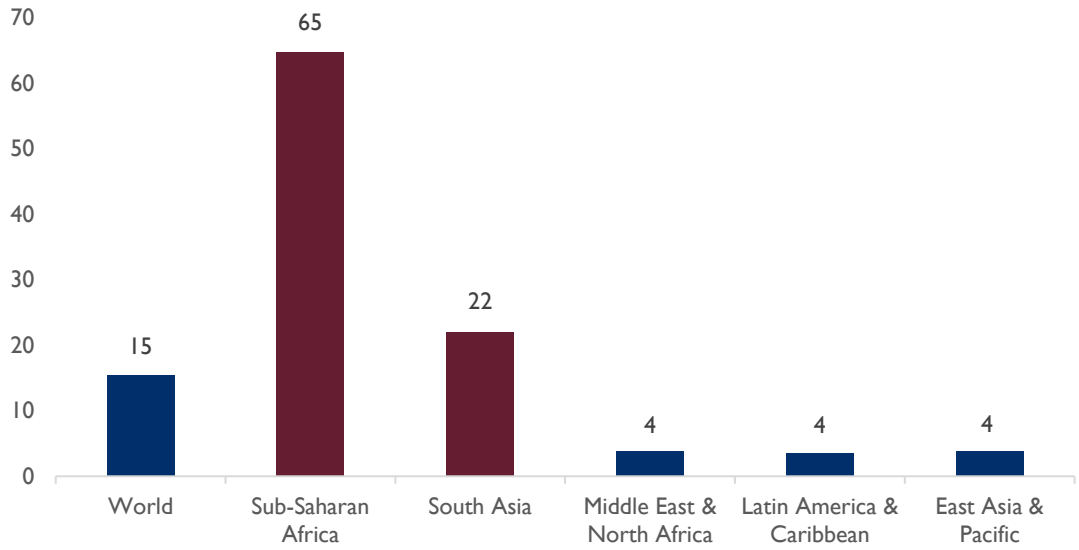
PREFACE

When global leaders met in 2015 to formally adopt the Sustainable Development Goals, universal access to modern energy services was presented as an essential component not just to improving the welfare of the poor, but necessary to meet vital global climate change, food security, and health targets. That this ambitious goal is within reach is predicated on a litany of recent advancements in off-grid energy technologies and financing models. This report examines a range of these innovations through the lens of decentralized energy investments made by the United States Agency for International Development (USAID). The goal of this report is to look realistically at when, where, and in what contexts decentralized energy solutions are most sustainable and scalable.

"Sustainable energy is opportunity – it transforms lives, economies and the planet." – Sustainable Development Goal 7: Ensure Access to Affordable, Reliable, Sustainable, and Modern Energy for All.

Featured prominently in this report are innovative grant and loan mechanisms that support small and medium sized enterprises well poised to scale energy solutions across large parts of the globe. Areas unlikely to receive service by national grid systems typically include remote communities, but decentralized solutions can also play a complementary role to the main-grid in urban settings where grid-capacity does not yet meet basic needs. As seen in Figure 1, energy poverty is especially prevalent in Sub-Saharan Africa and parts of South Asia. Further, extending access to the estimated 1.1 billion people world-wide that lack access to electricity[1] is a challenge that will require scalable public and private investments to sustainably finance and implement energy sector expansion, as well as reconstruction in post-conflict and post-disaster contexts.

Figure 1: Percent of Population without Access to Electricity



Source: World Development Indicators, 2012 base year.

[1] World Development Indicators. 2012 estimate.

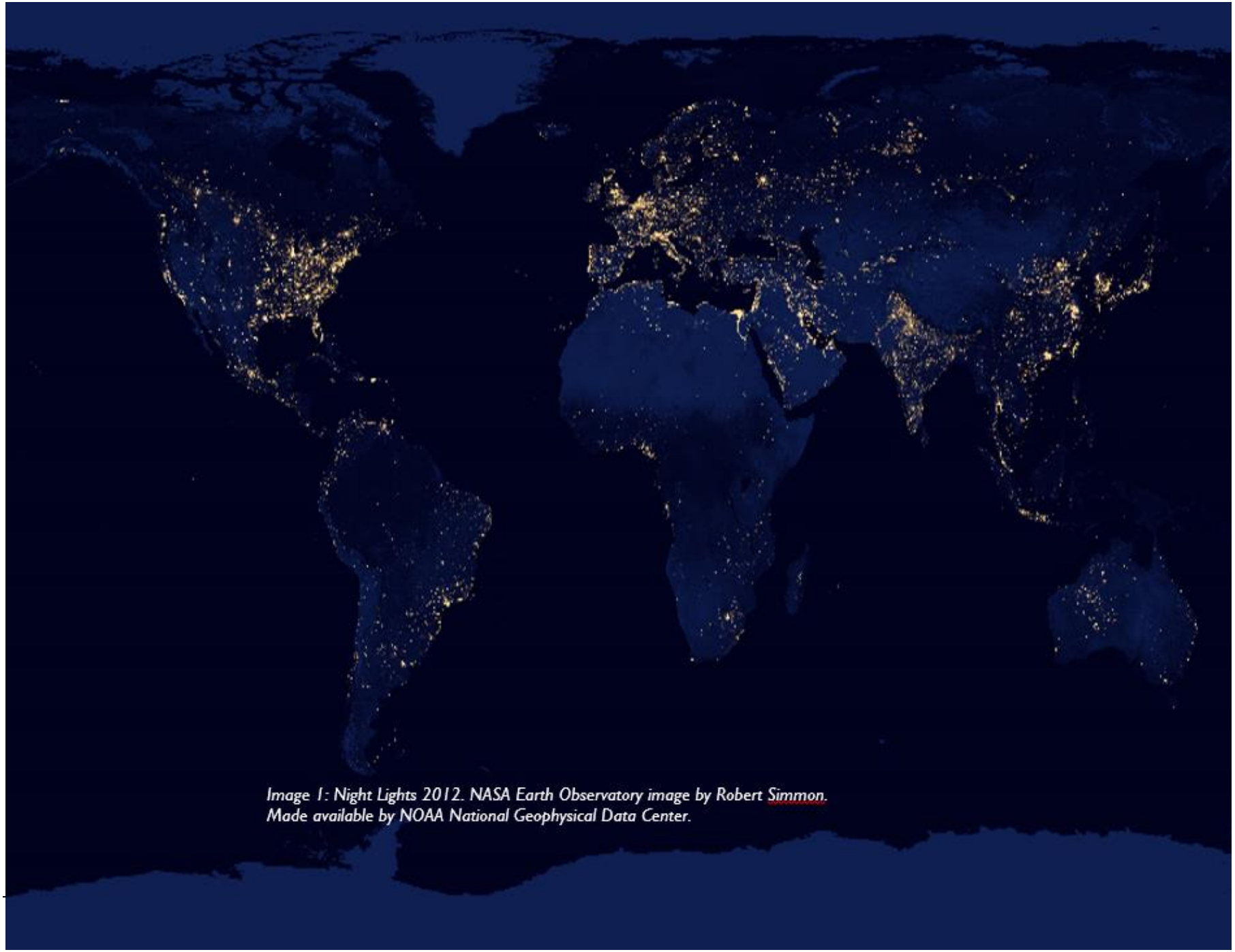


Image 1: Night Lights 2012. NASA Earth Observatory image by Robert Simmon.
Made available by NOAA National Geophysical Data Center.

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ACRONYMS

ACEP	Afghanistan Clean Energy Program
Af-Pak	Afghanistan and Pakistan
AMORE	Alliance for Mindanao Off-Grid Renewable Energy
CG	Credit Guarantee
CPC	Critical Priority Country
DD	Direct Delivery
DE	Decentralized Energy
DIV	Development Innovation Ventures (USAID)
E3	Bureau for Economic Growth, Education, and Environment (USAID)
E&E	Europe and Eurasia
EBRD	European Bank for Reconstruction and Development
EGG-Energy	Engineering Global Growth – Energy
ES	Enterprise Support
FENERCA	Financiamiento de Empresas de Energía Renovable en Centro America
HPPI	Humana People to People – India
IDI	In-depth Interview
LAC	Latin America and the Caribbean
LEAP	Liberia Energy Asstance Program
LESSP	Liberia Energy Sector Support Program
MGP	Mera Gao Power
MMEE	Mona-Mwanza Electrical and Electronics
MSI	Management Systems International
NATELI	Georgia New Applied Technology and Lighting Initiative
NGO	Non-governmental Organization
OPIC	Overseas Private Investment Corporation
PV	Photovoltaic
SARI-E	South Asia Regional Integration-Energy
SE4All	Sustainable Energy for All
SERED	Philippines Solar Energy for Rural Electrification and Development
SSP	Swayam Shikshan Prayog
STA	Sectoral Technical Assistance
UNDP	United Nations Development Program
USAID	United States Agency for International Development

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Image 2: Solar lantern recharging station in Adhauli Village, Uttar Pradesh, India.

Humana People to People-India received USAID support from 2009 to 2011 to establish 100 charging stations in western Uttar Pradesh. The activity supported women's self-help groups and encouraged female entrepreneurs to start solar lantern rental businesses to support the larger community's lighting access needs. *Photo by: Sam Hargadine.*

EXECUTIVE SUMMARY

Access to safe, affordable, reliable, and modern sources of energy is critical for generating broad-based economic growth and meeting basic human needs.[2] The United States Agency for International Development (USAID) advances energy access through programs designed to:

1. Scale renewable energy and increase energy efficiency;
2. Strengthen sector governance and utility performance;
3. Develop and scale decentralized energy solutions;
4. Promote increased energy trade and market integration; and
5. Support construction and rehabilitation of energy resources in post-conflict, conflict-prone, and post-disaster areas.

Since the early 2000s, remarkable advances in off-grid and renewable energy technologies have made decentralized approaches to extending energy access an affordable and attractive way to support the above aims, especially in contexts where the main electrical grid is unlikely to provide sufficient access in the near term. This report examines a range of decentralized energy (DE) approaches through the lens of USAID-specific investments. Its aim is to provide relevant findings, conclusions, and recommendations for future DE investments by retrospectively examining sustainability and scalability for a portfolio of DE activities initiated between 2004 and 2012.

DE in the context of this report refers to interventions supported by USAID that generate limited wattage, serve a small number of customers per system/installation, are off-grid, and utilize clean energy technologies. Examples of the technologies supported include solar powered micro-grids, household energy systems, micro-hydro generators, and biomass installations supported by a range of business models, financing mechanisms, public policy arrangements, and capacity-building assistance for system operations and maintenance.

Decentralized Energy

While traditional solutions to energy access (i.e., grid extension) have nearly closed the electricity access gap in all but the most remote and vulnerable communities in East Asia and Latin America, providing worldwide universal access is likely to require a nimbler toolkit. The concept of DE is not particularly new. In the 1970s, off-grid technology demonstrations (e.g., small-scale hydropower generating installations) were not unknown; however, the potential for renewable sources of energy, including solar photovoltaic (PV), biogas, and micro-hydro systems have multiplied over the years thanks to significant efficiency gains and cost reductions. Since the early 1990s, the focus of major DE investments has gradually moved away from technology demonstration towards private sector enterprise support and multi-stakeholder partnerships to increase the likelihood of sustained outcomes.[3] While modern DE solutions have broad applicability globally because of their reliance on clean and renewable sources and their potential for eventual grid integration, one of the most promising applications in terms of global human development is DE's potential to electrify even the most remote communities. A larger discussion of the development of the DE sector is provided in the body of this report starting on page 3.

[2] Karekezi et al. 2012 and USAID 2015a.
[3] Martinot et al (2002), Sovacool (2013), and Kruckenberg (2015).

Portfolio Review of USAID Decentralized Energy Activities

The range of activities representing the USAID DE portfolio includes 31 unique investments in 12 countries and includes 2 global credit guarantee facilities and a regional integration program serving the South Asia region. Based on criteria developed collaboratively with USAID, three countries were selected for specific in-depth study: India, Brazil, and Tanzania. The review team collected primary data for applicable DE investments in these three countries, which together represent 13 case studies.[4] The portfolio includes four overarching investment categories:

Direct Delivery (DD): USAID activities or activity component(s) in which the Agency or other donors invest the majority of the capital and other associated costs for repairing, procuring, and/or installing one or multiple DE systems. In addition to paying for capital costs, these activities may provide training, capacity building or other technical support for the installation and/or operation of the DE system.

Enterprise Support (ES): USAID grants made directly to clean energy enterprises to support testing and/or scaling of breakthrough technologies and solutions. This may include complementary technical assistance and training to the enterprise for such purposes as business acceleration, improved management, equipment sourcing, and increased access to financing. This category includes Development Innovation Ventures grants, grants under contracts, or larger umbrella mechanisms.

Sectoral Technical Assistance (STA): USAID activity or activity component(s) that strengthen the enabling environment for enhancing access to clean energy services in off-grid areas. This may include developing new policies, legislation, and/or regulations; strengthening relevant government agencies and higher education facilities; and training of financial institutions on off-grid clean energy lending.

Credit Guarantees (CG): Through the Development Credit Authority (DCA), USAID uses partial credit guarantees to mobilize local financing, by covering 50 percent[5] of the principal in loans to projects that advance the Agency's development objectives. This risk-sharing mechanism encourages commercial banks and other lenders and creditors to expand credit to sectors and industries they currently do not serve, or to lend with less collateral than previously required. The expectation is that during the guarantee period, the lender will get to know the industries and associated risks so that in the future, the lender will have the confidence to issue comparable credit without enhancements.

Portfolio Trends

Approximately $65.9 million was invested worldwide in DE ventures from the eight years starting in 2004. Table 1 breaks down this funding by investment modality. The majority of overall funding, including a super majority of DD investments (86 percent), were focused on critical priority countries (CPCs). CPCs are specific contexts deemed by the United States Government to be particularly challenging with respect to security, governance, and/or corruption. These are often conflict-prone or conflict-recovering regions such as Afghanistan and Iraq. Among the USAID DE portfolio, 68 percent of funding ($44.9 million) went to CPC contexts through 8 specific investments. Table 1 also shows the estimated amount and proportion of funding CPC contexts represent for each modality as well as overall. CPC contexts represented in the portfolio include Afghanistan, Liberia, and the Mindanao region of the Philippines.

[4] Five in Brazil. Five in India. Three in Tanzania.

[5] The large majority of CG activities cover 50 percent of the loan principle; however, there are exceptions. For example, a loan portfolio guarantee to a Nigerian financial institution covered up to 80 percent for loans disbursed for renewable energy promotion.

Table 1: Portfolio Investments per Modality

Investment Modality	Aggregated Investment	Proportion of Investment Spent in CPC-Context
DD	$34,321,391.00	$29,610,000.00 (86%)
STA	$20,859,252.00	$11,100,000.00 (53%)
ES	$5,984,409.00	$2,500,000.00 (42%)
CG (Subsidy)	$4,769,046.00	$1,699,736.00 (36%)
Total	**$65,934,098.00**	**$44,909,736.00 (68%)**

Figure 1 represents the starting year of specific investments for the overall portfolio. The figure does not represent funds disbursed in a given year; instead, it illustrates funds appropriated for the life of a DE investment (or investment component) initiated in that particular year. The most active funding year in the portfolio was 2009, as three multimillion dollar activities were initiated in that year. After 2009, increasing levels of support were given to enterprises through ES grants or through the backing of CG facilities, which were typically less resource intensive.[6]

Figure 1: Portfolio Investments by Initiation Year

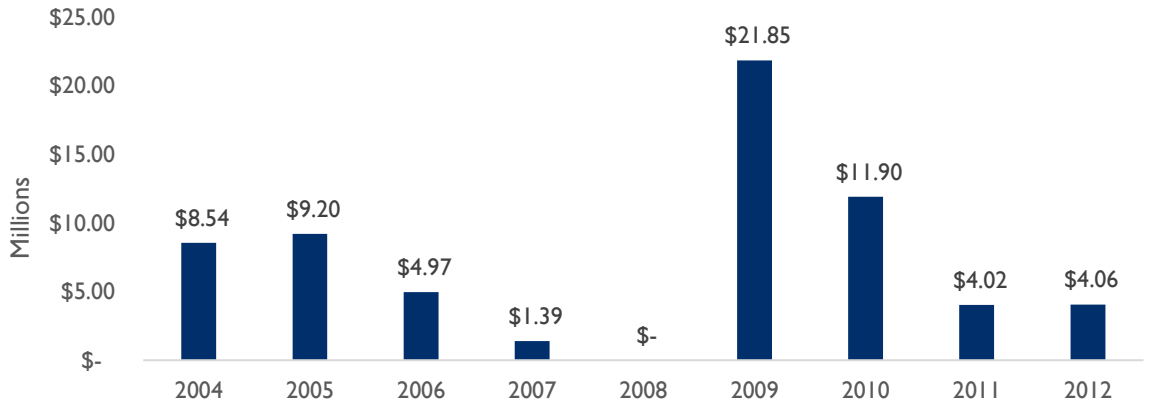


Figure 2 provides proportional DE funding trends by region. Asia received the most funding, mainly due to large investments throughout the 2000s in Mindanao (60.2 percent of total Asia regional DE funding). India hosted nine unique investments, the greatest number of any country included in the portfolio, but the India-specific portfolio (which is made up of mainly private sector oriented activities) accounts for only 25 percent of Asia regional funding and 8 percent of the whole portfolio's value.

Page 10 of this report provides a global map of DE activities for the overall portfolio.

[6] While the portfolio only includes activities initiated in or prior to 2012, it should be noted that the trend towards commercial approaches continued into 2013. Eight additional ES grants were disbursed in 2013 – three in India, three in Tanzania, and one each in Rwanda and Peru. The combined value of these eight investments was approximately $3.5 million.

Figure 2: Proportional Funding by Region

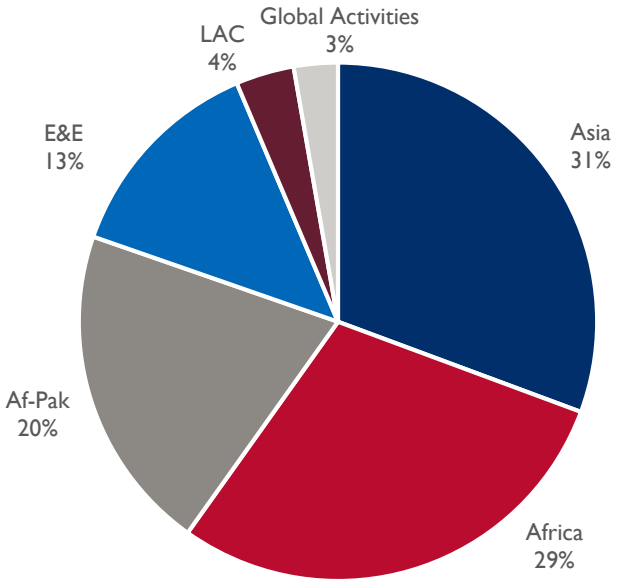
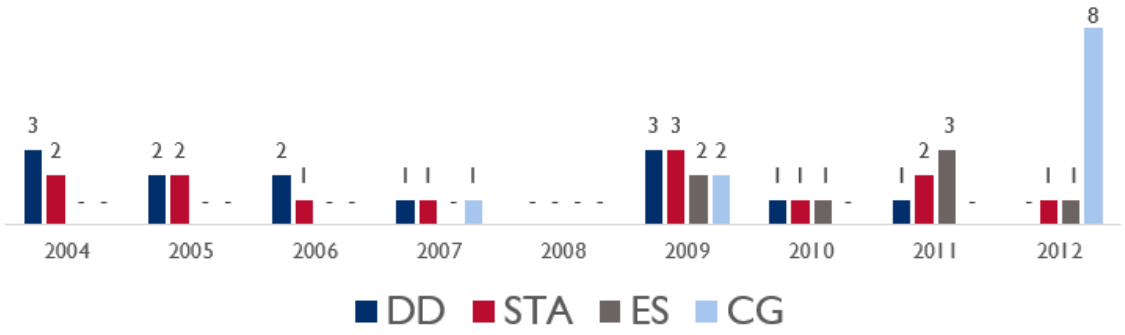


Figure 3 shows the number of activities, or for large investments, their sub-components, per investment modality. STA support remained relatively consistent throughout the portfolio. DD support was more common during the earlier stages of the period of interest. CG and ES funding combined represent private sector driven approaches and were increasingly utilized starting from about 2009, with large spikes in the later part of the timeline. The nature of STA support follows this trend, moving from public sector capacity building efforts towards private sector enabling environment support.

Figure 3: Number of Activities or Sub-Components Initiated per Implementation Modality



Review Findings and Conclusions

Successful DE investments in terms of sustainability and scale were typically designed to complement, address, or resolve matters concerning seven overarching themes. These themes are interrelated as they are the building blocks of a sustainable DE ecosystem. This review interviewed USAID partners, beneficiaries, and sector experts for 13 cases selected for in-depth study. Vital factors for sustainable outcomes and scale include:

1. Policy and regulatory issues;
2. Market considerations;
3. Social and economic context;
4. Social structures and community engagement;
5. Gender equality and female empowerment;
6. Operational factors; and
7. System maintenance.

Policy and Regulatory Issues

DE solutions generally provide an alternative to the grid where the grid is unavailable, unreliable, or unaffordable. Thus, the myriad decisions determining use and appropriateness of grid expansion and DE solutions are determined in part by physical, technical, and economic factors (e.g., population density, levels of demand, topography), but also by government policies and regulations.[7] The main challenge experiencing by USAID DE partners revolves around uncertainty. This is manifested in two main ways:

1. **Investment**: Policy uncertainty or unfavorable regulations create both real and perceived investment risk for potential commercial lenders to DE companies. This can lead to either lower investment or more stringent loan terms that are difficult for DE enterprises to meet.
2. **Demand**: Demand for DE products or services can be affected as users may be uncertain of investing in the technology amid a perception that the grid will eventually arrive. To the degree that DE is considered a "second-rate" electricity source, users may hesitate to take up the technology in hopes of eventual grid connection.

These factors can be seen in Tanzania, where the regulatory system is under development, and in India, where the regulatory system is more complex and evolving. Tanzania's policy and regulatory environment is among the least developed of the non-CPC host contexts in the portfolio. Until now, the Government of Tanzania emphasized expansion of the grid, particularly in service to economically productive activities. The expansion of the grid into areas of Tanzania where DE enterprises operate has differing implications for the companies, depending on the technology each offers. By contrast, India has a long record of policy and regulatory development in the electricity sector, including for DE. The issue in India is less about an underdeveloped and underspecified institutional structure and more about overlapping jurisdictions and shifting policy approaches and priorities. In India, lack of clarity regarding long-term commitment to DE, and the role of grid expansion as the country enacts ambitious energy access initiatives, affect the role of and support for DE. Policies and programs have been implemented to support DE in India, particularly since the Electricity Act of 2003 opened up the possibility of private sector participation in DE. However, areas of ambiguity remain and require further policy and regulatory development. For example, respondents in India raised the issue of private micro-grids installed in areas that will eventually be grid connected. Lack of clarity on what will happen to those capital investments increases the perceived investment risk.

Market Considerations

The key market factor that emerged from the review was the need for commercial capital to support promising new market entrants and enable growth for the purpose of scaling. If viewing DE from the perspective of an individual installation (e.g., a solar home system), it is remarkably low-cost in comparison to the expense of expanding the grid. However, much like the benefits of scale that the grid enjoys in urban settings, the capital requirements to establish and expand a whole DE commercial operation can be significant. For non-commercially oriented approaches (i.e., NGO-led) that may not seek expansion

[7] Zerriffi 2011.

through the same pathways an enterprise would, the lack of commercial capital may be of little importance because donor funds are used to achieve activity priorities. However, commercially oriented investments tend to prioritize expansion of their offerings, customer base, revenues, and profit; in other words, they are more likely to seek scale. For scaling to occur at the necessary pace to achieve global electricity access targets and attract talent, donor-provided capital alone is unlikely to be sufficient.[8]

Of the seven DE activities studied in-depth that took a commercial approach, all reported difficulties with either obtaining capital at all or the terms under which the capital was offered. Enterprise recipients, as well as sectoral-level interviewees, said that traditional financial institutions are generally unfamiliar with the DE sector and unable to appropriately underwrite credit for innovative startups. Specific issues respondents mentioned include:

- Investors do not have the proper models to assess DE businesses. For example, banks in India would use balance sheet or collateral based underwriting (i.e., assessing a business on the basis of prior revenues, expenditures, and assets), which start-ups would have a difficult time demonstrating. Cash-flow based financing, based on current and expected revenue flows, is arguably more relevant for the types of companies operating in the DE sector, but is not widely used in India. Furthermore, banks have one set of lending processes regardless of loan size, making it harder for smaller ventures to access capital.
- Investors viewed DE as a high-risk investment and were unwilling to lend. Investors view the sector as high-risk, due to their relative unfamiliarity with the technology and the market, the risks related to low-income consumers (e.g., payment ability, default rates), and the sectoral risks (e.g., grid expansion, policy uncertainty). For example, all three commercial implementers in Tanzania mentioned difficulty in attracting needed capital. One noted its reliance on grant mechanisms to scale up to a point where it would be "attractive" to outside capital.
- Due to the perceived and real investment risks in this sector, willing investors can leverage their position to generate terms that DE implementers cannot accept, particularly at this nascent stage of the market's development. In particular, required rates of return were such that investors expected to recoup their investment more rapidly than small-but-growing DE companies could deliver. One interviewee in India noted that banks may require greater than 12 percent cost of capital. The same respondent said that start-up DE companies might more comfortably be able to generate 10 to 12 percent returns. In one Indian case, even with a DCA-guaranteed loan, Orb Energy was unable to secure the necessary funds for its planned solar power operations because it could not meet the investment bank's strict lending requirements.

Enterprise loan and grant recipients perceived USAID funding as a powerful legitimizing agent for their business models and DE offerings. Enalter in Brazil credits their CG as instrumental in obtaining further financing. Others receiving DIV-grant funding (e.g., Mera Gao Power and Simpa Networks) echoed this. However, in the absence of a fully functioning commercial capital market for DE, implementers continue to rely on donor funds or social enterprise capital.

Social and Economic Context

Socio-economic status, wealth, and prestige is a key factor influencing household decisions. Wealth influences both the level of energy services demanded and the ability to pay for both the appliances needed and the electricity required to power them.[9] The large majority of the world's population that lacks electricity access resides in rural areas. By definition, rural areas have low population density, and their

[8] Williams 2015, Bhattacharyya 2013, and Glemarec 2012.
[9] Masera et al. 2000 and Kowsari et al. 2011.

often remote location makes grid extension costlier and less utilitarian than focusing public resources on urban areas. Additionally, rural communities often experience lower relative socio-economic status, resulting in varied public policy priorities that are manifested differently depending on cultural and economic context.

Leveraging Social Networks

The ability to use existing social networks or create new ones for marketing or sharing costs is a typical component of successful DE investments.[10] A challenge for commercial DE actors is deciding how to penetrate a new market and how to effectively serve that market. Existing social structures can provide a potential marketing avenue or can be used to reduce transaction costs. Examples include the use of community or self-help groups or existing retail networks that can serve as distribution points.

In both Brazil and India, the NGO-led activities relied heavily on social networks. An example of this is the case at Cachoeira do Aruã, where the implementer latched maintenance responsibilities to an existing community association with the capacity to organize its members and continue to develop the skills needed to manage the micro-hydro system well after donor funding ended.

Community Engagement

Community engagement is a form of end-user participation that is applicable to the project design process,[11] and can institutionalize (1) project flexibility to adapt to community based needs,[12] (2) consensus-oriented community decision making,[13] and (3) end-user financing.[14] This report distinguishes this form of participation form the social network discussion above because these approaches tend to be applied to successful medium to large sized installations serving a broad base. These installations, typically feature some need for shared decision making – distinct from the portfolio's enterprises that more typically offered household solutions.

The Brazil cases provide the clearest lessons relating to community engagement. In these models, community ownership, governance, and continued maintenance was a key factor in sustaining outcomes; however, these were not sufficient on their own. With the exception of Enalter, the Brazil cases represent non-commercial approaches to DE and did not prominently feature end-user financing schemes to maintain the systems. The Ceará State communities of Barra de Córrego and Bom Jesus provide a useful example. At these sites, community engagement was part of the planning process and resulted in community capacity to maintain systems for a time; however, community engagement was insufficient to repair complicated equipment not easily accessible by residents, nor establish the financial mechanisms necessary to repair expensive equipment when maintenance needs exceeded the routine.

Gender Equality and Female Empowerment

The 2012 USAID Gender Equality and Female Empowerment Policy recognizes women as powerful agents for human and economic development.[15] This policy requires USAID Missions and operating units to integrate gender equality and female empowerment approaches into their program cycle and requires Agency staff to hold implementing partners accountable to this aim as well. Recognizing that this review

[10] Van der Kroon et al. 2013.
[11] Brass 2012 and Mansuri and Rao 2013.
[12] Kruckenberg 2015.
[13] Kruckenberg 2015, Ansell and Gash 2008, and Terrapon-Pfaff et al 2014.
[14] Bazillian et al 2012, Brass et al 2012, Sovacool 2012, and Terrapon-Pfaff et al 2014.
[15] USAID 2012b.

is retrospectively examining a portfolio that was largely implemented prior to this directive, only a small number of investments meet the standards described in the policy.

For the investments in the portfolio that did specifically target female beneficiaries, they typically did so in the form of livelihoods support. DE technologies were used among these investments as a vehicle to achieve increased income generating opportunities for women, rather than structurally targeting energy access constraints. While these goals are certainly complementary, the mechanisms by which these investments were implemented resulted in differing immediate outcomes. This means that at least in part because these interventions did not feature end-user financing models, they struggled to institutionalize sustainable long-term systems. The review team's examination of these cases identified the following considerations.

First, donors have a unique ability to expand the evidence base relating to the relationship between broad energy access improvement and its effect on gendered outcomes. The DIV-grant structure already requires enterprise recipients to conduct internal studies, mainly to support the enterprise's eventual need to leverage customer usage information into scalable management systems (e.g., the grants to Simpa, MGP, and EGG all required this). For instance, the use of lighting inside the home deserves more study. End-user respondents from the Tanzania set of cases suggested that women in these context often do not have control of where installation lights are placed when the DE solution provides only basic lighting. A future consideration regarding activity design includes collecting and utilizing information relating to energy related decision-making may lead to projects that better meet community needs. Such programs would be useful to commercial actors seeking to expand their customer base by appealing directly to both men and women.

Second, end-user beneficiary interviews associated with the Zara Solar and EGG-Energy cases found that when women are sufficiently trained in their household system's capacity and maintenance needs, they are more likely to (1) be a primary user and (2) contribute to system sustainability by conducting routine maintenance. For these two cases, positive engagement with female end-users appeared to be the result of favorable socio-economic conditions and a local technician who made a special effort to educate and empower women to utilize and care for solar power systems.

Third, for enterprises operating in environments that are experiencing rapid economic development and increased opportunities in the energy sector, female, male, and unisex targeted products and financing schemes may become increasingly viable. This relates to Simpa and MGPs experience in Uttar Pradesh, whereby early attempts to use women's networks and organizations to generate customers were found to be an insufficient outreach model on their own. Yet, as clean energy technology becomes more common in these communities, and as incomes rise and women increasingly contribute to household coffers, it is worth re-examining this delivery approach to meet gender equity priorities. HPPI's approach was able to leverage female self-help groups; however, this was assisted by the NGO's sustained community involvement.

Operational Factors

Operational factors are the specific choices made by implementers with regard to activity design, customer targeting, technology offerings, rates, logistics, etc. While many of these factors have already been discussed, two points were of special importance for sustainability and scale: cash flow and talent acquisition.

For enterprises with tested and viable offerings, a key consideration for scale is striking the right cash flow balance. The Simpa case provides valuable lessons in this regard. USAID support contributed to the firm's ability to invest in its management processes through the provision of expert consultation and the

incorporation of customer data management software. This assistance led to changes in Simpa's DE installation leasing policies and the types of data Simpa collects from potential customers. Algorithms were developed to increase the accuracy of Simpa's customer review processes – automatically flagging concerns and recommending approval, denial, or a home visit to collect additional information. Simpa staff cited USAID assistance as valuable in the increasing sophistication of its operational approach and further noted USAID's position as an important sectoral actor; intangibly benefiting the firm by introducing it to regional partners working on similar issues as well as finance institutions familiar with the DE sector.

Across the portfolio, the ability to attract, develop, and retain human talent remains a major factor associated with sustained operations and scale. Depending on the technical approach, staff is necessary for marketing, installation, maintenance, fee collection, back-end support, strategic planning, etc. In some cases, the development of local workforces was a primary goal of the implementation. In other cases, local staff received training as a necessary component of the business model.

System Maintenance

Lack of maintenance and failure to replace failed components led to poor performance and overall system breakdowns. This can result in user dissatisfaction and, eventually, a reduced number of end-users and lack of sustainability. The review shows that maintenance is multi-faceted and depends on:

- Appropriate funding levels to anticipate and pay for technicians and parts;
- Appropriate levels of human talent (i.e., trained technicians); and
- Appropriate maintenance processes in place (e.g., problem reporting, sufficient inventory and access to parts, response times).

The NGO-led activities relied on a wide variety of maintenance provisions, including community members conducting maintenance and training of local technicians. In the cases associated with Brazil and India, these efforts were insufficient to maintain high levels of service for long periods after donor support ended. One important factor is that in addition to providing maintenance to existing equipment, it is necessary to have the ability to replace equipment as necessary, which was a constraint for the Pará State cases in Brazil and HPPI in India.

The commercial implementers were on the whole better equipped to provide ongoing maintenance services to their installations, especially so for those firms that continued to own their systems by providing customers with pay-as-you-go services (e.g., Egg-Energy and M-Power) and/or leasing schemes (e.g., Simpa). Essentially this model is predicated on continued ownership of assets and payment by customers depends on continued service. This provides a strong incentive for system maintenance.

No single maintenance system was found to be on the whole better. Rather, successful procedures all were able to provide long-term service through (1) availability of funds, (2) clear processes for users to report problems, and (3) the availability of trained personnel. A challenge for rapidly expanding enterprises includes sustained capacity to continue service to old customers. For example, as EGG shifted its model and geographic focus, this led to reports of existing customer neglect. This shift was likely a result of a rapidly expanding grid as well as an adaptation towards a separate offering that was perceived as a better application for customer demands.

While commercial approaches appear better geared towards building the financial infrastructure to maintain services, community ownership and training was also successful in at least improving the resiliency of DE installations. This was seen in the Maripá and Santí sites as well as the micro-hydro installation at Cachoeira do Aruã, Brazil. In both these cases, local groups took ownership of the DE systems and were

able to troubleshoot routine problems and in the case of Cachoeira do Aruã, maintain the same level of operations to this day.

Recommendations

Based on the findings and conclusions from this research, the review team provides the following recommendations:

1. USAID should continue to favor the use of commercial approaches for supporting DE systems when sustainability and scale are the objective.

Throughout this review, commercial approaches, all things being equal, were better able to organize sustained operations and maintenance systems that led to sustained end-user outcomes and greater scope for scaling DE solutions. Specifically, commercial approaches were better able to establish fee collection schemes that in turn contributed to firm capacity to develop, refine, and deploy offerings that addressed end-user needs and evolve with changing customer demands. DE technologies require periodic maintenance and commercial approaches were better equipped to satisfy the following:

- Collect adequate funds to anticipate and pay for technicians and parts;
- Attract appropriate human talent (i.e., trained technicians); and
- Implement appropriate maintenance processes (e.g., issue reporting by end-users, sufficient inventory and access to parts, response times, etc.).

Commercial approaches are complementary to USAID objectives in all contexts; however, CPC-contexts will likely remain a challenge for commercially oriented approaches due to the need for immediate and substantial initial investments to reconstitute vital public and private infrastructure and operational capacities. While these contexts may require direct delivery of capital in the medium-term, these investments can be linked to long-term strategies to equitably build the regulatory and policy framework that enables a responsive and high-functioning commercial DE sector.

2. USAID should prioritize gender sensitive data collection to better adapt its programming to intra-household energy usage trends.

Going forward, gender analysis findings should be integrated in the design of DE activities and sub-components to existing large-investments. For future DE investments, a larger evidence base examining gendered outcomes would likely contribute to better project designs that incorporate the energy access needs of women. While portfolio investments, when they targeted female beneficiaries at all, tended to prioritize income generating opportunities, there is a missing middle. Meaning on the one end, USAID prioritizes broad energy access and on the other the Agency works to link women to the clean energy value chain. These are complementary outcomes for women generally; yet, a larger evidence base for when, how, and why women in underserved communities are not able to use the energy that is available would likely help design future investments.

3. USAID should support partner governments in the effort to better integrate DE technologies into energy regulations and policy processes.

USAID should use its convening role to support partner governments in fostering greater integration of DE technologies formally into lowest-cost-greatest-benefit energy regulation and policy processes. Portfolio trends indicate that sectoral support and commercially oriented approaches are already on the

rise, but this form of support will continue to be vital as low-access countries rapidly develop their energy sector policy and regulatory systems.

4. USAID should provide additional access to capital programming for the benefit of promising DE enterprises.

A constraint universally felt by DE enterprises was the challenge of accessing sufficient capital. To achieve scale, large pools of capital are required to attract talented people to the firm and expand operations to new geographies and customers. USAID, according to grant recipients, is uniquely placed to underwrite capital and catalyzes market confidence for future investors. Until the DE market is sufficiently liquid, USAID should continue these efforts and integrate them into a coordinated approach to sector support.

5. USAID should establish clear management priorities to direct the types of data it collects and utilizes to design and monitor projects.

Data quality and availability was a challenge throughout this review. These issues limit the Agency's ability to retrospectively self-examine its investments and learn from past successes and failures. The types of data collected across portfolio investments appeared to be relatively ad hoc and did not seem to align to any coordinated management strategy – at least in terms of sustainability and scale. In future, the Agency should establish standard reporting requirements for DE investments along context-relevant factors that contribute to sustainability and scale.

Image 3: "Vouchers Available Here!" M-Power pre-paid service vendor in Arumeru Village, Tanzania.

M-Power, a Tanzanian offshoot of Off Grid: Electric, is a commercial enterprise based out of Arusha. It provides household solar power to customers through vendors like the one pictured. A customer pays a small installation fee and can pre-pays for a day or several days' service; providing an innovative flexible payment option for low income users.
Photo by: Elizabeth Baldwin.

INTRODUCTION

Access to safe, affordable, reliable, and modern sources of energy is critical for generating broad-based economic growth and meeting basic human needs.[16] The United States Agency for International Development (USAID) advances energy access through programs designed to:

1. Scale renewable energy and increase energy efficiency;
2. Strengthen sector governance and utility performance;
3. Develop and scale decentralized energy solutions;
4. Promote increased energy trade and market integration; and
5. Support construction and rehabilitation of energy resources in post-conflict, conflict-prone, and post-disaster areas.

Since the early 2000s remarkable advances in off-grid and renewable energy technologies have made decentralized approaches to extending energy access an affordable and attractive way to support the above aims, especially in contexts where the main electrical grid is unlikely to provide sufficient access in the near term. This report examines a range of decentralized energy (DE) approaches through the lens of USAID-specific investments. Its aim is to provide relevant findings, conclusions, and recommendations for future DE investments by retrospectively examining sustainability and scalability for a portfolio of DE activities initiated between 2004 and 2012.

Portfolio Review of USAID Decentralized Energy Activities

DE in the context of this report refers to interventions supported by USAID that generate limited wattage, serve a small number of customers per system/installation, are off-grid, and utilize clean energy technologies. USAID DE investments take the form of sectoral technical assistance, credit guarantees, enterprise support, and direct delivery modalities. Examples of the technologies supported include solar powered micro-grids, household energy systems, micro-hydro generators, and biomass installations supported by a range of business models, financing mechanisms, public policy arrangements, and capacity-building assistance for system operations and maintenance.

The range of activities representing the entire USAID DE portfolio includes 31 unique investments in 12 countries and includes two global credit guarantee facilities. Based on criteria developed collaboratively with USAID, three countries were selected for specific in-depth study: India, Brazil, and Tanzania. Primary data was collected for applicable DE investments in these 3 countries, which together represent 13 case studies.[17] This report also describes the overall portfolio based on available documentation, evaluation reports, performance monitoring data, and key informant interviews among implementing partners. Guiding this report are three research questions:

1. To what extent and under what conditions have USAID-supported decentralized energy systems been sustainable after USAID assistance ended?
2. To what extent and under what conditions have USAID-supported decentralized energy systems been replicated or scaled up after USAID assistance ended?
3. What decentralized energy implementation models and processes have been most effective at achieving sustainability, scale, or replication?

[16] Karekezi et al. 2012 and USAID 2015a.
[17] Five in Brazil. Five in India. Three in Tanzania.

METHODOLOGY

This portfolio review took place between December 2014 and April 2016 with time after set aside for presentations, comments, and final report preparation. The implementation of this study was designed to be collaborative with USAID, however, data was collected and analyzed by an independent, third party team managed by Management Systems International under the E3 Analytics and Evaluation Project.

The review used a mixed methods approach, organized by phases, to describe the DE portfolio and assess sustained outcomes for a selected subset of 13 activities meant to represent the larger 31-activity portfolio. Table provides an overview of the review's four phases, the function behind each phase, and the methods used.

Table 1: Overview of Portfolio Approach and Methodology

Phase	Functions and Parameters	Methods Used
Phase I: Inventory of USAID DE activities	• Cleaned a database of descriptive characteristics provided by USAID of DE activities began by the Agency around the period of interest. • Catalogued and categorized activity attributes. • After geographic and temporal trends were identified, developed a case study selection paper for USAID's review and comment. • Finalized portfolio of known USAID funded DE activities.	Document review, Internet research, data requests, and phone interviews with former implementers to screen for inclusion criteria.
Phase II: Review literature	• Anchor the study in larger academic discussion. • Inform development of hypotheses to be tested during case study work. • Validate research approach.	Document review, subject matter review, material synthesis.
Phase III: Case study research	• After priority counties were selected in collaboration with USAID, further analyzed available activity characteristics. • Conducted scoping interviews with applicable USAID Missions (Tanzania, Brazil, and India) and further refined list of potential case studies. • Selected between three and five cases for each of the three priority countries. • Collected primary data from stakeholders, beneficiaries, and sector experts for each of the 13 case studies. • Conducted site visits for applicable cases.	Document review, in-depth interviews, group interviews, and site visits.
Phase IV: Data analysis and synthesis	• Analyzed data through a comparative framework prioritizing contextual, implementation, and technical approaches to build explanations for specific case study results. • Analyzed cross-case data to identify similarities and differences between cases. • Synthesized findings from case studies and incorporated themes from the literature, descriptive statistics from the overall portfolio, and relevant external evaluations of USAID programs to present answers for all three research questions.	Content analysis, inductive analysis, triangulation, explanation-building, descriptive statistics, and tallying of relevant factors.

Three frames of analysis guide the comparison of cases, both between countries and within countries. These comparisons are meant to provide best practices and on the ground lessons learned relating to sustained outcomes, scale, and replicability for USAID DE investments. These frames are:

1. **Context factors**: The policies, regulations, enabling environment and related institutional context in which DE investment are being made that can either support or hinder DE implementation.
2. **Technical approach-related factors**: The investment modality being used to support DE.
3. **Implementation factors**: The factors specific to each implementation, such as technology, maintenance systems, fee structures, etc.

The review's country case methodology is further discussed in Annex B, including a discussion of case selection, data collection and analysis procedures, and study limitations.

BACKGROUND

The evidence is clear that access to reliable, clean, and affordable energy is a correlate of productive income generation, poverty reduction, and increases in human development.[18] Benefits to energy access include greater access to information, education, and health services; as well as increased manufacturing and commercial productivity and decreased costs associated with power-outages such as spoilage, cleanup, and lost-sales.[19] Approximately 1 in 6 people worldwide – 1.1 billion in total – do not have access to electricity, and an additional 1 billion people receive electricity services that lack the standards of quantity and reliability needed to sufficiently realize human welfare goals or contribute to sustained and inclusive economic growth.[20]

Of the 1.1 billion people without access to electricity, approximately 591 million reside in Sub-Saharan Africa and 378 million in South Asia.[21] Further, 40 out of 51 countries classified as "low-access" nations reside in Sub-Saharan Africa.[22] Current projections, based on the World Development Indicators database and UN Millennium Development Goals performance monitoring suggests that at the current pace of electrification, the absolute number of people without access across all low-access countries will rise by 40 percent by 2030.[23]

"Unless there is a big break from recent trends, the population without electricity access in Sub-Saharan Africa is projected to increase by 58 percent [between 2015 and 2030]."
-World Bank 2015

Context appears to be a factor in the direction of causality between extending energy access and human development gains. The World Bank recently conducted a systematic review of 32 impact evaluations across a range of approaches to extending electricity access. Among these studies, 24 provide evidence from Sub-Saharan Africa and South Asian contexts.[24] Among these studies, findings support a causal relationship from attaining energy access to increases in (1) children's study at home, (2) school enrollment, and (3) years of schooling. There was mixed evidence supporting a unidirectional causal relationship between greater electricity access and female empowerment: two of three studies detected an impact of energy access on lowered fertility rates – the third detected no direct impact. The evidence

[18] World Bank 2008.
[19] Foster and Steinbuks 2009.
[20] World Bank 2015.
[21] United Nations 2012.
[22] Ibid.
[23] World Bank 2015.
[24] Ibid.

supporting electricity usage and reductions in in-door air pollutants is stronger, which in traditional contexts disproportionately benefits women due to their role inside the home. The correlation between income gains and energy access remains apparent; however, the evidence base remains mixed about the directionality of this relationship.[25] Among the studies included in the World Bank review, increases in microenterprise profits had a relatively thin evidence base but household income was shown to have benefitted from electricity access.

United States Presidential initiatives, such as Power Africa, and global commitments, like that of Sustainable Energy for All (SE4All) and the Sustainable Development Goals, recognize that energy poverty is likely to become increasingly concentrated in parts of the African continent, as South Asia – like East Asia before it – continues to rapidly expand grid and off-grid connections. To counter prevailing trends, especially those associated with remote parts of Sub-Saharan Africa, continued engagement, innovation, and sectoral support from public and private-sector actors will be required to scale solutions that are affordable, clean, and accessible. Decentralized approaches to energy generation and distribution thus provide an opportunity to break from current trends and rapidly contribute to universal access and its associated benefits even in contexts that once represented severe challenges.

A Big Break

While traditional solutions to energy access (i.e., grid extension) have nearly closed the energy access gap in all but the most remote and vulnerable communities in East Asia[26] and Latin America, providing world-wide universal access is likely to require a nimbler toolkit – one that features DE-based solutions. The concept of DE is not particularly new. In the 1970s, off-grid technology demonstrations (e.g., small scale hydropower generating installation) were not unknown; however, the potential for renewable sources of energy, including solar photovoltaic (PV), biogas, and micro-hydro systems have multiplied over the ensuing years due to significant efficiency increases and cost reductions. Since the early 1990s, the focus of major DE investments has gradually moved away from technology demonstration towards private sector enterprise support and multi-stakeholder partnerships to increase the likelihood of sustained outcomes.[27] So the development hypothesis goes, a thriving and constantly innovating energy sector will improve operations and maintenance services in-line with consumer preferences long after donor assistance efforts end.

Image 4: EGG-Energy solar battery near Tanga, Tanzania.
Photo by: Ryan Thomas.

[25] Calderon and Servén 2014.
[26] China presents a counter example with its use of small hydro power installations and other off-grid electrification schemes in conjunction with large-scale expansion of its grid capacity.
[27] Martinot et al (2002), Sovacool (2013), and Kruckenberg (2015).

While modern DE solutions have broad applicability globally because of their reliance on clean and renewable sources and their potential for eventual grid integration, the most promising applications in terms of global human development is DE's potential to electrify even the most remote communities.

The last thirty years in the DE sector represents a dialectic; on the one hand technological advancements have made DE solutions applicable in even the most challenging environments (e.g., remote communities and conflict prone regions); on the other, donor approaches to support have shifted based on an increasing evidence base of what works. These advancements include efficiency gains in power output per unit, manufacturing costs, as well as innovative financing schemes that more appropriately underwrite credit and provide long-term repayment options for firms and households.

In part based on the renewable energy sector's relative competitiveness gains in the late 1990s and early 2000s, donor led electrification schemes began focusing on private sector oriented initiatives. These early approaches focused mainly on household electrification or public buildings, while largely ignoring the need for broader electrification sector support to stimulate local systems and institutions. Further, these approaches largely ignored difficulties in sustaining systems supported by low-income users with low consumption patterns.[28] Gradually, towards the mid and late 2000s, donor priorities shifted towards enabling environment support, recognizing that strong energy sector institutions, policies, and linkages to the broader economy are prerequisites for sustaining DE solutions.[29]

The trends described above, starting with technological demonstration in the 1970s through the 1990s, and resulting in gradually more sophisticated private-sector approaches, mimics patterns seen in the USAID portfolio over the same time-period. The next section describes USAID's work in the DE sector from roughly 2004 onwards.

THE USAID DECENTRALIZED ENERGY PORTFOLIO

This report examines trends across 31 USAID investments across 12 countries, including 2 global credit guarantees, and a regional integration project in South Asia. A full list of these investments with relevant descriptions is provided as Annex C. Four overarching investment categories make-up the USAID portfolio:

Direct Delivery (DD): USAID activities or activity component(s) in which USAID or other donors invest the majority of the capital and other associated costs for repairing, procuring, and/or installing one or multiple DE systems. In addition to paying for capital costs, these projects may provide training, capacity building or other technical support for the installation and/or operation of the DE system.

Enterprise Support (ES): USAID grants made directly to clean energy enterprises to support testing and/or scaling of breakthrough technologies and solutions. This may include complementary technical assistance and training to the enterprise for such purposes as business acceleration, improved management, equipment sourcing, and increased access to financing. This category includes Development Innovation Ventures grants (Box 1),[30] grants under contracts, or larger umbrella mechanisms.

Sectoral Technical Assistance (STA): USAID project or project component(s) that strengthen the enabling environment for enhancing access to clean energy services in off-grid areas. This may include, for

[28] Zerriffi 2011.
[29] Baldwin et al 2015.
[30] USAID 2016.

example, developing new policies, legislation, and/or regulations, strengthening relevant government agencies and higher education facilities, and training of financial institutions on off-grid clean energy lending.

Credit Guarantees (CG): Through the Development Credit Authority (DCA), USAID uses partial credit guarantees to mobilize local financing, by covering 50 percent[31] of the principal in loans to projects that advance the Agency's development objectives. This risk-sharing mechanism encourages commercial banks and other lenders and creditors to expand credit to sectors and industries they currently do not serve, or to lend with less collateral than previously required. The expectation is that during the guarantee period, the lender will get to know the industries and associated risks so that in the future, the lender will have the confidence to issue comparable credit without enhancements.

These categories are not mutually exclusive, and among large investments, it is common for components to represent a range of approaches (i.e., USAID may directly provide capital for installations in target communities while simultaneously supporting enabling environment improvements through technical assistance to a policy or regulatory body).

Funding and Implementation Patterns

The portfolio under review is inclusive of known DE investments initiated by USAID in the time period of interest (2004 to 2012). Because the starting period is more than a decade old and activity documentation was limited for the older portion of the portfolio, it is possible that this list is not fully exhaustive. Further, the review team worked collaboratively with USAID to estimate funding values where financial statements did not specify DE component funding amounts. All funding patterns presented below present an instructive relative picture; however, they reflect a degree of subjectivity due to various educated estimates used by the review team and USAID.

Approximately $65.9 million was invested worldwide in DE ventures from the eight years starting in 2004. Table 2 breaks down this funding by investment modality and Figure shows the relative proportion of funding each modality received. The majority of overall funding, including a super majority of DD investments (86 percent), were focused on critical priority countries (CPCs). CPCs are specific contexts deemed by the United States Government to be particularly challenging with respect to security, governance, and/or corruption. These are often conflict-prone or conflict-recovering regions such as Afghanistan, Pakistan, and Iraq. Among the USAID DE portfolio, 68 percent of funding ($44.9 million) went to CPC contexts through eight specific investments. Table 2 also shows the estimated amount and proportion of funding CPC contexts represent for each modality as well as overall. CPC contexts represented in the portfolio include Afghanistan, Liberia, and the Mindanao region of the Philippines.

Box 1: Development Innovation Ventures (DIV) Profile

The DIV program is a USAID open competition that finds, tests, and scales breakthrough solutions to global development challenges. It is not a targeted mechanism for only the energy sector; rather applicants submit proposals across a wide-range of sectors. DIV is however prominently featured among the Agency's DE ES-type funding. DIV's funding model is organized into three windows. The first is proof of concept. Selected grantees are awarded up to $100,000 to pilot their innovative technology, business model, or public policy idea. The second provides grantees with up to $1 million to test this model at scale. The final phase offers grantees up to $15 million to help scale solutions that have sufficiently proven that their model is viable and can be scaled to benefit millions of people.

[31] The large majority of CG activities cover 50 percent of the loan principle; however, there are exceptions. For example, a loan portfolio guarantee to a Nigerian financial institution covered up to 80 percent for loans disbursed for renewable energy promotion.

Table 2: Portfolio Investments per Modality

Investment Modality	Aggregated Investment	Proportion of Investment Spent in CPC[32]-Context
DD	$34,321,391.00	$29,610,000.00 (86%)
STA	$20,859,252.00	$11,100,000.00 (53%)
ES	$5,984,409.00	$2,500,000.00 (42%)
CG (Subsidy)[33]	$4,769,046.00	$1,699,736.00 (36%)
Total	$65,934,098.00	$44,909,736.00 (68%)

Figure 2: Funding Proportion per Investment Modality

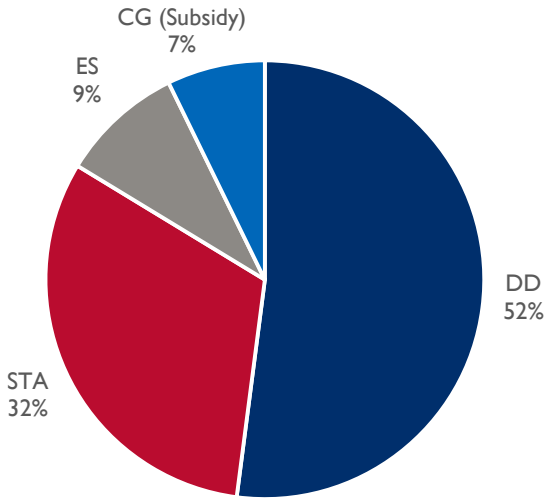


Table 3 shows the number of activities, or for large investments, their sub-components, per investment modality. STA support remained relatively consistent throughout the portfolio. DD support was more common during the earlier stages of the period of interest. CG and ES funding combined represent private sector driven approaches and were increasingly utilized starting from about 2009, with large spikes in the later part of the timeline. The nature of STA support follows this trend; moving from public sector capacity building efforts towards private sector enabling environment support. While the portfolio only includes activities initiated in or prior to 2012, it should be noted that eight additional ES grants were disbursed in 2013 – three in India, three in Tanzania, and one each in Rwanda and Peru. The combined value of these eight investments began in 2013 was approximately $3.5 million.

[32] Critical Priority Countries

[33] The credit subsidy cost is defined as the estimated long-term cost to the government of a loan guarantee, calculated on a present value basis, excluding administrative costs (USAID 2012a).

Figure 3: Number of Activities or Sub-Components Initiated per Implementation Modality[34]

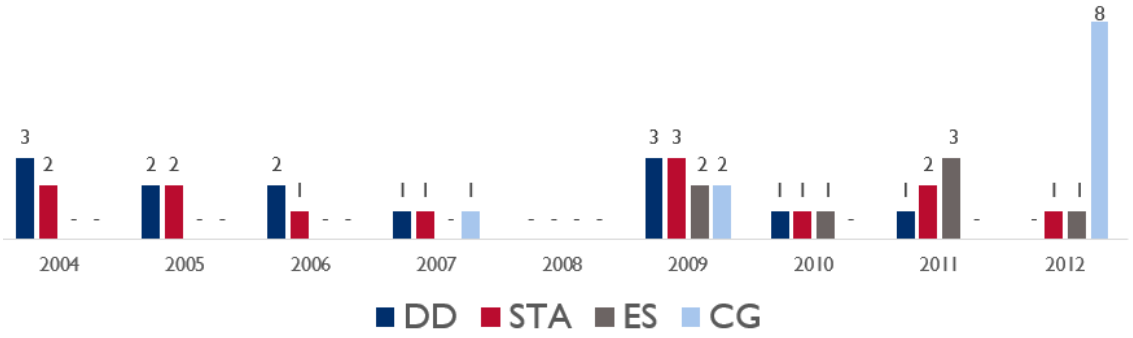


Figure represents the starting year of specific investments for the overall portfolio. Note that the below figure does not represent funds dispersed in a given year, rather, it illustrates funds appropriated for the life of a DE investment (or investment component) initiated in that particular year. The 2009 period was the most active funding year in the portfolio in the sense that three multimillion dollar activities were initiated in 2009.[35] After 2009, increasing levels of support were given to enterprises through ES grants or through the backing of CG facilities.

Figure 4: Portfolio Investments by Initiation Year

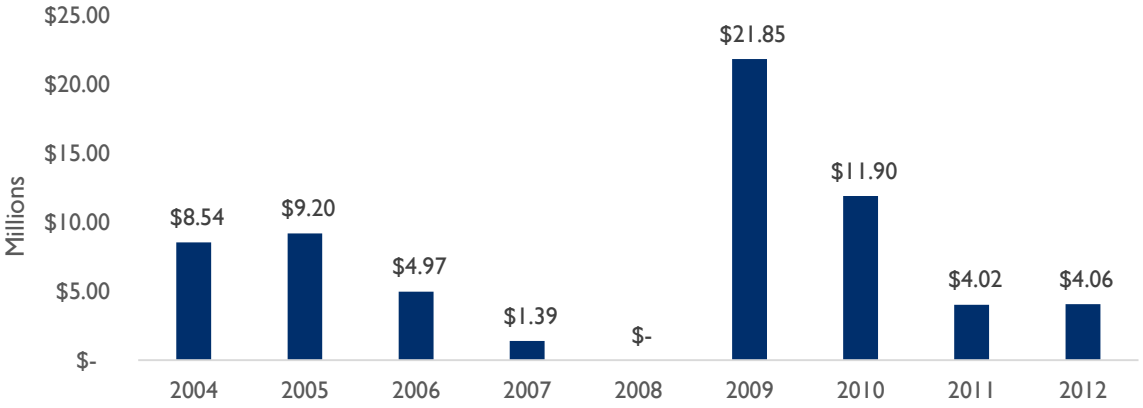


Figure 2 and Figure 3 provide estimated absolute and proportional DE funding trends respectively by region. Figure 4 maps the global concentration of portfolio activities. Asia received the most funding, mainly due to large investments throughout the 2000s in Mindanao (53.5 percent of total Asia regional DE funding). Meanwhile India hosted six unique investments,[36] the greatest concentration for any country included in the portfolio. That said, the India-specific portfolio, which is made up of mainly private sector

[34] Count is calculated based on activity components. Twelve activities represent multiple investment modalities.
[35] See Annex C and the descriptions for ACEP, AMORE-Phase 3, and C&RE. The Ecobank and International Bank CGs in Liberia were also initiated that year, Only C&RE (Brazil) represents a non-CPC context.
[36] Including the SARI-Phases 2 and 3 regional investments.

oriented activities, accounts for only 17 percent of Asia regional funding and 5 percent of the whole portfolio's value.

The Af-Pak region only had the one activity with DE components in Afghanistan (see Box 2); however, it was the largest single investment in the portfolio ($13.5 million). All of Europe and Eurasia (E&E) funding was focused on Georgia. Two activities make up the Latin America and Caribbean (LAC) portfolio, consisting of two multipronged NGO-implemented investments in Brazil. The global activities represent the subsidy cost for two CG facilities that were global in scope.

Box 2: Afghanistan Clean Energy Program (ACEP) Profile

Implemented from 2009 to 2012, ACEP introduced 11,583 total DE power systems in rural Afghanistan for the purpose of improved health, education, nutrition, and consumption outcomes for target beneficiaries. ACEP was also designed to build government capacity to include DE solutions in Afghan government project portfolios as well as provide technical workshops for engineering experts in the field of solar, wind, and micro-hydro technologies.

Figure 2: Portfolio Investments per Region

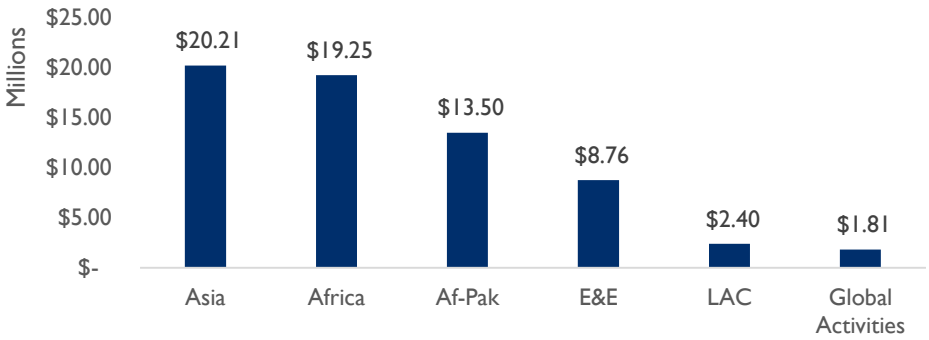


Figure 3: Proportional Funding by Region

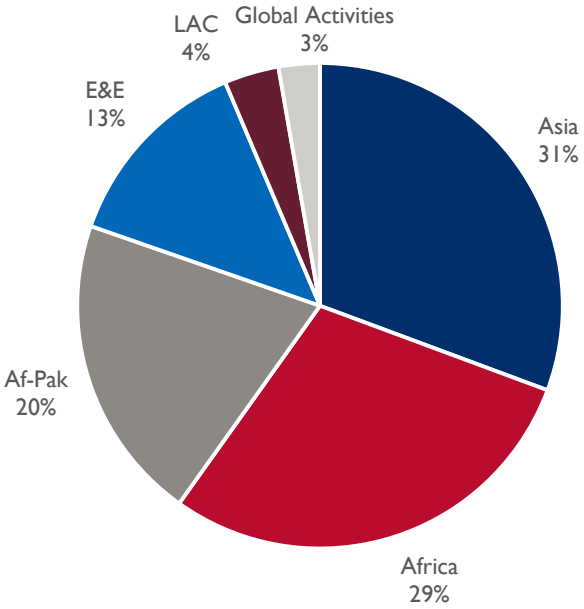


Figure 4: Concentration of Global USAID DE Investment Portfolio[37]

[37] Notes: The two global CG facilities are not plotted and SARI-E Phases 2 and 3 are counted as part of the India portfolio due to the project's headquarters in Delhi. The small grants portion of the SARI-E Program, Phases 2 and 3, were disbursed across the region with notable concentrations in Pakistan, Bangladesh and Nepal, in addition to India. All three Philippines activities were focused on Mindanao.

Portfolio Discussion

Critical Priority Country Contexts

As seen in Table 2, the 8 investments implemented in Afghanistan, Liberia, and the Mindanao region of the Philippines make up approximately 68 percent of the total funding value of the portfolio. These investments are characterized as post-conflict or conflict-prone energy sector support efforts. They include:

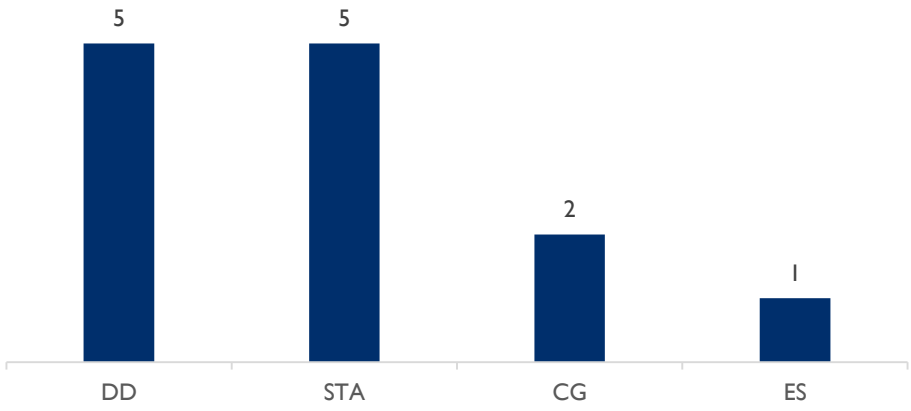
1. ACEP 2009-2012 (DD, STA);
2. Liberia Energy Support Sector Program (LESSP) 2010-2014 (DD, STA);
3. Liberia Energy Assistance Program (LEAP) 2006-2009 (DD, STA);
4. Alliance for Mindanao Off-grid Renewable Energy (AMORE-Phase 2) 2004-2009 (DD);
5. Alliance for Mindanao and Multi-Regional Renewable/Rural Energy Development (AMORE-Phase 3) 2009-2013 (ES, STA);
6. USAID/Philippines Solar Energy for Rural Electrification and Development (SERED) 2004-2007 (DD, STA);
7. Ecobank Liberia Limited 2009-2019 (CG); and
8. International Bank Liberia 2009-2019 (CG).[38]

Box 3: Liberia Energy Assistance Program (LEAP) Profile

The LEAP activity provides an instructive example of the type of work conducted in CPC contexts. LEAP delivered technical assistance for energy policy, institutional strengthening, and rural energy development. DE components included sectoral assistance that supported the development of Liberia's first National Energy Policy and the creation of various government entities, including the Rural and Renewable Energy Agency and the Department of Energy within the Ministry of Lands, Mines, and Energy. LEAP also delivered pilot solar projects to rural Liberian communities selected based on shared priorities between the host-government and the wider USAID operational presence in Liberia.

Figure 5 illustrates the breakdown between investment modalities among CPC investments. As seen, DD and public institution oriented STA are commonly used as fundamental support modalities to reconstitute or build energy sector capacity in post-conflict or conflict-prone regions. Opportunities for supporting ES activities may be limited as there may be fewer energy entrepreneurs operating in these environments.

Figure 5: Number of Investment Components within the CPC-specific Portfolio



[38] See Annex C for specific information about these investments.

Of the 12 activities in the portfolio that house multiple intervention arms (i.e., distinct components representing a different technical approach), six were implemented in CPC contexts. These six investments represent 65 percent of total portfolio spending. Somewhat by definition, these investments represent ambitious interventions looking to revitalize or significantly boost energy sector capacity in challenging operating environments. While the scale of need in these contexts explains the large funding values, note that these activities were not chiefly concerned with DE-based objectives. For instance, the ACEP activity in total was a $23.8 million investment; however, DE components account for roughly $13.5 million of that larger figure. Beyond the delivery of energy installations to target communities and technical assistance to relevant government ministries, ACEP was concerned with overall health and education targets. This distinction is important because sustainability and scale of DE components appeared to be less of a direct focus, given the magnitude of effort involved, as compared to targeted grants to specific entrepreneurial actors elsewhere in the portfolio.

Trends in Private Sector Approaches

Based on portfolio trends, 2009 was a watershed year. From 2009 onward, USAID DE support increasingly focused on private sector pathways to extending energy access. This was correlated with a number of important factors. First, technology advancements and efficiency gains in the generation and storage capacity of renewables over the early and mid-2000s greatly reduced the capital requirements necessary to start private energy service companies. Second, early success cases, like that of California-based SolarCity, demonstrated to a global audience that renewable energy solutions can provide consumers with energy prices below that of standard utility rates. Third, based on the relative success of early actors, investors became increasingly exposed to and confident in the potential of renewable technologies. As mentioned by DE sector entrepreneurs interviewed as part of this review (staff from SELCO and Simpa Networks), this third step was, and remains, especially important. While the technology was demonstrating its viability, the average consumer – even in rich countries – had a low propensity to buy DE systems outright. According to interviewees, this was likely because those who had the cash upfront to purchase these systems were wealthy, niche customers looking to live without use of the main grid, sell generated energy to the grid, or were particularly interested in lowering their personal carbon footprint. As more and more capital became available to these early renewable energy firms, innovative financing models were created to broaden the potential customer base.

Box 4: Case Study 12 – Simpa Networks (India)

The DIV grant provided to Simpa Networks in 2013 provides a useful illustration of the private sector oriented support mechanisms favored in the later years of the portfolio. Founded in 2010, Simpa Networks sells solar power through a process similar to mobile credit purchasing. The grant was provided to Simpa to (1) rollout the firm's offering to 12,000 households mainly in Uttar Pradesh and (2) measure the social impact and financial viability of the approach in order to attract additional private investment.

A major contributor to Simpa's success has been its ability to attract low-cost, long-term debt in order to finance its expansion plans and offer low usage fees to its customers. The nature of its fee collection scheme is innovative, using a pay-as-you-go model that allows energy poor households to access comparatively sophisticated solar home systems without the up-front costs that would be associated with purchasing a system on their own. This pay-as-you-go system with buyout options requires Simpa's continued engagement in the regular maintenance of its products (the firm continues to own the system), until the user is able/chooses to pay-off the system or return it. While Simpa has attracted an impressive degree of additional financing for its expansion, its plans for 10 percent month on month growth is ambitious. Simpa, appears secure in the medium term but uncertainty with respect to public subsidies for solar home lighting systems that may compete with its unsubsidized model, along with uncertain grid-expansion plans, pose risks for the firm's long-term prospects.

Meanwhile, donors like USAID were developing a new cadre of private sector support vehicles. A prominent example of this was the 2010 launch of the DIV approach (see Box 1). These grants, in conjunction with other donor backed schemes including those by the Overseas Private Investment Corporation (OPIC), the World Bank, and the European Bank for Reconstruction and Development (EBRD), began replicating the California experience (i.e., providing access to capital) to developing country enterprises looking to scale their renewable energy offerings to an increasingly large base of potential customers, including to those at the bottom of the income distribution.

FINDINGS AND CONCLUSIONS

While portfolio trends are instructive; not least because they reflect gradually changing priorities and capabilities, this review's main purpose is to provide lessons learned with respect to sustained outcomes and scale. This section draws predominately from 13 in-depth case studies for which the review team collected primary data. These 13 cases come from the Brazil, Tanzania, and India-specific portfolios. A full discussion of country and case selection is included in the Methodology Annex (Annex B); however, the most prominent justifications for each priority county is provided below.

- **Brazil**: Represents a relatively older set of activities from the first half of the portfolio. The Brazil cases were favorable in the sense that their relative age allowed for a retrospective examination of sustainability and scale. Brazil also represents an upper-middle income context with the energy poor mainly residing in extremely remote regions.
- **Tanzania**: Represents a low-access, Sub-Saharan African context with a varied portfolio of ES type investments representative of recent trends. Grant and loan recipients targeted customers across the income distribution in both semi-urban and rural communities.
- **India**: Represents the most active country in the portfolio by number of activities. All investment modalities are represented within the India portfolio, providing a unique opportunity to examine contexts where DE solutions both compete with and complement expanding grid service.

Table 1: Level of Electricity Access Penetration

Country	Proportion of Population with Electricity Access	Proportion of Rural/Urban Population with Electricity Access
Brazil	99.5%	97% rural / 99.9% urban
Tanzania	15.3%	3.6% rural / 46.4% urban
India	78.7%	69.7% rural / 98.2% urban

Source: World Development Indicators, 2012 base year.

Annexes D, E, and F provide the executive summaries of the review's standalone reports for Brazil, Tanzania, and India respectively.[39] While case study profiles are highlighted throughout this report, Table 2 provides a structured introduction of all 13 cases and their relative success in terms of sustainability and scale.

[39] In addition, the full reports are available here: http://pdf.usaid.gov/pdf_docs/pbaaf013.pdf (Brazil), http://pdf.usaid.gov/pdf_docs/pbaaf012.pdf (Tanzania), and http://pdf.usaid.gov/pdf_docs/pbaaf011.pdf (India).

Table 2: Summary of the 13 Case Studies

Case Study Number	Case Study, Investment Modality, and Country	Brief Description	Additional Details	Sustainability Score[40] Max score: 15	Scaled (Y/N)	Relevant Factors Contributing to or Hindering Sustainability and Scale
1	Cachoeira do Aruã (DD), Brazil	Remote community in northern Brazil that received USAID funds to install a mini-grid. USAID funding ended in 2008 and the installation remains functional but now serves double the original number of households. Service has degraded mainly due to the wider user base with no additional generating capacity. Sustainable maintenance services were designed into the implementation approach based on a community ownership model.	Box 11	10	No	Favorable public policies, high-degree of community engagement and strong local partnerships, well-conceived maintenance processes.
2	Maripá and Santí (DD), Brazil	Brazilian NGO IDEAAS received Lemelson Foundation and USAID funds (Agency contribution approximately 10 percent of total) to install 48 household solar systems in two remove communities in northern Brazil. Thirty-five of 48 installations remain operational. Funding was cut earlier than expected resulting in the cessation of IDEAAS' fee-for-service model that was designed to continue operations and maintenance service. In large part due to local NGO PSA's strong community ties, rudimentary maintenance services were adapted, contributing to a modest level of sustainability given the implementation challenges.	Box 18	7.5	No	High degree of community engagement and strong local partnerships.
3	Ceará PV Irrigation (DD, STA), Brazil	Two communities in Ceará State received USAID funds and installed PV powered water pumps assisting 24 households with field irrigation. Funding also supported livelihoods training and marketing assistance to sell organic produce. Systems were maintained for two to three years after the end of donor support; however, foreign part replacement and expensive maintenance needs were beyond the capacity of the community to keep up with. The installations were no longer operating at the time of the review team's visit.	Box 12	0	No	Technology choice was a poor match in terms of sustainability for the communities receiving assistance.
4	Quixeramobim Biofuel Power (DD), Brazil	Starting in 2005, USAID provided coordination and administration support to a proof-of-concept biofuel plant at Quixeramobim, Ceará State. The installation was designed to provide electricity to a nearby rural community. At the end of 2007 the pilot site was shut down. The main-grid was extended to the community the installation was meant to serve, obviating the need for continued service. At its peak, the site provided power to 26 households, a school, and a community center.	Box 13	0	No	Grid extension obviated the need for continued service. Government policy began favoring soybean based biofuels as opposed to castor oil.

[40] Sustainability scores are based on the sustainability matrix in Annex B. The review team assigned a score of 0 to 3 to each of five dimensions of sustainability, allowing for a maximum score of 15.

Case Study Number	Case Study, Investment Modality, and Country	Brief Description	Additional Details	Sustainability Score[40] Max score: 15	Scaled (Y/N)	Relevant Factors Contributing to or Hindering Sustainability and Scale
5	Enalter (CG), Brazil	Commercial enterprise that received a loan from E+Co and Shorebank through a global credit guarantee mechanism. Enalter produces a solar water heating product originally for industrial uses but increasingly utilized by lower-income communities and households. A sustainability score is not applicable because the sites visited were not directly associated with the operating expenses supported by CG backed loan. The business as a whole though has been able to scale its offerings in large part due to favorable public policy and regulatory schemes, thereby providing instructive lessons of benefit to this review. Further, this case provides a valuable comparison between other non-commercial Brazilian cases as well as other enterprise based approaches in India and Tanzania.	Box 7	n/a	Yes	Favorable public policies and regulations requiring a minimum level of spending on clean energy technologies. Viable commercial model with diverse set of operations and wide-customer base.
6	Zara Sola (ES), Tanzania	Zara Solar, related to Mona-Mwanza Electrical and Electronics (MMEE) received three loans from E+Co, a USAID partner that provided technical assistance and access to capital globally through the FENERCA program. Zara utilized these loans to build a successful household solar vertical; first by consulting solar providers throughout East Africa and then purchasing solar products in bulk to reduce costs. Zara's target demographic are well-off professionals in the Mwanza region. The firm has benefitted from favorable contexts including a long-standing Government and UNDP solar technician training operation that allows the solar savvy customer base to procure their own maintenance services at modest cost and high quality.	Box 10	13	Yes	Commercial approach that targets customers that are able to pay for installations upfront. Customers rely on a large pool of maintenance workers trained by a Government-UNDP program that has made solar technology well-known and understood in the region. Access to capital remains a challenge.
7	EGG-Energy (ES), Tanzania	Commercial approach that first sought to develop solar powered battery charging hubs; however, shifted to providing household systems to middle class and well-off residents near Tanga. The case represents a flexible model that was responsive to customer complaints about convenience (with respect to its original battery hub model). DIV-grant funding was provided to test EGG's technology and business model and develop EGG's data infrastructure; contributing to EGG's ability to provide customers the option to pay using mobile money. The firm uses existing agriculture associations to market its products. EGG's ability to remotely shut-off installations for non-payment reduces costs and allows flexibility for seasonal workers.	Box 5	10	Yes	Commercial approach that effectively utilizes existing social networks to market products. EGG shows adaptability in management approach and uses technology to increase efficiencies and provide customers with flexibility. Customers cite slow maintenance response times as an issue and EGG staff note that access to capital is a constraint on growth.

Case Study Number	Case Study, Investment Modality, and Country	Brief Description	Additional Details	Sustainability Score[40] Max score: 15	Scaled (Y/N)	Relevant Factors Contributing to or Hindering Sustainability and Scale
8	M-Power (ES), Tanzania	Off-Grid: Electric's Tanzanian franchise, M-Power, was founded in 2011. The company has expanded to 11 districts throughout Tanzania. M-Power's basic systems feature three lights and a mobile phone charger and costs users approximately $1.25 per week. M-Power has received two USAID DIV grants, both for $100,000. M-Power has experienced significant scaling over the past few years, delivering over 60,000 DE installations across the country, and expanding beyond its home base of Arusha.	Box 8	8.5	Yes	Commercial approach with access to expertise and assistance from Off Grid: Electric. Targets low-income users therefore has a wide potential customer base. Competes with subsidies to low-income households in areas where the grid is rapidly expanding, a concern for the long-term viability of the model.
9	Mera Gao Power (ES), India	Commercial enterprise that received DIV-grant funding to test the viability of its solar powered micro-grid offering. Target customers are the rural energy poor in Uttar Pradesh State. The micro-grid model creates efficiencies in fee collection because multiple households are responsible for service and community members hold each other accountable. Further efficiencies are generated from MGP's expansion plan favoring concentrated operations over geographic breadth. Sustainability is assisted by trained MGP technicians that quickly are dispatched to address customer requests. MGP is rapidly expanding and at the time of the review team's visit in 2015 had scaled to more than 20,000 households.	Box 6	11	Yes	Viable commercial approach providing affordable DE solutions to a wide-base of rural customers. Innovative fee collection procedures reduce risk and geographic concentration allows for quick responses to customer maintenance requests. Uncertainty in grid-expansion poses a long-term investment risk; however, MGP is able to quickly recoup costs based on its current approach.
10	Humana People to People – India (DD), India	HPPI utilized a USAID grant to directly provide 100 solar lantern charging stations (with 60 lanterns each) for use in western Uttar Pradesh (UP). Implemented from 2009 to 2011, the activity had a women's empowerment component that supported women's self-help groups and entrepreneurs. A select group of entrepreneurs were provided the lanterns in-kind and lanterns were then rented out to community members for a fee (ranging from a per night basis in some communities to as long as a month). Since USAID funding ended, the estimated remaining lanterns had fallen from 6,000 to 2,000 due to maintenance issues.	Box 9	6	No	Successfully integrated solar lantern renting models into its women's self-help group model; however, rental fees were not enough to replace the donated lanterns after several years of continued use.

Case Study Number	Case Study, Investment Modality, and Country	Brief Description	Additional Details	Sustainability Score[40] Max score: 15	Scaled (Y/N)	Relevant Factors Contributing to or Hindering Sustainability and Scale
11	Swayam Shikshan Prayog (STA), India	Through the W-Power initiative, USAID funds were used to train female entrepreneurs to sell clean energy products through associated distribution schemes. This sector support was meant to empower women and link them to commercially oriented value chains. To generate demand, efforts were made to promote clean energy technologies at the community level through promotional materials (e.g., extension efforts to rural market stalls, community group meetings, and wall murals), and the establishment of an "energy hub" where nearby residents could assess various products and speak with knowledgeable suppliers. The energy hub also served as the training space for the initiative's female entrepreneurs. At the end of the activity, 1,010 entrepreneurs were trained, selling solar lanterns to an estimated 40,000 households. While respondents indicated that empowerment efforts were relatively successful, there are concerns about the future of the training program and resource center because it is overly reliant on donor assistance rather than revenue generation.	Box 16	10	No	Uses commercially focused DE value chains an an opportunity for female income generation. Successful in this; however, the model is reliant on donor funds to continue running the technology demonstration and entrepreneurship hub.
12	Simpa Networks (ES), India	Commercial enterprise that received DIV-grant funding to test the financial viability of the firm's offerings at scale. By the end of the funding period Simpa had achieved its expansion targets and was growing at a pace of approximately 10 percent month on month. This rapid expansion potential is largely attributable to Simpa's impressive capacity to attract donor backed and commercial capital. Simpa's systems attract higher-end customers than MGP's offerings and are more powerful; albeit the firm provides sufficient financing options to attract a wide customer base. The pay-as-you-go fee structure ensures that the firm is responsible for maintenance while it continues to own the system; however, allows for customers to purchase the system outright – an option that most end-users found attractive.	Box 4	11	Yes	Viable commercial approach providing high-quality home solar systems through flexible financing options. The firm utilizes sophisticated data processing software to improve its risk calculation and marketing approach. Simpa is currently able to attract large amounts of capital however grid expansion uncertainty leaves some domestic debt providers with concerns.

Case Study Number	Case Study, Investment Modality, and Country	Brief Description	Additional Details	Sustainability Score[40] Max score: 15	Scaled (Y/N)	Relevant Factors Contributing to or Hindering Sustainability and Scale
13	Orb Energy (CG), India	Orb Energy is a private enterprise selling distributed solar PV and solar thermal water heaters. In 2012 Orb obtained access to a portable loan guarantee. Orb aimed to scale its operations to establish 500 branches within 3 years. Under this arrangement, Orb at the time of the review team's visit had obtained $1 million from Deutsche Bank with the support of the CG. This first tranche was for backward integration within its solar water heater vertical (i.e., towards setting up a manufacturing facility for solar water heaters with an eventual capacity of 1,500 systems per month, which would result in greater cost efficiencies and improved margins). At the time of the review team's visit Orb was unable to secure the second tranche of funds through Deutsche Bank due the bank's collateral requirements. This case did not examine individual installation sustainability, rather it provides a useful example of how CGs are applied to DE enterprises.	Box 17	n/a	n/a	Viable medium sized firm; but is concerned with changes in the regulatory regime that will lower profit margins for household PV. Seeks to increase its manufacturing capacity to provide services to industrial customers. Accessing capital to achieve this aim has been difficult.

Based on the evidence gathered and analyzed from the 13 case studies presented above, trends in the portfolio, associated literature, and activity documentation, this review presents findings and conclusions across 7 relevant themes contributing to sustainability and scale. These themes are not mutually exclusive; in fact, they overlap a great deal. This report simply uses them to structure findings in an expedient fashion. The themes are:

1. Policy and regulatory issues;
2. Market considerations;
3. Social and economic context;
4. Social structures and community engagement;
5. Gender equality and female empowerment;
6. Operational factors; and
7. System maintenance.

Policy and Regulatory Issues

DE solutions generally provide an alternative to the grid where the grid is unavailable, unreliable, or unaffordable. A 2015 World Bank review of electrification programs stated that in most country contexts conventional grid extension is generally the most cost effective means of increasing electricity access; however, a well-coordinated off-grid strategy is essential in light of geospatial settlement and density patterns.[41]

> *"Off-grid electrification that is well coordinated with grid-based electrification is an essential part of a nationwide least-cost electrification strategy." – World Bank 2015*

Thus, the myriad decisions determining use and appropriateness of grid expansion and DE solutions are determined in part by physical, technical, and economic factors (e.g., population density, levels of demand, topography, etc.), but also by government policies and regulations.[42] A policy example is a subsidy program designed to make certain electrification options less expensive for target consumers. Regulation examples include rules governing market actors and technical requirements governing installation and operation of electricity generation and distribution equipment. Therefore, in this report's vernacular, *policies* are meant to advance particular government priorities while *regulations* establish allowable actions.

Policies and regulations can either enhance or limit the environment for DE. This happens in two ways:

1. Policies and regulations that govern grid operations can promote or limit grid expansion, and correspondingly influence the degree to which DE can act as a grid alternative. Coal subsidies in India meant to favor large centralized power plants is an example of this. Context remains important though. India's subsidized grid electricity rates that are below the cost of supply, coupled with large numbers of unmetered customers are part of why national and state utilities have faced financial hardship and difficulties in expanding the grid. By contrast, in Brazil, mandated rates for low-income and rural customers are also below cost but are coupled with monopoly service territory rules that include universal service obligations. This makes it much harder for DE solutions to compete with utilities in Brazil in comparison to India. This result is seen in communities like the Brazil Pará State cases (Case Studies 1 and 2); where a strictly commercial approach to DE was less viable and scaling appeared to be a lesser priority than was the case with the various ES approaches.
2. Policies and regulations specifically geared to DE either provide incentives and ease the barriers to entry for DE or hinder new DE implementations. This can include incentives for different types of DE approaches, as well as regulatory rules regarding what entities can run electricity operations and how. For example, the provision in the Indian law allowing for independent off-grid suppliers, in theory, opens up a space for DE solutions to meet user needs in the absence of a functioning grid system. DE can also benefit from subsidy or pricing policies (e.g., subsidies on capital costs for installing DE equipment, as in India, or feed-in tariffs for off-grid power, as in Tanzania).[43] It can also be limited by regulations that favor grid extension, as in Brazil. Table 3 provides several examples from Tanzania, India, and Brazil regarding how policies and regulations have enabled or hindered DE approaches.

[41] World Bank 2015.
[42] Zerriffi 2011.
[43] Ahlborg et al. 2014 and Bhattacharyya et al. 2009.

Table 3: Policies and Regulations Enhancing and Limiting DE Performance

Country	DE-Enhancing Policies and Regulations	DE-Limiting Policies and Regulations
Tanzania	• Incentives promoting DE	• Grid expansion policy emphasis • Subsidies for grid electricity
India	• Subsidized rates contributed to poor utility performance and lack of expansion • Electricity Act explicitly allows for local generation • Subsidies for DE technology capital costs	• Current emphasis on grid expansion • Current policy focus on improving grid reliability • Highly subsidized electricity rates • Subsidies for centralized generation
Brazil	• Universal access policy creates incentive for serving rural populations • Franchise model to allow utilities and DE systems to work together	• Subsidized rates for grid electricity are hard to meet for DE systems • Universal service territories for utilities make micro-grids illegal for non-utilities • Universal service mandate for utilities result in expansion of grid and utility off-grid electricity

Policy and Regulatory Uncertainty

Policy and regulatory uncertainty in the energy sector impacts DE enterprises in two ways:

1. Investment: Policy uncertainty or unfavorable regulations create both real and perceived investment risk for potential commercial lenders to DE companies. This can lead to either lower investment or more stringent loan terms that are difficult for DE enterprises to meet.
2. Demand: Demand for DE products or services can be affected as users may be uncertain of investing in the technology amid a perception that the grid will eventually arrive. To the degree that DE is considered a "second-rate" electricity source, users may hesitate to take up the technology in hopes of eventual grid connection.

These factors can be seen in Tanzania, where the regulatory system is under development, and in India, where the regulatory system is more complex and evolving. Tanzania's policy and regulatory environment is among the least developed of the non-CPC host contexts in the portfolio. Until now, the Government of Tanzania emphasized expansion of the grid, particularly in service to economically productive activities. The expansion of the grid into areas of Tanzania where DE enterprises operate has differing implications for the companies, depending on the technology each offers. The EGG-Energy case (Box 5) is especially instructive when it comes to the challenges uncertainty poses for DE enterprises, especially firms targeting middle-class and wealthier customers – likely the first to access the grid once it reaches their communities.

The review team visited Tanzania in 2015 and interviewed sector specialists and energy entrepreneurs. Among entrepreneurs, respondents generally viewed grid expansion as undercutting the market for the DE companies whose operations lay within proposed expansion zones. For example, the head of Zara Solar (Box 10) noted in the interview that its customer base is relatively well-off rural professionals without grid access. These customers are more likely to be able to afford the upfront cost of grid electricity connection, to demand the higher levels of power the grid can provide, and to be able to afford the monthly electricity bill. Zara's customers are also not seeking an alternative or backup for the grid because grid power is cheaper than their solar power system. EGG-Energy faces similar challenges. By contrast, M-Power's low-power offering appeals to those who are unlikely to use grid power due to the higher fees, even with current subsidies.

Box 5: Case Study 7 – EGG-Energy

Engineering Global Growth (EGG)-Energy is a commercial firm providing energy services to rural Tanzanians. Founded in 2009, EGG's original offering was solar powered battery-charging hubs. In 2012, EGG received a $100,000 DIV grant in to test the viability of this model. Over the course of this grant period, EGG recognized that its hub approach to disseminating energy services was found to be inconvenient by customers. The firm then switched its focus to rent-to-own solar systems for household/small business use (systems generating between 50 and 200Wp). EGG also tapped into agriculture networks as a key customer outreach tool when it switched its operations away from its base in Iringa, towards Tanga. The 2013 DIV grant (also $100,000) was provided to improve EGG's data infrastructure, which linked mobile money systems with the company's customer service records; developed data applications to track logistics, inventory, and customer management; and trained staff to use new software systems.

USAID support for EGG-Energy has only recently ended; however, the adaptability of the firm provides instructive lessons in flexible commercial approaches to DE programming. EGG's original battery-charging hubs remain operational, but exposed the firm to non-payment risks which became evident early in the 2012 grant's implementation. The revised approach will likely be more sustainable based on several promising improvements: (1) EGG provides financing options to customers based on a rent-to-own scheme, widening its customer base and encouraging customers to payoff systems instead of losing accumulated equity. (2) EGG now uses Global System for Mobile Communication (GSM) applications to switch off systems that have outstanding payments. This reduces the need to repossess units unless payment remains delinquent for extended, and un-communicated, periods (EGG is flexible with seasonal workers with unsteady incomes). (3) Partnerships with agricultural organizations have shown to be a successful way to market offerings to target customers and conduct basic customer-credit inquiries. The review team concluded that EGG's model has the potential to scale; however, EGG employees claimed that poor access to capital is a constraint on the firm's growth. Staff also stated that USAID early-support has been instrumental in attracting the financing the firm has been able to secure. Further, EGG's model requires a critical mass of customer penetration in any given region to make viable its O&M model; making rapid expansion to new regions challenging. Grid expansion also poses a medium to long-term challenge; EGG's CEO stated that grid-connected customers typically remain interested in off-grid solutions due to reliability concerns; yet, nonpayment is more common within this demographic.

By contrast, India has a long record of policy and regulatory development in the electricity sector, including for DE. The issue in India is less about an underdeveloped and underspecified institutional structure and more about overlapping jurisdictions and shifting policy approaches and priorities. In India, lack of clarity regarding long-term commitment to DE, and the role of grid expansion as the country enacts ambitious energy access initiatives, affect the role of and support for DE. Policies and programs have been implemented to support DE in India, particularly since the Electricity Act of 2003 opened up the possibility of private sector participation in DE. However, areas of ambiguity remain and require further policy and regulatory development. For example, respondents in India raised the issue of private micro-grids installed in areas that will eventually be grid connected. Lack of clarity on what will happen to those capital investments if the grid arrives increases the perceived investment risk. This is an issue particularly for commercial approaches that will depend on access to capital to grow and will need to be able to demonstrate the ability to generate returns for their investors (Mera Gao Power provides a useful illustration of this, see Box 6).

In addition, the emphasis on DE as part of the solution to rural electrification has shifted over the years, with the current Indian Government placing the greatest emphasis on rapid grid extension.[44] A government official noted that energy access requires more than just meeting minimal household needs.

[44] Based on interviews with Ministry of New and Renewable Energy, 2015.

In his view, DE (1) provides minimal power compared to the grid, (2) is limited to households, (3) is not primarily geared towards productive activities, and (4) is expensive. as people lower down the income distribution tend to end up paying more per kWh. Other interviewees in India also noted that in many cases DE acts as a temporary substitute for the grid when it is either not yet available or is unreliable, implying that significant efforts to extend and upgrade the grid will shrink the market for DE. This balancing of considerations is an important one: one the one hand, grid extension in the Indian contexts makes sense from the perspective of public-aims geared towards achieving universal access; however, DE enterprises will need access to considerable capital to complement the grid in places where (1) it is unreliable, (2) does not produce the quality or quantity needed, or (3) is not likely to arrive in the near future. Without certainty of how and when the grid will be expanding, investors will continue to see risks associated with investing in DE enterprises, especially those whose business models essentially compete with grid service.

Box 6: Case Study 9 – Mera Gao Power (India)

Mera Gao Power (MGP) received a USAID-DIV grant in 2011. Funding was provided to (1) build off previous pilot-testing and test the commercial viability of MGP's solar micro-grid technology and (2) assess the development impact of these micro-grids on the lives of customers. Activities were concentrated in Uttar Pradesh. MGP reports having reached 20,000 households across 1,073 villages with its micro-grid operation.

MGP operates an unsubsidized-driven business model and has witnessed rapid growth. MGP's success to date has been on account of its standardized micro-grid technology that caters to basic energy needs at an accessible price with prompt and hassle-free service. This service includes a customer service line that logs customer complaints and dispatches an MGP trained technician to address maintenance issues. MGP's fee collection approach has been effective; where a weekly fee is collected from community customer groups that hold individuals accountable. Another critical factor that has contributed to MGP's growth has been its focused operations within a limited geography, which has contributed to efficiencies in operations. The main threat to MGP's business model is from the arrival of the main grid into communities it is currently serving, but 100 percent household connectivity and reliable energy service provision through the main-grid appears unlikely in the medium term. A factor that will determine MGP's future growth is its ability to develop innovative solutions to meet the increasing aspiration levels of their customers.

Image 5: MGP micro-grid household connection point in Maniharanpurwa Village. Photo by: Narmada Purohit, MSI

An additional administrative factor, affecting large and small countries alike, are the associated challenges of overlapping jurisdictions and authorities. In large economies like India, individual states wield their own incentive programs, plans, and regulations, obliging DE operators to comply with both national and state level requirements. In small countries, efficiencies of scale encourage regional integration of major power producing investments that will likely result in similar operating landscapes such as that of a federated system.

State or community based policies and regulations can be just as impactful to DE as national ones. For example, while seeking to support the emergence of a commercial solar energy market, the State Government of Uttar Pradesh, India is simultaneously providing free solar home systems to below-poverty-line households. This has two potential effects. First, it can directly reduce the customer base seeking commercial DE solutions (e.g., households obtaining free systems would not likely join an MGP micro-grid, for instance). Second, it could indirectly dissuade non-beneficiary households from obtaining their own service or system in the hopes of obtaining a free system – particularly if the subsidy program is poorly targeted. No evidence yet shows that the free system program has had an impact on commercial solar suppliers in Uttar Pradesh, but the program is ongoing.

Market Considerations

The key market factor that emerged from the review was the need for commercial capital to support promising new market entrants and enable growth for the purpose of scaling. If viewing DE from the perspective of an individual installation (e.g., a solar home system), it is remarkably low-cost in comparison to the expense of expanding the grid. However, at the scale needed to electrify a whole community or set of communities, the capital requirements to establish and expand a DE commercial operation can be significant. For non-commercially oriented approaches (i.e., NGO-led) that may not seek expansion through the same pathways an enterprise would, the lack of commercial capital may be of little importance because donor funds are used to achieve activity priorities. However, commercially oriented investments tend to prioritize diversifying their offerings, expanding their customer base, assuring revenues, and generating profit; in other words, they are more likely to seek scale. For scaling to occur at the necessary pace to achieve global electricity access targets and attract talent, donor-provided capital alone is unlikely to be sufficient.[45]

Of the 13 investments studied in-depth, seven were commercially oriented and run by private companies. All seven relied on some form of outside capital in addition to the support of USAID. Furthermore, the funds from USAID were a small portion of the total capital raised by the commercial entities, though arguably it came at important junctures in the firms' growth (e.g., Zara Solar in Tanzania and MGP in India). Outside capital took the form of other grants, social impact investment capital, and commercial private capital, as seen in Table 4.

Table 4: Comparison of USAID Funding with Known Sources of Funding from Other Actors

Activity	USAID Funding	Investments from Non-USAID Sources	Note
India – Mera Gao Power	ES grant $300,000	$2.4 million	Combination of grants, debt and other financial commitments, mainly from impact investors.
India – Simpa Networks	ES grant $968,000	$6 million	Combination of debt and equity from impact investors. $2 million

[45] Williams 2015, Bhattacharyya 2013, and Glemarec 2012.

Activity	USAID Funding	Investments from Non-USAID Sources	Note
			came the same year as USAID funding.
India – Orb Energy	CG backed loan $1 million	Specific amount unknown	Combination of debt and equity from impact investors, including public development finance institutions.
Tanzania – Zara Solar	ES loan $350,000[46]	Specific amount unknown	Donor-supported investment funds.
Tanzania – EGG Energy	ES grants (x2) $200,000	Specific amount unknown	GDF-Suez, Invested Development, and other donor supported investment funds.
Tanzania – M-Power	ES grants (x2) $200,000	$7 million	Impact investors, donor backed funds, and private-equity lenders through its ties to Off:Grid Electric.
Brazil – Enalter	CG backed loan $26,000	Specific amount unknown	Reliance on public policy minimum spending schemes incentivizing clean energy use.

All DE activities across the three countries that took a commercial approach to implementation reported difficulties with either obtaining capital at all or the terms under which the capital was offered. Enterprise recipients, as well as sectoral level interviewees, said that traditional financial institutions are generally unfamiliar with the DE sector and unable to appropriately underwrite loans for innovative startups. Specific issues respondents mentioned include:

- Investors do not have the proper models to assess DE businesses. For example, banks in India would use balance sheet or collateral based underwriting (i.e., assessing a business on the basis of prior revenues, expenditures, and assets), which start-ups would have a difficult time demonstrating. Cash-flow based financing, based on current and expected revenue flows is arguably more relevant for the types of companies operating in the DE sector, but is not widely used in India. Furthermore, banks have one set of lending processes regardless of loan size, making it harder for smaller ventures to access capital.
- Investors viewed DE as a high-risk investment and were unwilling to lend. Investors view the sector as high-risk, due to their relative unfamiliarity with the technology and the market, the risks related to low-income consumers (i.e., payment ability, default rates), and the sectoral risks (e.g., grid expansion, policy uncertainty). For example, all three commercial implementers in Tanzania mentioned difficulty in attracting needed capital. One noted its reliance on grant mechanisms to scale up to a point where it would be "attractive" to outside capital.
- Due to the perceived and real investment risks in this sector, willing investors can leverage their position to generate terms that DE implementers cannot accept, particularly at this nascent stage of the market's development. In particular, required rates of return were such that investors expected to recoup their investment more rapidly than small-but-growing DE companies could deliver. One interviewee in India noted that banks may require greater than 12 percent cost of capital. The same respondent said that start-up DE companies might more comfortably be able to generate 10 to 12 percent returns. In one Indian case, even with a DCA-guaranteed loan, Orb Energy was unable to secure the necessary funds for its planned solar power operations because it could not meet the investment bank's strict lending requirements.

[46] It remains unclear whether or not all three E+Co loans were supported through the USAID-FENERCA program.

Access to Capital

Enterprise loan and grant recipients perceived USAID funding as a powerful legitimizing agent for their business models and DE offerings. Enalter in Brazil (see Box 7) credits their CG as instrumental in obtaining further financing. Others receiving DIV-grant funding (e.g., Mera Gao Power and Simpa) echoed this. However, in the absence of a fully functioning commercial capital market for DE, implementers continue to rely on donor funds or social enterprise capital. For the DE sector in India, this is a major challenge. India's relatively long history of DE, large market for DE solutions, and technological and entrepreneurial base would suggest that it should be in a position where the sector has significant potential to attract private debt. However, according to a number of respondents, the financial sector's reluctance to engage in the DE sector is an impediment to growth.

Box 7: Case Study 5 – Enalter (Brazil)

Enalter is a Brazilian commercial enterprise that received a $26,000 loan in 2007 through a global CG mechanism held by E+Co and Shorebank. Enalter sought to expand its operations budget and marketing mechanisms for its solar water heating systems. While these heating systems are not meant for electricity generation, this case was selected because it represents a contrasting commercial approach relative to the other cases in Brazil. At the time of USAID's investment, Enalter was mainly serving middle-class customers; however, in the intervening years, Enalter contracted with multiple state-sponsored programs to provide solar water heating systems to lower-income clients.

Enalter representatives cited receipt of the USAID-backed loan as a contributing factor to their success in attracting further sources of financing. The review team concluded that the Enalter case was the most sustainable in the sense that it is a growing business with a gradually increasing customer base and strong maintenance and customer service reviews. Contributing to Enalter's success is national and state policies that mandate that 0.5 percent of utilities revenue be reinvested in energy efficiency programs, hence Enalter's participation with state-sponsored distribution schemes to lower-income customers.

Access to capital results in tangible operational choices. For example, DE enterprises may target the relatively well-off because these customers are able to pay up front fees and installation costs (e.g., Zara Solar). On the contrary, Simpa and MGP, who have been able to access greater amounts of capital than Zara and EGG, translated this financing into lower upfront costs to their customers and fairly elaborate warranty options, thereby increasing consumer confidence. Across all the enterprise cases, staff and managers stated that for enterprises to scale after donor assistance ends, access to capital is vital to the expansion of operations into new geographies or product lines.

Social and Economic Context

Over the course of the review, several socio-economic considerations were found to affect DE operations, which subsequently contributed to or hindered the potential for sustaining outcomes and achieving scale. The next three sections therefore examine DE use, sustainability, and scale through the lenses of (1) socio-economic status, (2) the ability to use existing social networks and cultivate community ownerships, and (3) gender.

Socio-Economic Status

Socio-economic status, wealth, and prestige is a key factor influencing household decisions. Wealth influences both the level of energy services demanded and the ability to pay for both the appliances needed and the electricity required to power them.[47] The large majority of the world's population that lacks

[47] Masera et al. 2000 and Kowsari et al. 2011.

electricity access resides in rural areas (approximately 87 percent of 1.1 billion people worldwide lacking access[48]). By definition, rural areas have low population density, are more remote and tend to have consumers with low consumption levels. This all makes grid extension costlier and those costs are harder to recover.

Box 8: Case Study 8 – M-Power (Tanzania)

Off-Grid: Electric, known in Tanzania as M-Power, is a clean-energy start-up that began selling low-cost lighting and cellphone charging services at prices competitive with kerosene. The firm's Tanzanian offshoot was founded in 2011 and uses Arusha as its base of operations. The company has since expanded with offices in 11 districts throughout Tanzania. M-Power's basic systems feature three lights and a mobile phone charger and costs users approximately $1.25 per week. M-Power has received two USAID DIV grants. The first in 2013 was for $100,000 and assisted with operating costs and was meant to facilitate company growth from roughly 500 installations to 1,500 installations. The second, in 2014, also for $100,000, was designed to test the firm's model at scale in new locations and with new approaches to agent training and compensation.

At the time of the review team's visit, M-Power reports having installed over 60,000 systems with a repossession rate of approximately three to four percent. A key component of M-Power's success is that it has been able to provide an offering that is competitive with kerosene and uses advanced software systems to track company performance and customer usage statistics. The firm has created a four-week academy that trains potential M-Power employees in basic business practices and M-Power's technical offerings. This training program has allowed M-Power to staff its rapidly growing number of offices spread out over 11 districts. A customer complaint is that M-Power uses a fee-for-service approach with no option for customer buyout of the system. Grid expansion poses risks because low-usage customers (those using less than 50kWh per month), are eligible to receive a subsidy from the national utility that would effectively offer low-quantities of energy at a third of M-Power's weekly rate. Accessing this subsidy of course requires the grid's presence in one's community (and $20 connection fee). For households consuming more than 50kWh, M-Power's offering remains competitive; although M-Power's services typically cater to basic needs. Despite these medium to long-term challenges, M-Power has achieved a remarkable degree of beneficiary and geographic coverage and shows strong potential to sustain its operations if is able to adapt to Tanzania's rapidly changing set of regulatory and economic contexts.

DE solutions are advantageous in these rural contexts because they can operate off-grid. Recognizing that rural individuals and households are not a homogenous group, the USAID portfolio provides valuable opportunities to compare different offerings targeting different types of rural customers. For example, Simpa and MGP both operate in Uttar Pradesh, India and use a solar-based technology. Yet Simpa's offering provides more power (at a higher price) than MGP's. A similar comparison can be made between the three Tanzanian cases because they each target a different income group. Zara targets relatively well-off rural professionals; Egg-Energy targets the middle-tier, usually agriculture oriented consumer; and M-Power (Box 8) focuses on lower-income consumers. Each of these three Tanzanian examples provides different levels of service with associated tradeoffs in user fees and services included (e.g., maintenance).

Profit-Driven Approaches

For the profit-driven set of cases, market segmentation based on wealth and ability to pay was dependent on the particular distribution of wealth in a given region. The socio-economic makeup of a target region therefore has implications for scalability and replicability of any given model as it seeks to expand and capture different geographies or customer groups. This raises the possibility of competition between commercial DE solutions; although during the course of the review, the review team did not observe direct competition between any two USAID supported investments (or investments made by other large donors for that matter). This may be for two reasons:

[48] Review team's calculation based on World Development Indicators.

1. Investments, even in the same geographic area, served different segments of the market through their different offerings (e.g., the Tanzanian cases).
2. In at least two country contexts (India and Tanzania), the number of rural households without access to electricity remains quite high (both in absolute and relative terms[49]). Thus the market remains large and unsaturated. For instance, MGP operates in an area that has multiple solar system providers, a state-level subsidized solar program and grid expansion. However, the large market size and particular type of offering MGP implements still provides scope for expansion. Relatedly, M-Power in Tanzania noted that population growth was outpacing grid expansion, so their market continues to grow.

NGO-Led Approaches

NGO-led activities typically approached their investments outside of the profit motive. Rather this set of activities typically implemented their programs with social or human development priorities in mind. Indian-NGO HPPI provides a clear example of this (see Box 9). While HPPI encountered sustainability challenges because there was no mechanism in place to replace solar lanterns as they broke down, end-users were largely satisfied with the product when it was first provided (both in terms of cost and quality). Further, the introduction of solar lanterns through the HPPI activity coincided with small scale clean energy supply shops appearing in rural communities of Uttar Pradesh (HPPI's focus area). While multiple factors likely influenced this, HPPI staff and beneficiary respondents both said that the introduction of the solar lanterns helped increase demand for energy – meaning once an individual has access to lighting, they are unlikely to go without it again by choice. Criticisms to the approach include the lack of sustainable mechanisms to replace donated lanterns or to keep pace with rising energy needs and expectations of an increasingly energy literate user base.

Box 9: Case Study 10 – Humana People to People (India)

Humana People to People – India (HPPI), utilized a USAID grant and in-kind support from the Tata Energy Research Institute to directly provide 100 solar lantern charging stations (with 60 lanterns each) for use in western Uttar Pradesh (UP). Implemented from 2009 to 2011, the activity had a women's empowerment component that supported women's self-help groups. These groups were geared towards pooled savings plans that assisted women in times of personal shocks (e.g., a family health crisis), micro-investments (e.g., to start a commercial activity), and selected female entrepreneurs to start up solar lantern rental businesses to support the larger community's lighting access needs. Female entrepreneurs were provided the lanterns in-kind and were usually selected from within the existing self-help group structures. Lanterns were then rented out to community members for a fee (ranging from a per night basis in some communities to as long as a month).

At the time of the review team's visit in 2015, it was estimated that between 50 and 60 percent of the solar lanterns were still in working order, which given the typical life-span of similar products, was in line with expectations. There is no mechanism in place to replace the donated lanterns or continue servicing them to extend their already stretched lifespan. An indirect achievement was a noticeable increase in demand for solar products in the communities HPPI served, according to residents. "Saur Urja shops" are entering the market displaying a number of solar products with increasing sophistication. A concern for these shop keepers however is that their more expensive, higher-quality products, compete with cheap, low quality imported torches which are more accessible to the low-income communities that make up the bulk of the energy poor in western UP. The female entrepreneurs renting out the HPPI lanterns noted that their small-business ventures contributed to an increase in their household's income and increased their agency within the community. The review team concluded that HPPI's model was successful in empowering specific female entrepreneurs and the women's groups it works with; however, the technical products it provided are unlikely to be sustained or replaced in the long-term and its model is unlikely to scale due to its reliance on donor support.

[49] See Table 1.

Social Structures and Community Engagement

Prominent in the literature is the theme of end-user participation,[50] however, this can take multiple forms based on context and technical approach. Most relevant to the USAID portfolio are themes concerning social networks and community engagement.

Leveraging Social Networks

The ability to use existing social networks or create new ones for marketing or sharing costs is a typical component of successful DE investments.[51] A challenge for commercial DE actors is deciding how to penetrate a new market and how to effectively serve that market. Existing social structures can provide a potential marketing avenue or can be used to reduce transaction costs. Examples include the use of community or self-help groups (e.g., MGP and HPPI) or existing retail networks that can serve as distribution points (e.g., Case Study – 11: Swayam Shikshan Prayog). Zara Solar (Box 10) benefitted from an existing Government-UNDP training scheme near its base of operations. The program trained a cadre of clean energy technicians that resulted in an advantageous scenario for Zara Solar; whereby the firm did not have to directly provide ongoing maintenance services. This was due to the large reservoir of trained clean energy technicians in the area, and the ease at which customers could contract directly with technicians at an affordable rate and convenient turnaround time. Similarly, M-Power has achieved relative success in cultivating its own pool of technicians and human resource officers through its multi-week training program. This has helped M-Power achieve both market depth and breadth across 11 districts in Tanzania.

Box 10: Case Study 6 – Zara Solar (Tanzania)

Zara Solar is related to the older company Mona-Mwanza Electrical and Electronics (MMEE). MMEE/Zara received three loans (in 2001, 2004, and 2005) from E+Co, a USAID partner implementing an enterprise support and technical assistance program called FENERCA. E+Co, through the FENERCA program and on its own, provided technical assistance and access to capital to MMEE/Zara in order to build the firm's expertise and offerings in the solar market. Starting in 2000, MMEE became increasingly interested in selling solar home systems and began working with solar experts in East Africa, including E+Co. The 2001 loan of $50,000 allowed MMEE to expand its retail business to include solar PV systems. E+Co provided technical assistance to help MMEE complete a business plan and in 2004 disbursed a second loan for $100,000. The second loan enabled MMEE to purchase solar PV components in bulk. As a condition of the third loan ($200,000), MMEE split its operations into two; opening Zara Solar, Ltd. MMEE/Zara maintained the same owner, location, and business model, but Zara exclusively provided customers with high-quality solar PV systems targeted to relatively well-off rural residents of the Mwanza region.

The review team found Zara to be the most successful in terms of sustainability among the three Tanzanian cases. A major contributing factor to Zara's sustainability is its strategic partnerships with a Tanzanian Government-UNDP collaboration that trains solar technicians and maintenance workers in the region. At least in part due to the solar training scheme, the region enjoys a sophisticated understanding of solar products, which supports demand for Zara's offerings and allows savvy consumers to easily tap into technician networks to maintain purchased systems. Zara's upfront pricing reduces risk and financing costs for the company, but also limits its customer base to those who can afford the system in full. Zara's systems provide sufficient power to meet household needs for lighting and television and can support small-scale entrepreneurial activity. The firm has experienced substantial growth in recent years; although it has not expanded beyond the Mwanza Region. Because of Zara's business model, strategic partnerships, and Mwanza's structural advantages, the review team speculates that scaling the firm's offering outside of Zara's home region would require significant adaptation.

[50] See Brass et al 2012, Mansuri and Rao 2013, Hirmer and Cruikshank 2014, and van Els et al 2012.
[51] Van der Kroon et al. 2013.

In both Brazil and India, the NGO-led activities relied heavily on social networks. An example of this is the case at Cachoeira do Aruã (Box 11), where the implementer latched maintenance responsibilities to an existing community association with the capacity to organize its members and continue to develop the skills needed to manage the micro-hydro system well after donor funding ended.

Box 11: Case Study 1 – Cachoeira do Aruã (Brazil)

From 2005 to 2008, USAID directly supported a micro-hydropower installation in Cachoeira do Aruã, Pará State in Brazil's northern Amazon region. The case utilized the implementer's PRISMA model, which is a project design paradigm that couples sustainable livelihoods and enterprise development approaches to (1) confirm community ownership of the power generator and (2) raise beneficiary incomes. At the time of the review team's visit in 2015, the mini-grid was still functioning. The number of households receiving service doubled from 60 to 120 between the end of USAID support and 2015. According to community members, this growth in beneficiary utilization resulted in a degradation of service to original users due to the system's relatively consistent output level. Conditions that contributed to the system's sustainability included favorable national and state policies, a high degree of community engagement, and strong partnerships with local NGOs. There was no indication that the mini-grid investment was replicated or scaled elsewhere.

Another example is EGG-Energy which gradually adapted its business model to target local agriculture associations. These networks, especially for the commercial approaches, served as powerful tools for efficiency and growth insofar as they acted as a pipeline for new customers.

The Mera Gao Power micro-grid model provides a different view. The firm's model is based on the creation of a self-selected group in the community meant to hold individual consumers responsible, like that of a microfinance program. This approach provides MGP with fee collection efficiencies, thereby reducing its collection costs and providing assurances that fewer customers are likely to become delinquent in their payments.

Community Engagement

Community engagement is a form of end-user participation that is applicable to the project design process;[52] and can institute (1) project flexibility to adapt to community based needs;[53] (2) consensus oriented community decision making;[54] and (3) end-user financing.[55] This report distinguishes this form of participation from the social network discussion above because these approaches tend to be applied to medium to large sized installations serving a broad base. These installations, like that of Cachoeira do Aruã's micro-hydropower generator, typically feature some need for shared decision making – distinct from the portfolio's enterprises that more typically offered household solutions.

The Brazil cases provide the clearest lessons relating to community engagement. In these models, community ownership, governance, and continued maintenance was a key factor in sustaining outcomes; yet, these were not sufficient on their own. With the exception of Enalter, the Brazil cases represent non-commercial approaches to DE and did not prominently feature end-user financing schemes to maintain the systems. The Ceará State communities of Barra de Córrego and Bom Jesus provide a useful example (Box 12). At these sites, community engagement was part of the planning process and resulted in community capacity to maintain systems for a time; however, community engagement was insufficient to repair complicated equipment not easily accessible by residents, nor establish the financial mechanisms necessary to repair expensive equipment when maintenance needs exceeded the routine.

[52] Brass 2012 and Mansuri and Rao 2013.
[53] Kruckenberg 2015.
[54] Kruckenberg 2015, Ansell and Gash 2008, and Terrapon-Pfaff et al 2014.
[55] Bazillian et al 2012, Brass et al 2012, Sovacool 2012, and Terrapon-Pfaff et al 2014.

Box 12: Case Study 3 – Ceará PV Irrigation (Brazil)

From 2003 to 2008 USAID provided support to two communities named Barra de Córrego and Bom Jesus in Ceará State in northeastern Brazil. This support was funded through the Energia Produtiva and Energy and Development Programs. Agency investments assisted in (1) the installation of solar PV powered water-pumping and micro-irrigation systems, (2) capacity building for farmers in organic agriculture practices, and (3) commercialization support for marketing the produce grown using the irrigation systems (e.g., business planning, credit acquisition). The installations in Barra de Córrego and Bom Jesus were able to operate for two to three years as a result of beneficiary engagement and sufficient training to maintain the systems for a time. At the end of USAID involvement, the PV-systems were helping 24 households irrigate their fields. However, the water-pumping system eventually began to malfunction. The installations utilized Danish parts and was expensive and time-consuming to repair. By the time of the review team's visit in 2015, the operation had ceased entirely. Beneficiaries further cited difficulties in marketing the organic products produced at the sites. The review team identified no evidence of scaling or replication of this activity.

The moderately sustained Pará State installations at Maripá and Santí (Box 18) relied on a straightforward solar PV offering and the community was sufficiently trained to provide routine care for the installations. Notably, the Maripá and Santí installations utilized community engagement to build local ownership, but also leveraged the existing capacity of a locally-based NGO to provide continued assistance after donor funding was cut. End-users noted that the presence of the local NGO was vital to sustaining operations. This type of partnership more closely resembles the leveraging of existing networks, not dissimilar from Zara Solar's reliance on the Tanzanian Government-UNDP scheme, rather than the form of community engagement that prioritizes shared community participation and decision making. That said, Maripá and Santí's strong community engagement early on in the activity's design likely contributed to the systems' resilience to the premature withdrawal of donor funds.

Box 13: Case Study 4 – Quixeramobim Biofuel (Brazil)

Starting in 2005, USAID provided coordination and administration support to a proof-of-concept biofuel plant at Quixeramobim, Ceará State. The pilot site was financially supported by the state government and a consortium of companies called CENP Energia. The installation was designed to provide electricity to a nearby rural community. At the end of 2007 the pilot site was shut down. The main-grid was extended to the community the installation was meant to serve, obviating the need for continued service. In addition, no evidence was found to suggest the pilot site was replicated elsewhere. Around the same time, the Brazilian government shifted its priorities towards soybean based biofuel as opposed to the pilot site's use of castor oil.

While utilizing existing networks is helpful for all technical delivery approaches, community engagement appears to be most associated with approaches that provide a DE generator that is widely shared (e.g., Cachoeira do Aruã) or will require shared maintenance systems to sustain remote operations (Ceará PV). That said, all the cases that exhibited moderate to high levels of sustainability had some mechanism in place to tailor their offerings to existing needs and capacities or designed their offerings to build that capacity. The case that exhibited the greatest lack of sustainability exhibited neither. The biofuel pilot at Quixeramobim (Box 13) was neither sustained nor scaled. Based on available documentation and interviews with the implementing partner, it is not clear if the biofuel pilot was ever meant to be sustained. A fee scheme developed with the community via USAID support suggests that it was; however, the arrival of the grid so soon after the initiation of the site suggests that the grid's arrival had been long expected. Further, operations and maintenance funds available through the implementing consortium were unlikely to continue service for very long after the pilot completion.

Communications and Sectoral Assistance

Elsewhere in the portfolio, large sectoral support mechanisms and regional integration programs prioritized stakeholder engagement, coordination, and sustained communication efforts. Two prominent

examples of this are the SARI-E Program (Box 15) and LESSP (Box 14). A 2015 Performance Evaluation of LESSP[56] found that communication was lacking between the project and institutions within the host government. According to the report, this contributed to a lack of ownership felt by host government actors. This was likely harmful given that the project was in part designed to bolster the capacity of such institutions in the delivery of energy services.

Box 14: Liberian Energy Sector Support Program (LESSP) Profile

LESSP was concerned with (1) increasing sustainable access and affordability of electricity for rural and urban communities, (2) improving performance of local governments, civil society and private sector actors in monitoring, regulating, and managing renewable energy resources, (3) increasing the percentage of households and businesses utilizing clean energy, and (4) changing policies to improve the investment climate for the energy sector. An estimated $8.8 million was used to demonstrate, through pilots, rural energy service delivery mechanisms; however, these were not completed. An estimated $3 million was used to provide short-term training to senior managers within the Rural and Renewable Energy Agency; however, funds were used to fill critical staffing gaps. This activity's performance was likely impacted by the Ebola crisis that occurred during LESSP's period of performance.

A 2015 performance evaluation concluded that biomass pilots associated with LESSP ran into critical challenges relating to technology choice and local capacity. The evaluators recommended additional research and development support to find a solution to the adverse effects of crude palm oil and other biomass inputs on the gasifier technologies of choice. The evaluation report further concluded that there was little in the way of construction or implementation oversight for the biomass facilities, and the cooperatives expected to operate the sites would need extensive capacity building support to pilot the operation. Capacity gaps included revenue and expense planning as well as the need for sustained collaboration with qualified engineers. An interviewee from one of the cooperatives that received support stated that the LESSP training, "amounted to having a four-year college course crammed into two weeks." The evaluation report also noted that the solar technologies supported by the project represented a relatively more successful technology choice given the challenges experienced with specific biomass investments.

SARI-E experienced other communications challenges within its stakeholder networks. According to its Phase 3 Final Evaluation Report,[57] SARI-E's programs would have benefitted from increased stocktaking, and sharing of best practices and lessons learned. Few stakeholders knew what other project components were accomplishing. The 2011 report concludes that SARI-E partners likely would have been able to accomplish greater integration across the region if lessons about DE financing and beneficiary impact were discussed among its wide-network of actors working on similar grants and investments.

Box 15: South Asia Regional Integration-Energy Project (SARI-E) Profile

SARI-E Phases 2 and 3 were both part of this review. While this review counts the activity as headquartered in India, it maintained country coordination offices across the region. SARI-E was broadly concerned with building institutional capacities, promoting private sector and civil society participation in energy policy, and creating and strengthening regional forums, networks, and associations across the South Asia region. Starting in Phase 2, SARI-E initiated a small grants program that utilized DE technologies. Grants funded a number of DE installations, commercial actors, and sectoral assistance activities. These included: (1) strategic planning and technical assistance to the Lahore Energy Supply Company to develop a solar electricity program; (2) a survey of household energy needs and consumption patterns for a consumer rights group; and (3) various grants to universities and NGOs to directly install mechanized water pumps and solar powered lighting systems. Reports suggest that the direct delivery schemes suffered from premature breakdown of vital technical components (e.g., batteries). Phase 3 continued the small grants program and coupled these investments with general STA support. Examples include: (1) installing PV powered water pumps for agricultural uses in rural Bangladesh, (2) women's empowerment schemes promoting clean energy enterprises in India, (3) support to the micro-hydro sector in Nepal, (4) building capacity to utilize biomass technologies in rural Sri Lanka, among others.

[56] USAID 2015b.
[57] USAID 2011.

Gender Equality and Female Empowerment

The 2010 Quadrennial Diplomacy and Development Review and the 2012 USAID Gender Equality and Female Empowerment Policy recognize women as powerful agents for human and economic development.[58] Further, the 2012 USAID Policy requires Missions and operating units to integrate gender equality and female empowerment approaches into their program cycle and requires Agency staff to hold implementing partners accountable to this aim as well. Recognizing that this review is retrospectively examining a portfolio that was largely implemented prior to this directive, only a small number of investments meet the standards described in the policy. There are, however, instructive lessons to be drawn from those activities that did approach DE through the lens of female empowerment - especially as they relate to sustainability and scale.

Available Evidence

There is a limited evidence base relating to the causal relationship between energy access and female empowerment. This is likely due to a research trend in electrification studies favoring household surveys instead of intra-household interviews.[59] This trend limits the incorporation of female voices into study conclusions because a household is considered to be one unit, never mind the differing experiences of the individuals within that household. This is surely a weakness of the academic and policy community and findings from this review suggest that future programs would greatly benefit from better data concerning these intra-household trends. That said, several activities within the portfolio specifically targeted female beneficiaries and their experiences naturally differed depending on investment scope and context.

Box 16: Case Study 11 – Swayam Shikshan Prayog (India)

From 2012 to 2015, Swayam Shikshan Prayog (SSP) received USAID grant support for the purpose of strengthening DE distribution pathways in Maharashtra and Bihar. USAID funds were used to train female entrepreneurs to sell clean energy products through associated distribution schemes. To generate demand, efforts were made to promote clean energy generation technologies at the community level through promotional materials (e.g., extension efforts to rural market stalls, community group meetings, and wall murals), and the establishment of an "energy hub" where nearby residents could assess various products and speak with knowledgeable suppliers. The energy hub also served as the training space for the initiative's female entrepreneurs. At the end of the activity, 1,010 entrepreneurs were trained, selling solar lanterns to an estimated 40,000 households.

USAID support for SSP only recently ended, making an assessment of sustainability provisional. This report speculates that while existing systems have been sustained to date, long-term funding systems are not in place to ensure the sustainability of the SSP entrepreneurial-training model, nor the long-term operations of the energy-hub. Social benefits of the program included an uptake in solar lamp usage to replace kerosene across the regions where entrepreneurs operated. In addition, the female entrepreneurs interviewed stated that they have gained stronger household decision-making authority because of the income they are able to bring into the home. Without continued donor support, it is unlikely that the SSP model will achieve scale beyond its current network.

Activities Specifically Targeting Women

The investments in the portfolio that did specifically target female beneficiaries typically did so in the form of livelihoods support. DE technologies were typically used among these investments as a vehicle to achieve increased income generating opportunities for women, rather than structurally targeting energy

[58] U.S. Department of State 2010 and USAID 2012b.
[59] Pachauri and Rao 2013.

access constraints. While these goals are certainly complementary, the mechanisms by which these investments were implemented resulted in differing immediate outcomes.

Image 6: Entrepreneurs discuss services provided at the SSP hub in Latur District, Maharashtra. Photo by: Narmada Purohit

Examples from the portfolio that viewed DE technologies as female income generating opportunities include mainly DD and STA investments implemented by NGOs. The nature of these investments affords USAID more control in activity design and implementation decisions than an enterprise grant or CG provides. This is because DD and STA models are typically managed through agreements or contract awards, as opposed to an initial grant for a start-up or a loan guarantee to an existing business.

For instance, HPPI supported the creation of women's self-help groups, akin to a microfinance model, to generate group savings accounts. Women from the group pool their resources and extend loans to members in times of stress (e.g., a family illness). When HPPI and its partners provided solar lantern charging stations to target communities (selected through an initial survey), HPPI used this self-help part of its implementation to select female entrepreneurs to host the installations and manage the renting of lanterns to the community. According to HPPI and a non-random sample of end-users, the activity contributed to a steep decline in kerosene use within implementation zones. It also resulted in modest income gains for the female entrepreneurs managing the rental service.

As mentioned in this report's Background section, replacing kerosene use appears to be one of the greatest contributions clean energy programs generate for women. This is in large part due to kerosene's negative impact on indoor air quality. A sector specialist also noted the danger kerosene brings into the home due to an increased risk of catching fire to clothing or furniture.

The SSP activity (Box 16) provides another example: USAID support was designed to build the capacity of over 1,000 female entrepreneurs to effectively engage in the clean energy sector. While it was too soon after implementation to assess the level of sustainability, the review team found no viable financial mechanisms in place to keep activity operations going after donor assistance ends.

Both SSP and HPPI represent two relatively successful investments from the perspective of women's empowerment programs. Respondents from both activities overwhelmingly claim that the intervention contributed to an increase in their agency. This includes increased ability to contribute to household income generation and increases in social prestige. One SSP entrepreneur even credited the activity with giving her the confidence to run for local political office. However, a consideration going forward is, should these activities be primarily considered DE investments? This review at least presents the consideration that these may be more aptly described as income generating or empowerment activities that happen to use DE as a vehicle for social development; albeit they are complementary to energy access initiatives as well.

"I stood in the last election and now I am a member of the Gram Panchayat."[60]
– Maharashtra based entrepreneur involved in the SSP activity

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Similar to SSP, the South Asia Regional Integration-Energy Project (SARI-E) (Box 15) also provided support to a female focused sustainable energy hub, this time in Karnataka. The 2011 Final Performance Evaluation, found that while the women's center was successful in women's livelihoods generation to the energy efficiency value chain, the center itself was not sustainable in the long-run. The reasons were the same – no activities that were likely to generate meaningful financial income for the center and an over reliance on donor funding for continued operations.[61]

Commercial Approaches and Gender

A conclusion of this report is that commercial approaches, all things being equal, are more likely to sustain operations with greater scope for scaling than NGO-driven models. That said, NGO-driven models typically allow donors to more acutely target social development objectives such as female empowerment and/or achieve equity targets by directly delivering support to vulnerable groups. This leaves donors with four considerations for future investments:

First, donors have a unique ability to expand the evidence base relating to the relationship between broad energy access improvement and its effect on gendered outcomes. The DIV-grant structure already requires enterprise recipients to conduct internal studies, mainly to support the enterprise's eventual need to leverage customer usage information into scalable management systems (e.g., the grants to Simpa, MGP, and EGG all required this). For instance, the use of lighting inside the home deserves more study. End-user respondents from the Tanzania set of cases suggested that women in these context often do not have control of where installation lights are placed when the DE solution provides only basic lighting. Designing programs with better data regarding these intra-household dynamics would likely lead to better targeted projects, or be useful to commercial actors seeking to expand their customer base by appealing directly to women.

Second, end-user beneficiary interviews associated with the Zara Solar and EGG-Energy cases found that when women are trained in their household system's capacity and maintenance needs, they are more likely to (1) be a primary user and (2) contribute to system sustainability by conducting routine maintenance. For these two cases, positive engagement with female end-users appeared to be the result of favorable socio-economic conditions and a local technician who made a special effort to educate and empower women to utilize and care for solar power systems.

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[60] Local governing body
[61] USAID 2011.

Third, grants provided to enterprises studied in-depth were all led by men. This is inconsistent compared to the overarching aims of several of the NGO-led activities (e.g., HPPI and SSP) that seek to link women to the clean energy value chain. In future, there will likely be opportunities to support innovative enterprises led or controlled by women, and through them, an opportunity to explore whether this results in any operational differences when it comes to offering energy services to female customers.

Fourth, for enterprises operating in environments that are experiencing rapid economic development and increased opportunities in the energy sector, female, male, and unisex targeted products and financing schemes may become increasingly viable. This relates to Simpa and MGPs experience in Uttar Pradesh, whereby early attempts to use women's networks and organizations to generate customers were found to be an insufficient outreach model on their own. Yet, as clean energy technology becomes more common in these communities, and as incomes rise and women increasingly contribute to household coffers, it is worth re-examining this delivery approach to meet gender equity priorities. HPPI's approach was able to leverage female self-help groups; however, this was assisted by the NGO's sustained community involvement. It may be worth testing a hybrid of these approaches.

Image 7: Women's self-help group poses with their group savings ledger as part of the HPPI activity in Adhouli Village, Uttar Pradesh. Photo by: Sam Hargadine

Operational Factors

Operational factors are the specific choices made by implementers with regard to activity design, customer targeting, technology offerings, rates, logistics, etc. While many of these factors have already been discussed, this section provides additional details on two points found to be associated with sustainability

and scale: first, financing models and second, talent acquisition. A third operation factor, maintenance, is treated separately in the following section.

Revenues, Profit, and Cost Recovery

End-user financing is as an important component of sustained and scaled activities. The investments that most commonly featured this component were commercially oriented and were typically driven by some combination of profit and social impact objectives. In contexts with low access to capital, enterprises typically organized their offerings to target customer segments that could afford upfront costs and required less in the way of long-term financing (e.g., Zara Solar). This is reminiscent of the SolarCity example, where early customers were commonly assumed to be the wealthy or those who put a very high priority on generating their own electricity. Only after SolarCity was able to access significant pools of capital was it able to provide longer term financing options to a broader base of customers.

For enterprises with tested and viable offerings, a key consideration for scale is striking the right cash flow balance. The Simpa case provides valuable lessons in this regard. USAID support contributed to the firm's ability to invest in its management processes through the provision of expert consultation and the incorporation of customer data management software. This assistance led to changes in Simpa's DE installation leasing policies and the types of data Simpa collects from potential customers. Algorithms were developed to increase the accuracy of Simpa's customer review processes – automatically flagging concerns and recommending approval, denial, or a home visit to collect additional information. Simpa staff cited USAID assistance as valuable in the increasing sophistication of its operational approach and further noted USAID's position as an important sectoral actor; intangibly benefiting the firm by introducing it to regional partners working on similar issues as well as finance institutions familiar with the DE sector.

Orb Energy (Box 17) provides a different example. Orb sought to expand its capacity to self-manufacture its solar water heating and PV offerings in order to improve its profit margins and greatly increase its rate of expansion. This decision was reached due to regulatory and economic challenges facing the firm in the near and medium terms. According to Orb staff, these factors included the end of a subsidy program that had lowered the end-user price for Orb's offerings and the general reluctance of banks to provide capital for end-user financing. Thus, Orb sought rapid expansion in the near-term to increase its capacity to deliver large-scale solar options catering to commercial and industrial customers and improve the firm's long-term financial outlook given the current headwinds.

Box 17: Case Study 13 – Orb Energy (India)

Orb Energy is a private enterprise selling distributed solar PV and solar thermal water heaters. In 2012 Orb obtained access to a portable loan guarantee backed by USAID's Development Credit Authority. Orb aimed to scale its operations to establish 500 branches within 3 years (ending in 2016). Under this arrangement, Orb at the time of the review team's visit had obtained $1 million from Deutsche Bank with the support of the CG. This first tranche was for backward integration within its solar water heater vertical (i.e., towards setting up a manufacturing facility for solar water heaters with an eventual capacity of 1,500 systems per month, which would result in greater cost efficiencies and improved margins).

Orb has been unable to secure the second half of its CG backed ceiling towards similar backward integration within its solar PV business line. This was due to Deutsche Bank's internal criteria, which limited the bank's exposure to one-third of the net assets of a firm. Meaning, for the bank to lend $2 million to Orb, the firm's net assets would need to be in excess of $6 million as opposed to Orb's current $4.9 million. Orb representatives told the review team that they hope for USAID's support in ongoing discussions with Deutsche Bank to relax the criteria, due to the risk sharing nature of the CG.

Acquiring, Developing, and Retaining Talent

Across the portfolio, the ability to attract, develop, and retain human talent remains a major factor associated with sustained operations and scale. Depending on the technical approach, staff is necessary for marketing, installation, maintenance, fee collection, back-end support, strategic planning, etc. In some cases, the development of local workforces was a primary goal of the implementation (e.g., SSP) In other cases, local staff received training as a necessary component of the business model. This was the case with the local NGO that took over maintenance for the micro-hydro installation in Cachoeira do Aruã, Brazil, and MGP and M-Power's training programs for its staff in India and Tanzania respectively. Zara, by contrast, relied on previously trained local technicians rather than directly engaging in staff training. For Zara, this was simple and cost-effective, but this approach ties the firm to geographies where there are existing technicians.

Challenges encountered by implementers across the portfolio included variations on the struggle to keep up with rapidly changing contexts. This was often exacerbated when the implementer was the first DE actor to enter an underserved or remote community. For example, HPPI and its partners, began activities without trained maintenance technicians in place but had to identify and train technicians as maintenance issues quickly arose. Further, when DE actors seek scale, their expansion plans rarely are as straightforward as simple replication schemes. On the contrary, large investments in human talent acquisition are required to bring in the expertise to manage a rapidly expanding set of products, services and technical needs often beyond the home region of the firm. For example, extension agent-based marketing systems, such as the Urja Mitra (energy buddy) approach employed by Simpa requires constant hiring, training, and communication efforts to appropriately identify qualified agents in new districts and territories. Simpa's current growth trends suggest a 10 percent month on month expansion rate. The challenge of staffing this rate of expansion is a major focus of senior management. MGP faces similar challenges due to its rapidly expanding need for qualified fee collection agents and the establishment of nodal centers. These nodes are used to maintain the level of customer service cited by customers as a strength of MGP's offering.

System Maintenance

This report has discussed maintenance and maintenance systems throughout; however, its centrality to sustaining DE outcomes cannot be overstated. As with any technology, DE systems require routine maintenance, as well as component replacement as unforeseen technical challenges arise.

Lack of maintenance and failure to replace failed components led to poor performance and overall system breakdowns. This can result in user dissatisfaction and, eventually, a reduced number of end-users and lack of sustainability. The review shows that maintenance is multi-faceted and depends on:

- Appropriate funding levels to anticipate and pay for technicians and parts;
- Appropriate levels of human talent (i.e., trained technicians); and
- Appropriate maintenance processes in place (e.g., problem reporting, sufficient inventory and access to parts, response times, etc.).

The NGO-led activities relied on a wide variety of maintenance provisions, including community members conducting maintenance (e.g., Maripá and Santí, Box 18) and training of local technicians. In the cases associated with Brazil and India, these efforts were insufficient to maintain high levels of service or present significant challenges to sustainability in the future. One important factor is that in addition to providing maintenance to existing equipment, it is necessary to have the ability to replace equipment as necessary, which was a constraint for the Pará State cases in Brazil and HPPI in India.

Box 18: Case Study 2 – Household PV in Maripá and Santí Communities (Brazil)

In 2007, USAID provided direct assistance to the Maripá and Santí communities, Pará State, in Brazil. Prior to Agency involvement, the NGO IDEAAS developed a fee-for-service solar PV system for home use and piloted this approach in Rio Grande do Sul. Based on IDEAAS' early success, it sought to replicate this model at Maripá and Santí. To accomplish this, IDEAAS partnered with an organization based in Pará called Projeto Saúde e Alegria (PSA) and secured approximately $224,000 from the Lemelson Foundation. USAID provided an additional $20,000, less than 10 percent of total.

According to IDEAAS, its funding was later cut (both by Lemelson and USAID) and it was forced to cease its support for the fee-for-service scheme. This meant that installations were left in Maripá and Santí and IDEAAS' operations and maintenance services stopped. End-users estimated that the fee-for-service scheme ended after about 16 months of service. From that point on, households stopped paying the monthly fee and assumed responsibility for maintenance of their own systems.

By the time USAID's limited involvement ended in 2008, 48 household systems had been installed and 35 remained in operation when the review team visited in 2015. While the cessation of maintenance services provided by IDEAAS likely constrained the potential of the activity, community members were able to maintain about 73 percent of the units provided. Factors contributing to this case's relative success in adapting to changing circumstances was a strong partnership with an NGO based nearby (PSA), community engagement in the activity's planning process, and the relatively simple maintenance needs of the installations.

The commercial implementers were on the whole better equipped to provide ongoing maintenance services to their installations, especially so for those firms that continued to own their systems by providing customers with pay-as-you-go services (e.g., Egg-Energy and M-Power) and/or leasing schemes (e.g., Simpa). Essentially this model is predicated on continued ownership of assets and payment by customers depends on continued service. This provides a strong incentive for system maintenance.

No single maintenance system was found to be on the whole better. Rather, successful procedures all were able to provide long-term service through (1) availability of funds, (2) clear processes for users to report problems, and (3) the availability of trained personnel. A challenge for rapidly expanding enterprises includes sustained capacity to continue to service old customers. For example, as EGG shifted its model and geographic focus, this led to reports of existing customer neglect. This shift was likely a result of a rapidly expanding grid as well as an adaptation towards a separate offering that was perceived as a better application for customer demands.

While commercial approaches appear better geared towards building the financial infrastructure to maintain services, community ownership and training was also successful in at least improving the resiliency of DE installations. This was seen in the Maripá and Santí sites as well as the micro-hydro installation at Cachoeira do Aruã. In both these cases, local groups took ownership of the DE systems and were able to troubleshoot routine problems and in the case of Cachoeira do Aruã, maintain the same level of operations to this day.

RECOMMENDATIONS

Recommendation 1: USAID should continue to favor the use of commercial approaches for supporting DE systems when sustainability and scale are the objective.

Throughout this review, commercial approaches, all things being equal, were better able to organize sustained operations and maintenance systems that led to sustained end-user outcomes and greater scope for scaling DE solutions. Specifically, commercial approaches were better able to establish fee collection

schemes that in turn contributed to firm capacity to develop, refine, and deploy offerings that addressed end-user needs and evolve with changing customer demands. DE technologies require periodic maintenance and commercial approaches were better equipped to satisfy the following:

- Collect adequate funds to anticipate and pay for technicians and parts;
- Attract appropriate human talent (i.e., trained technicians); and
- Implement appropriate maintenance processes (e.g., issue reporting by end-users, sufficient inventory and access to parts, response times, etc.).

Commercial approaches are complementary to USAID objectives in all contexts; however, CPC-contexts will likely remain a challenge for commercially oriented approaches due to the need for immediate and substantial initial investments to reconstitute vital public and private infrastructure and operational capacities. While these contexts may require direct delivery of capital in the medium-term, these investments can be linked to long-term strategies to equitably build the regulatory and policy framework that enables a responsive and high-functioning commercial DE sector.

Recommendation 2: USAID should prioritize gender sensitive data collection to better adapt its programming to intra-household energy usage trends.

For future DE investments, a larger evidence base examining gendered outcomes would likely contribute to better project designs that incorporate the energy access needs of women. The Tanzanian cases in particular highlight that women at times do not have control over how household energy systems are utilized (especially those that only provide basic service). Meanwhile, women who were trained in various Tanzanian communities to directly care for their systems appear well equipped to administer installations or procure regular maintenance services. While portfolio investments, when they targeted female beneficiaries at all, tended to prioritize income generating opportunities, there is a missing middle. Meaning on the one end, USAID prioritizes broad energy access and on the other the Agency works to link women to the clean energy value chain. These are complementary outcomes for women generally; yet, a larger evidence base for when, how, and why women in underserved communities are not able to use the energy that is available would likely help design future investments.

Recommendation 3: USAID should support partner governments in the effort to better integrate DE technologies into energy regulations and policy processes.

USAID should use its convening and capacity building role to support partner governments in fostering greater integration of DE technologies formally into lowest-cost-greatest-benefit energy regulation and policy processes. Portfolio trends indicate that sectoral support and commercially oriented approaches are already on the rise, but this form of support will continue to be vital as low-access countries rapidly develop their energy sector policy and regulatory systems. Levelling the playing field for distributed energy such that it can contribute to national energy access goals and targets in ways that are sustainable and scalable while also equitable in terms of cost and service to the consumer requires integrated policies and appropriate regulations. USAID can enable learning across global contexts and concentrate technical support to appropriate policy and regulatory development.

Recommendation 4: USAID should provide or facilitate additional access to capital for the benefit of promising DE enterprises.

A constraint universally felt by DE enterprises was the challenge of accessing sufficient capital. Access to capital allows firms to pass on flexible financing options to end-users, thereby expanding the beneficiary base to those that would otherwise be unable to purchase DE installations outright. DIV-grants were shown to be especially effective in providing startup firms with sufficient seed capital to test their business model and technological offerings. Credit guarantees were shown to be effective with medium-sized

established firms and/or in countries with sophisticated domestic financial markets. Across this review it was clear that to achieve scale, large pools of capital are required to attract talented people to the firm and expand operations to new geographies and customers. USAID, according to grant recipients, is uniquely placed to underwrite capital and catalyzes market confidence for future investors. Until the DE market is sufficiently liquid, USAID should continue these efforts and integrate them into a coordinated approach to enabling sectoral growth.

Recommendation 5: USAID should establish clear management priorities to direct the types of data it collects and utilizes to design and monitor projects.

Throughout this review, data quality and availability was a challenge. This limits the Agency's ability to retrospectively self-examine its investments and learn from past successes and failures. The types of data collected across portfolio investments appeared to be relatively ad hoc and did not seem to align to any coordinated management strategy – at least in terms of sustainability and scale. In future, the Agency should establish standard reporting requirements for DE investments along context-relevant factors that contribute to sustainability and scale.

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ANNEX B: COUNTRY CASE METHODOLOGY

Case Selection

In April 2015, the review team delivered a country selection paper which laid out justifications for primary data collection in three regions: Southeast Asia, Sub-Saharan Africa, and India. India hosted the largest number of projects in the portfolio, accounting for 6 of 31 activities. Among Sub-Saharan African countries, Tanzania was selected because it represents a low-access, low-income, majority-rural context, while hosting a diverse set of USAID investments in the energy sector. Because a significant body of research was already available for USAID investments in the Philippines and Indonesia, Brazil was suggested by USAID as a replacement to the Southeast Asia focus. The Brazil-specific portfolio was attractive for in-depth study due to its relatively older portfolio of investments than was the case in Tanzania and India. In addition, Brazil represented a starkly different context compared to the other two countries, which supported the comparative case study design underpinning this review.

In consultation with USAID, the review team was encouraged to expand the potential list of cases to those activities that bordered the 2004 to 2012 timeframe requirement. This flexibility allowed the team to investigate investments that were (1) unknown to the review team prior to consultations with the applicable Mission and (2) received USAID support from activities with implementation start dates prior to 2004 – e.g., Cachoeira do Aruã (Brazil) which recieved support from USAID prior to the review's specific period of interest. In essence, this flexibilty made sense because time-frame cutoff concerns were secondary to collecting relevant ex post findings from a rich set of varied cases.

Priority case-sites were first selected to meet the three frames of analysis for later cross-case comparison. Cases were further cut to include both likely successes and failures. Finally, practical considerations such as (1) responsiveness of informants, (2) logistics, (3) schedule, and (4) budget were weighed to arrive at the three to five cases selected for each priority country. In the end 13 cases were selected: 5 in India, 5 in Brazil, and 3 in Tanzania.

Data Collection

The team used semi-structured guides to orient procedures for in-depth interviews (IDIs) and group discussions with implementing partners and site-specific beneficiaries. Table 7 shows the number of interviews conducted, broken down by each case study.

Table 5: Respondents by Type for Each Activity

Case Name	IDI - Context Provider	IDI - Implementer	IDI - Beneficiary	Group Interview - Beneficiary	Site Visits
Cachoeira do Aruã (Brazil)	2	3	5	-	1
Maripá and Santí SHS (Brazil)		3	5	-	1
Ceará PV Irrigation (Brazil)	1	2	-	2	2
Quixeramobim Biofuel (Brazil)	1	2	-	-	1
Enalster SHS (Brazil)	1	1	-	1	1
Mera Gao Power (India)	10	2	4	4	4
HPPI (India)		3	3	3	3
Swayam Shiksan Prayog (India)		1	3	1	3
Simpa Networks (India)		2	4	4	4
Orb Energy (India)		1	-	-	-
Zara Solar (Tanzania)	1	2	9	-	7
EGG-Energy (Tanzania)	2	6	12	-	6
M-Power (Tanzania)	2	2	15	-	15
Total	20	30	60	15	48

Data Analysis

The qualitative responses to the IDI and group discussions noted above were coded according to several analysis tools developed specifically for this review. These tools included:

1. Sustainability Matrices;
2. Sustainability Factors Tables; and
3. Replication and Scaling Checklists

Sustainability Matrix

The review team developed a systematic tool to assess each site visited and determine the extent to which activity outcomes were sustained. This qualitative rating tool compared activity outcomes at the end of USAID funding to outcomes at the time of field data collection for this study. The sustainability matrix includes five dimensions of sustainability:

- System production capacity;
- Current system condition;
- Maintenance capacity;
- Number of end beneficiaries; and
- Capacity to meet beneficiary needs.

The matrix uses a scale to rate the effectiveness of each dimension of sustainability:

- Total failure (0);
- Below expectations (1);
- Sustained (2); and
- Exceeded expectations (3).

The team based these rankings on a combination of data, including activity implementers' assessments of activity sustainability, triangulated with reported numbers of systems installed and information from site observations and interviews with end-user beneficiaries. The team compiled relevant data for each dimension of sustainability, then synthesized and summarized findings on each dimension of sustainability. The findings are based on the review team's observations, which may not be representative of the entire activity; instead, the matrix provides a snapshot of the sustainability of activities at visited sites. Where the review team visited more than one site per case (e.g., Mera Gao Power), the findings for each dimension of sustainability were combined into an overall sustainability ranking for the case study.

Sustainability Factors Table

The sustainability factors table is based on coded passages related to the contextual factors and activity-specific factors that affect sustainability, as identified in the review's literature review and confirmed in collaboration with USAID.

Replication and Scaling-Up Checklist

The review team adapted MSI's "Scaling-Up Typology"[62] to identify factors commonly associated with replication and scaling.

Limitations

This study pulls prominently from qualitative interviews. This allowed the review team to discuss trends prominent in the portfolio with a wide range of beneficiaries, implementing partners, host government officials, and sector practitioners. A limitation to this approach is that only 13 cases of 39 total activities were studied in depth. Efforts were made to select a representative sample; however, no primary data was collected for CPC contexts, which by funding amount represent a majority of resources disbursed. To counteract this, the review team reviewed available documentation for these reports and incorporated findings as they applied to the trends identified over the course of the review.

Another limitation is the portfolio itself. Prior to this study, no definitive list of USAID DE investments was known to the review team. Thus, compiling an accurate and complete list was an endeavor shared by the review team, USAID, and multiple implementing partners who graciously provided their time. The categorization of activities and estimated funding amounts represent a degree of subjectivity. It is also possible that other investments unknown to the review team contained additional DE components.

[62] Management Systems International 2006.

ANNEX C: INVENTORY OF USAID DE INVESTMENTS

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Afghanistan	Afghani-stan and Pakistan	CPC	Afghanistan Clean Energy Program (ACEP) EPP-I00-03-00006-00	2009 – 2012	DD, STA	$10,000,000	n/a	$3,500,000	$23,839,956	Hydro, Solar, Wind	All Purpose	ACEP introduced 11,583 total DE power systems in rural Afghanistan for the purpose of improved health, education, nutrition, and consumption outcomes for target beneficiaries. ACEP was also designed to build government capacity to include DE solutions in Afghan government project portfolios as well as provide technical workshops for engineering experts in the field of solar, wind, and micro-hydro technologies.	No
Kenya	Africa	No	Acumen Fund, 615-DCA-12-014	2012 – 2017	CG	n/a	$1,000,000	n/a	$1,000,000	Solar	Household	M-Kopa is a private clean energy firm based in Kenya with access to a USAID/DCA 50 percent loan guarantee. The guarantee supported a working capital loan that has been fully utilized. The loan financed solar home clean energy lighting systems for re-sale to rural Kenyans.	No
Kenya	Africa	No	Letshego Kenya Limited (Micro Africa Limited Kenya), 615-DCA-12-016C (SIDA co-guarantee)	2012 - 2019	CG	n/a	$79,540	n/a	$2,000,000	Not applicable	All purpose	MALK has access to a 50 percent loan portfolio guarantee through USAID (20 percent) and SIDA (30 percent). MALK is a micro-finance institution based in Nairobi targeting higher-end micro clients. Ten percent of the facility is reserved for clean energy uses. To date the facility's utilization percentage is four percent and has generated 193 unique loans.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Kenya	Africa	No	SMEP Microfinance Limited, 615-DCA-12-016B (SIDA co-guarantee)	2012 - 2019	CG	n/a	$3,125,529	n/a	$4,000,000	Not applicable	All purpose	USAID (20 percent) and SIDA (30 percent) established a 50 percent loan portfolio guarantee for the independent deposit taking micro-finance institution Small and Micro Enterprise Programme (SMEP). Ten percent of the facility is reserved specifically for clean energy. To date the facility's utilization percentage is 78 percent and has generated 7,044 unique loans.	No
Kenya	Africa	No	Kenya Women Finance Trust (KWFT), 615-DCA-12-016A (SIDA co-guarantee)	2012 - 2019	CG	n/a	$5,000,000	n/a	$5,000,000	Not applicable	All purpose	KWFT is the largest deposit-taking micro-finance institution operating in Kenya. It has access to a 50 percent loan portfolio guarantee through USAID (20 percent) and SIDA (30 percent). Ten percent of the facility is reserved for clean energy uses. The facility has fully utilized its disbursement ceiling across 21,566 unique loans.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Liberia	Africa	CPC	Liberia Energy Assistance Program (LEAP)	2006 – 2009	DD, STA	$2,500,000	n/a	$2,000,000	$10,941,522	Solar	All purpose	LEAP delivered technical assistance for energy policy, institutional strengthening, and rural energy development. DE specific components included sectoral assistance that supported the development of Liberia's first National Energy Policy and thus the creation of various government entities, including the Rural and Renewable Energy Agency and the Department of Energy within the Ministry of Lands, Mines, and Energy. LEAP also delivered pilot solar projects to rural Liberian communities. Integration with other USAID sponsored activities and host government priorities were the criteria used to select which sites received direct support.	No
Liberia	Africa	CPC	Ecobank Liberia Limited, 669-DCA-09-001	2009 – 2019	CG	n/a	$1,343,567	n/a	$4,240,000	Solar, Bio	Agriculture	Ecobank Liberia has access to a USAID/DCA 50 percent loan portfolio guarantee facility. The purpose of the facility is to spur lending to agriculture SMEs in support of clean energy technologies. To date, facility utilization stands at approximately 32 percent and has generated 10 unique loans.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Liberia	Africa	CPC	International Bank Liberia, 669-DCA-10-002	2009 – 2019	CG	n/a	$4,784,551	n/a	$6,868,000	Solar, Bio	Agriculture	International Bank Liberia has access to a USAID/DCA 50 percent loan portfolio guarantee facility. The purpose of the facility is to spur lending to agriculture SMEs in support of clean energy technologies. To date, facility utilization stands at approximately 70 percent and has generated 25 unique loans.	No
Liberia	Africa	CPC	Liberia Energy Support Sector Program (LESSP) AID-OAA-TO-14-00046	2010 – 2014	DD, STA	$8,800,000	n/a	$3,000,000	$21,861,947	Solar, Bio	All purpose	LESSP was concerned with (1) increasing sustainable access and affordability of electricity for rural and urban communities, (2) improving performance of local governments, civil society and private sector actors in monitoring, regulating, and managing renewable energy resources, (3) increasing the percentage of households and businesses utilizing clean energy, and (4) changing policies to improve the investment climate for the energy sector. It is estimated that approximately $8.8 million was used to demonstrate, through pilots, rural energy service delivery mechanisms; however, these were not completed. An estimated $3 million was used to provide training to senior managers within the Rural and Renewable Energy Agency. This activity's performance was likely impacted by the Ebola crisis that occurred during LESSP's period of performance.	2013 Mid-term Performance Evaluation; 2015 Final Performance Evaluation

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Nigeria	Africa	No	Ecobank Nigeria, 620-DCA-12-007	2012 – 2022	CG	n/a	$932,261	n/a	$5,000,000	Not applicable	Agriculture	Ecobank Nigeria has access to a USAID/DCA loan portfolio guarantee to extend credit to SMEs working in the renewable energy, energy efficiency, and agriculture sectors. The guarantee covers 80 percent of potential losses for borrowers utilizing the loan for renewable energy and 30 percent coverage for other uses in the agriculture sector. To date five unique loans have been dispersed under the facility and utilization stands at approximately 19 percent.	No
Tanzania	Africa	No	EGG-Energy Franchised Solar Hubs, AID-OAA-G-12-00014	2012 – 2013	ES	$100,000	n/a	n/a	$100,000	Solar	Household	This USAID/DIV stage-1 grant supported EGG-Energy's franchised solar-hub model in the Iringa region. This model experienced challenges and the firm began focusing on rent-to-own individual solar systems near Tanga. At the end of the grant period, two 200Wp and four 50Wp solar charging hubs were established. EGG later received a second DIV grant which further supported the revised business plan.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Tanzania	Africa	No	EGG-Energy Franchised Solar Hubs, AID-OAA-F-13-00054[63]	2013 – 2014	ES	$100,852	n/a	n/a	$100,852	Solar	Household	This was the second DIV grant provided to EGG-Energy. This grant was designed to extend EGG's capacities pursuant to its (1) customer and management information systems, (2) financing procedures (i.e., end-user financing options), and (3) training programs to franchisees and technical teams. EGG-Energy established six solar hubs in the greater Iringa region and installed more than 600 solar home systems across four other regions - the most popular systems sized at 50Wp.	No
Tanzania	Africa	No	Off-Grid Electric/M-Power, AID-OAA-F-13-00003[64]	2013 – 2014	ES	$100,000	n/a	n/a	$100,000	Solar	Household	Off-Grid Electric's model is designed to mimic/harness the approach of mobile phone operators and use mobile money to distribute pre-pay solar lighting in the home. The model is meant to significantly lower the up-front costs and risks to clients and cheaply provide lighting while reducing kerosene use. USAID/DIV provided this grant to support the development of a hub near Arusha that would assist in the refinement of the firm's distribution model (including training of additional staff) and incorporate operational procedures needed to attract additional, private, financing.	No

[63] EGG-Energy's second DIV grant, disbursed in 2013, is included in this table for reference. It is not counted as part of the portfolio due to is post-2012 start date. Information is provided because it is relevant to the case study discussion pertaining to the 2012 grant, listed above.
[64] Information regarding M-Power's 2013 DIV grant is provided because it was selected as a case study; however, it was not used in the portfolio-wide funding calculations.

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Uganda	Africa	No	Lighting Rural Uganda with Solar (LRUS), AID-OAA-G-10-00016	2010 – 2011	ES	$98,360	n/a	n/a	$98,360	Solar	Household	LRUS obtained a USAID grant to tap into existing saving and credit cooperatives in order to develop retail operations for solar lantern products. The lanterns were donated in-kind by Green Light Planet and LRUS support was targeted to the Kalalagla region. The purpose of the grant was to build the capacity of LRUS to work with these cooperatives (thereby improving the distribution network) as well as improve coordination efforts with local financial institutions.	No
Uganda	Africa	No	Centenary Rural Development Bank Ltd., 617-DCA-12-018	2012 - 2020	CG	n/a	$1,400,000	n/a	$1,400,000	Solar	Household	SolarNow Uganda obtained $2.5 million in private sector financing through a 50 percent loan guarantee agreement between USAID/DCA and Centenary Bank. The loan's purpose was to reduce costs and rapidly expand the solar panel market to 120,000 rural customers.	No
India	Asia	No	Humana People to People - India	2009 – 2011	DD	$450,000	n/a	n/a	$450,000	Solar	Household	HPPI received a grant from USAID and in-kind support from Tata Energy Research Institute to provide solar lanterns to rural households in Uttar Pradesh. The activity had a women's empowerment component through self-help groups, savings plans, and specifically targeted female entrepreneurs to start up solar lantern station businesses.	No

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India	Asia	No	Mera Gao Power (MGP), AID-OAA-G-11-00067	2011 – 2013	ES	$300,000	n/a	n/a	$300,000	Solar	Household	MGP received USAID/DIV stage-2 funding to (1) further test the commercial viability of its micro-grid design, which it believes has the lowest capital and operational costs per user in the market, and (2) assess the development impact of these micro-grids on the lives of customers. Activities were concentrated in Uttar Pradesh. To date, MGP reports having reached 20,000 households across 1,073 villages with its micro-grid operation.	No
India	Asia	No	W-POWER/Swayam Shikshan Prayog (SSP)	2012 – 2015	STA	n/a	n/a	$1,000,000	$1,000,000	Various	Not applicable	SSP received a USAID grant in conjunction with the Partnership on Women's Entrepreneurship in Clean Energy (W-POWER) program in India. SSP is an NGO serving communities mainly in Maharashtra and Bihar and USAID funds are used to train female entrepreneurs to sell clean energy products through associated distribution schemes. At the end of the activity, 1,010 entrepreneurs were trained, selling solar lanterns to an estimated 40,000 households.	No
India	Asia	No	Orb Energy, 386-DCA-12-005	2012 – 2020	CG	n/a	$1,000,000	n/a	$2,000,000	Solar	Industrial	Orb Energy is a private limited enterprise selling distributed solar PV and solar thermal water heaters. USAID/DCA's portable 50 percent loan guarantee helped secure a loan from Deutsche Bank for backward integration within Orb's solar water heating business line. To date, half of the facility has been utilized.	No

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India	Asia	No	Simpa Networks, AID-OAA-F-13-00028[65]	2013 – 2015	ES	$968,000	n/a	n/a	$968,000	Solar	Household	Simpa sells solar power through a process akin to mobile credit purchasing. The firm obtained a USAID/DIV stage-2 grant to test their model at scale. Specifically, the grant was designed to rollout Simpa's model to 12,000 households, which was achieved, and measure the social impact and financial viability of the approach in order to attract additional private investment. Activities were mainly concentrated in Uttar Pradesh.	No
Indonesia	Asia	No	Indonesia Capacity for Indonesian Reduction of Carbon in Land use and Energy (CIRCLE) AID-497-A-12-00001	2011 – 2014	ES	$1,462,744	n/a	n/a	$1,462,744	Bio	Industrial	CIRCLE provided technical assistance to more than a dozen Indonesian palm oil mills to address carbon challenges and improve the sustainability of palm oil manufacturing. This assistance took the form of financial feasibility studies and sustainability screenings. The goal of the activity was to convert palm oil waste into renewable energy while also reducing carbon emissions.	No

[65] Information regarding Simpa's 2013 DIV grant is provided because it was selected as a case study; however, it was not used in the portfolio-wide funding calculations.

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Indonesia	Asia	No	Indonesia Clean Energy Development (ICED) AID-497-TO-11-00004	2011 – 2015	ES, STA	$1,000,000	n/a	$500,000	$16,250,000	Not applicable	All purpose	ICED provides sectoral policy support to the government of Indonesia at local and national levels. This is meant to help the Government of Indonesia achieve its aim of increasing energy access while reducing greenhouse gas emissions. ICED included a small grants component and associated technical assistance to clean energy entrepreneurs.	No
Nepal	Asia	No	Micro-Hydro Projects for People and Biodiversity In Shey Phoksundo National Park, Dolpa & Kangchenjunga Conservation Area, Taplejung	2006 – 2008	DD	$467,000	n/a	n/a	$467,000	Hydro	Household	Three micro-hydro energy projects were completed under this grant. Two were located in Dolpa, benefitting an estimated 320 households. A third micro-hydro project was installed in Kangchenjunga benefitting approximately 91 households. Each of these three sites were near conservation areas and meant to improve livelihoods of residents as well as reduce the use of fossil and wood fuels for lighting and cooking.	No

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Philippines	Asia	CPC	USAID/Philippines Solar Energy for Rural Electrification and Development (SERED), 492-A-00-04-0040	2004 – 2007	DD, STA	$310,000	n/a	$100,000	$410,000	Solar	All purpose	SERED was a compliment to AMORE 2, implemented as part of the same cooperative agreement. DE components included the direct delivery of solar home lighting and lantern charging systems in AMORE supported districts. As part of this direct support, SERED provided financial management training to community groups to encourage the continued financial viability of the installations. Sectoral support included energy supply chain development through the training of solar PV technicians. SERED also contributed to the development of PV certification standards and regulations in the region to improve the quality of this technical training.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Philippines	Asia	CPC	Alliance for Mindanao Off-grid Renewable Energy (AMORE) – Phase 2, 492-A-00-04-0040-00	2004 – 2009	DD	$8,000,000	n/a	n/a	$8,000,000	Solar, Hydro	All purpose	AMORE 2 directly delivered renewable energy installations in Mindanao and integrated private sector mechanisms into its support in order improve the likelihood of sustained operations. Phase 2 saw the installation of solar and micro-hydro systems in 268 and 6 barangay/districts respectively. Efforts to sustain the installations took the form of (1) capacity development, information sharing, and network development for local community and NGO groups, (2) the design of an operations and maintenance fund to cover recurring expenses, and (3) natural resource management awareness and training to improve the reliability of sources of renewable power.	No
Philippines	Asia	CPC	Alliance for Mindanao and Multi-regional Renewable/Rural Energy Development (AMORE) – Phase 3, 492-A-00-04-0040-00	2009 – 2013	ES, STA	$2,500,000	n/a	$2,500,000	$6,000,000	Solar, Hydro	All purpose	The goal of AMORE 3 was to strengthen rural energy services via public-private partnerships. AMORE 3 DE relevant ES activities included direct co-funding, capacity building, and business model support to specific enterprises working in the renewable energy space in Mindanao. The STA component included (1) capacity building for local associations and institutions, (2) developing female entrepreneurship relating to renewable energy micro-enterprises, and (3) supporting the supply chain for distributed PV.	2014 Final Performance Evaluation

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
South Asia Regional	Asia	No	South Asia Regional Initiative for Energy (SARI/E) – Phase 2, LAG-386-C-00-03-00135-00	2004 - 2006	DD, STA	$112,586	n/a	$21,621	$65,000,000 (Phase 1-3)	Various	All purpose	The SARI/E small grants program was a major initiative within the larger SARI/E program that began near the start of Phase 2 and continued through Phase 3. Information was available for grants provided to Pakistan during Phase 2. Grants funded a number of DE installations, commercial actors, and sectoral assistance activities. These included: (1) strategic planning and technical assistance to the Lahore Energy Supply Company to develop a solar electricity program; (2) a survey of household energy needs and consumption patterns for a consumer rights group; and (3) various grants to universities and NGOs to directly install mechanized water pumps and solar powered lighting systems. Reports suggest that the direct delivery scheme suffered from premature breakdown of vital technical components (e.g., batteries).	No

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South Asia Regional	Asia	No	South Asia Regional Initiative for Energy (SARI/E) – Phase 3, LAG-386-C-00-03-00135-00	2007 - 2012	DD, STA	$781,805	n/a	$500,000	$65,000,000 (Phase 1-3)	Various	All purpose	SARI/E was concerned with building institutional capacities, promoting private sector and civil society participation in energy policy, and creating and strengthening regional forums, networks, and associations across the South Asia region. DE specific components for Phase 3 included: (1) the establishment of a regional hub for micro-hydro initiatives based in Nepal, (2) support to the Small Scale Sustainable Infrastructure Development Fund to analyze innovative means of financing small hydropower projects in Nepal, (3) a small grants program for both not-for-profit and for-profit firms seeking funding for small scale energy systems, and (4) numerous workshops and trainings relating to renewable energy coordination and financing across the region. Phase 3 small grants included activities such as (1) installing PV powered water pumps for agricultural uses in rural Bangladesh, (2) women's empowerment schemes promoting clean energy enterprises in India, (3) support to the micro-hydro sector in Nepal, (4) building capacity to utilize biomass technologies in rural Sri Lanka, among others.	2011 Final Performance Evaluation

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Georgia	Europe and Eurasia	No	Rural Energy Program (REP), AID-114-A-00-05-00106	2005 – 2009	DD, STA	$2,000,000	n/a	$6,000,000	$10,800,000	Hydro	All purpose	DE components included approximately $1 million in grants to rehabilitate small hydro power facilities and an additional (estimated) $1 million was spent on technical assistance mainly on the preparation of watershed management activities. STA support took the form of commercially oriented development of small hydro investments through support of the private sector.	2009 Final Performance Evaluation

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Georgia	Europe and Eurasia	No	New Applied Technology Efficiency and Lighting Initiative II (NATELI II) AID-114-A-00-05-00106	2011 – 2013	DD, ES, STA	$523,305	n/a	$237,631	$4,240,929	Hydro, Solar, Biogas	All purpose	NATELI II was a $4.2 million activity based in Georgia designed to (1) increase grid-connected and off-grid supply of energy in rural areas, (2) improve in-country capacity to produce, manage, and utilize clean energy, and (3) build capacity to protect the local energy resources base. Specific DE components included two of ten total grants given to local organizations meant to pilot innovative approaches or technologies relating to energy use/production. Grant 1 ($149,675) was concerned with ecological tourism (solar panel and water pump used to power a public bath). Grant 2 ($123,630) introduced solar panels and biogas technologies to provide autonomous power to a rural community. NATALI II also subcontracted to a local partner to rehabilitate a 250kW hydro power turbine located in a rural community (est. $250,000). Finally, a higher education component provided sectoral support by providing scholarships to 41 master degree candidates studying renewable energy and energy efficiency ($94,675) and provided grants to local education institutions to build their energy studies programs ($142,956).	2012 Mid-term Performance Evaluation

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Global	Global	No	E+Co, Inc. and ShoreBank, 099-DCA-07-001	2007 - 2017	CG	n/a	$1,500,000	n/a	$1,500,000	Solar, Bio, Hydro	Not applicable	E+Co obtained a 50 percent loan portfolio guarantee through USAID/DCA which was used to finance activities in Brazil, Cambodia, Guatemala, Honduras, and Nepal. The guarantee was fully utilized and funded enterprises concerned with solar PV, small hydro, and biomass gasifiers installations. Note that it was not possible to isolate loans for activities that fit the DE definition used in this report therefore the full disbursement amount is used. Actual lending for DE was likely smaller.	No
Global	Global	No	Acumen Fund, 099-DCA-12-010	2012 – 2022	CG	n/a	$0	n/a	$15,000,000	Not applicable	Not applicable	Acumen Fund invests in social enterprises globally. USAID/DCA partnered with Acumen to establish a portable loan guarantee facility with the aim of extending credit to SMEs in underserved regions. This facility has not been utilized to date.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Brazil	Latin America and the Caribbean	No	Energia Renovavel e Desenvolvimento (E&D), 512-A-00-05-00025	2005 – 2008	DD, STA	$400,000	n/a	$800,000	$2,031,531	Solar, Bio, Hydro	All purpose	E&D was designed to support activities that utilize renewables and efficiency technologies as a means for promoting social and economic development while also addressing climate change. E&D DE components included direct delivery of five solar powered pumping systems for hydroponics, a small hydropower system in Pará State, solar driers for produce, solar desalinators for agriculture production, and a demonstration facility for biofuel manufacturing. STA support took the form of (1) market research, (2) public policy engagement, (3) developing national and international partnerships to attract sustained financing, and (4) capacity building for community groups, the banking sector, and government bodies for the purpose of strengthening the renewable energy sector.	No

Country	Region	CPC Status	Activity or Partner Name and Award Number (if available)	Time Period	Modality	Estimated Resources Allocated (DD, ES)	CG Disbursement	Estimated Resources Allocated (STA)	Total Award Amount or CG Ceiling	Type of Technology	Type of End User	Activity/DE Component Description	Evaluation Report Availability
Brazil	Latin America and the Caribbean	No	Clean & Renewable Energy (C&RE), AID-512-A-09-000002	2009 – 2012	DD, ES, STA	$500,000	n/a	$700,000	$4,806,000	Solar, Bio	All purpose	DE specific components for C&RE included (1) instructing students and teachers about the use, benefits of, and how to access sources of renewable energy, (2) direct provision of solar PV to target communities for use in the agro-tourism sector, (3) various partnerships with industrial partners to increase their capacity to produce bio-digester products for use in the agriculture sector, (4) support for a carbon credit scheme in the form of monitoring greenhouse gas emissions, and (5) Various forms of support to policy actors and public awareness campaigns to incentivize the use of clean energy solutions.	No

ANNEX D: BRAZIL PORTFOLIO REPORT EXECUTIVE SUMMARY[66]

Portfolio Review of USAID Decentralized Energy Activities

This document presents and compares five Brazilian case studies that inform a wider portfolio review of USAID decentralized energy (DE) investments began between 2004 and 2012. DE in this context refers to interventions supported by USAID that generate limited wattage, serve a small number of customers per system/installation, are off-grid, and utilize clean energy technologies. USAID DE investments take the form of sectoral technical assistance, credit guarantees, enterprise support, and direct delivery modalities. Examples of the technologies supported include solar powered micro-grids, household energy systems, micro-hydro generators, and biomass installations supported by a range of business models, financing mechanisms, public policy arrangements, and capacity-building assistance for system operations and maintenance (O&M).

The range of activities representing the entire USAID DE portfolio includes 31 unique investments in 12 countries, including 2 global credit guarantee facilities. Based on criteria developed collaboratively with USAID, three countries were selected for in-depth study: Brazil, Tanzania, and India.[67] Therefore primary data was collected for applicable DE investments in these 3 countries, which together represent 13 case studies.[68] In a separate Synthesis Report, these case studies – the 5 Brazil cases of which are summarized in this document – along with a literature review, summary of related performance evaluations, and descriptive statistics relating to the entire 31-activity portfolio are used to answer the review's 3 research questions:

1. To what extent and under what conditions have USAID-supported decentralized energy systems been sustainable after USAID assistance ended?
2. To what extent and under what conditions have USAID-supported decentralized energy systems been replicated or scaled up after USAID assistance ended?
3. What decentralized energy implementation models and processes have been most effective at achieving sustainability, scale, or replication?

USAID DE Investment Modalities

Global USAID DE investments fall into four overarching categories, which are:

Credit Guarantees (CG): Through the Development Credit Authority (DCA), USAID uses partial credit guarantees to mobilize local financing, by covering 50 percent[69] of the principal in loans to projects that advance the Agency's development objectives. This risk-sharing mechanism encourages commercial banks and other lenders and creditors to expand credit to sectors and industries they currently do not serve, or to lend with less collateral than previously required. The expectation is that during the guarantee

[66] The full Brazil report is available here: http://pdf.usaid.gov/pdf_docs/pbaaf013.pdf.
[67] The review team delivered a country selection paper in April 2015, justifying primary data collection in three regions: Southeast Asia, Sub-Saharan Africa, and India. Because a significant body of research was already available for USAID investments in the Philippines and Indonesia, Brazil was suggested by USAID for in-depth study due to its relatively older portfolio of investments than was the case in Tanzania and India. In addition, Brazil represented a starkly different context compared to the other two countries, which supported the comparative case study design underpinning this review.
[68] Five in Brazil. Five in India. Three in Tanzania.
[69] The large majority of CG activities cover 50 percent of the loan principle; however, there are exceptions. For example, a loan portfolio guarantee to a Nigerian financial institution covered up to 80 percent for loans disbursed for renewable energy promotion.

period, the lender will get to know the industries and associated risks so that in the future, the lender will have the confidence to issue comparable credit without enhancements.

Direct Delivery (DD): USAID activities or activity component(s) in which USAID or other donors invest the majority of the capital and other associated costs for repairing, procuring, and/or installing one or multiple DE systems. In addition to paying for capital costs, these projects may provide training, capacity building or other technical support for the installation and/or operation of the DE system.

Enterprise Support (ES): USAID grants made directly to clean energy enterprises to support testing and/or scaling of breakthrough technologies and solutions. This may include complementary technical assistance and training to the enterprise for such purposes as business acceleration, improved management, equipment sourcing, and increased access to financing. This category includes Development Innovation Ventures (DIV) grants and grants under contracts or larger umbrella mechanisms.

Sectoral Technical Assistance (STA): USAID project or project component(s) that strengthen the enabling environment for enhancing access to clean energy services in off-grid areas. This may include, for example, developing new policies, legislation, and/or regulations, strengthening relevant government agencies and higher education facilities, and training of financial institutions on off-grid clean energy lending.

DE in Brazil

One of the key contextual factors affecting Brazilian DE investments since the early 2000s is the government's drive to achieve universal electrification. Government initiatives led to major investments for grid extension throughout the country, which resulted in more than 19 million new connections between 2000 and 2010 (IBGE 2000 and 2011). At the time of the 2010 Brazilian census, fewer than one million households lacked grid access. These remaining households without access reside in remote communities mainly in the north and northeast of Brazil, where USAID focused a large proportion of its off-grid support.

USAID DE Investments in Brazil

USAID DE investments in Brazil are most commonly found as components to larger support mechanisms working in the clean energy, energy efficiency, and/or sustainable livelihoods sectors. Two multi-pronged Brazil-based activities and one global credit guarantee met the parameters for inclusion for the review's full 31-activity portfolio inventory. These are:

1. Energia Renovavel e Desenvolvimento (E&D);
2. Clean & Renewable Energy (C&RE); and
3. E+Co, Inc. and ShoreBank Portfolio Credit Guarantee.

Implemented between 2005 and 2008, E&D was designed to support activities that utilize renewables and efficiency technologies as a means for promoting social and economic development while also addressing climate change. E&D DE components included direct delivery of five solar powered pumping systems for hydroponics, a small hydropower system in Pará State, solar driers for produce, solar desalinators for agriculture production, and a demonstration facility for biofuel manufacturing. STA support took the form of (1) market research, (2) public policy engagement, (3) developing national and international partnerships to attract sustained financing, and (4) capacity building for community groups, the banking sector, and government bodies for the purpose of strengthening the renewable energy sector. The case studies in Cachoeira do Aruã (Case Study 1) and Ceará State (Case Studies 3 and 4) received partial support from the E&D activity.

Implemented between 2009 and 2012, C&RE was designed as a consortium with seven grantees supporting a wide-array of policy and community interventions to promote sustainable clean and renewable energy usage. C&RE-DE specific investments included the DD, ES, and STA modalities. The activity directly provided solar PV to target communities for use in the agro-tourism sector. ES support took the form of various partnerships with industrial actors to increase their capacity to produce biodigester products for use in the agriculture sector. And STA support included: (1) instructing students and teachers about the use, benefits of, and how to access sources of renewable energy; (2) support for a carbon credit scheme in the form of monitoring greenhouse gas emissions; and (3) various forms of support to policy actors and public awareness campaigns to incentivize the use of clean energy solutions. E&D and C&RE were both implemented by *Instituto de Desenvolvimento Sustentável e Energias Renováveis* (Sustainable Development and Renewable Energy Institute – IDER).

Since 2007, E+Co and ShoreBank have held a 50 percent loan portfolio guarantee through USAID's Development Credit Authority (DCA) which has been utilized to finance activities in Brazil, Cambodia, Guatemala, Honduras, and Nepal. The guarantee's coverage ceiling of $1.5 million has already been reached; however, the guarantee's coverage window lasts until 2017. It has been used to finance enterprises concerned with solar PV, small hydro, and biomass gasifiers installations. In Brazil, E+Co/ShoreBank extended a loan, backed by the CG, to Enalter which is discussed as Case Study 5.

Energia Produtiva (EP)

Of additional note is *Energia Produtiva* (EP), which was implemented between 2003 and 2005 by Winrock International. Its start date was prior to 2004, thus its exclusion from the inventory; however, EP provided support to the case studies in Cachoeira do Aruã (Case Study 1) and the PV irrigation site in Ceará (Case Study 3). More broadly, EP directly installed various solar PV and biodigestion systems in northeast Brazil to support the agriculture sector, including but not limited to organic farming. STA support took the form of NGO and renewable energy stakeholder capacity building. In addition, EP assisted several small-scale hydro plants to attract private financing. The activity closed two years early due to concerns over the availability of Mission resources.

Activities Selected as Cases

This report summarizes then compares five case studies from Brazil which were selected through a collaborative process with USAID.

Individual cases represent one to two investment "sites," which were usually components of a larger activity, e.g., the E&D activity provided support for Case Studies 1, 3, and 4.

The five in-depth case studies included:

Case Study 1 – PRISMA Hydro Mini-grid in Cachoeira do Aruã (DD): This site represents a micro hydropower mini-grid serving a community of approximately 120 households along the Aruã River, roughly 145 km southwest of Santarém in Pará State. The case utilized the implementer's PRISMA model, which is a project design paradigm that couples sustainable livelihoods and enterprise development approaches to (1) confirm community ownership of the power generator and (2) raise beneficiary incomes.

Conclusions: USAID support ended in 2008 and the mini-grid was still functioning at the time of the review's visit in 2015. The number of households receiving service has doubled from 60 to 120 in the intervening years, resulting in a degradation of service, according to community members, because of the wider-base utilizing the system's relatively consistent output level. Conditions that contributed to the system's sustainability included favorable national and state policies, a high degree of community engagement, and strong partnerships with local NGOs. There was no indication that the mini-grid investment was replicated elsewhere.

Case Study 2 – Household PV SHS in Maripá and Santí Communities (DD): This DE activity was a replication of a successful fee-for-service Photovoltaic Solar Home System (PV-SHS) activity implemented by IDEAAS in Rio Grande do Sul from 2000–2003.[70] This activity was implemented in the geographically isolated communities of Maripá and Santí, Pará State, which will not be able to access grid-based electrification in the foreseeable future. To replicate the fee-for-service PV–SHS model in these remote communities, IDEAAS partnered with a local NGO, Projeto Saúde e Alegria (PSA), and offered three PV-SHS options with different levels of capacity. The implementers developed what they considered to be a viable "fee-for-service" business model, but due to lack of funds, IDEAAS was not able to continue supporting the business model and stopped providing maintenance services about a year and a half after installation. From that point on, households stopped paying the monthly fee and assumed responsibility for maintenance of their own systems.

IDEAAS secured USD $224,000 in funding from the Lemelson Foundation. This was supplemented by $20,000 from USAID, which constituted less than 10 percent of the total funding received and was used to provide technical assistance. Multiple informants told the review team that the fee-for-service scheme was suspended after just 16 months due to cuts in funding, including cuts from USAID.

Conclusions: USAID support ended between 2008 and 2009 and the PV–SHS systems in Maripá and Santí were marginally sustained. At the end of USAID funding, 48 systems were in operation, but this number had decreased to 35 at the time of the review team's visit. Roughly 16 months after system installation, IDEAAS stopped responding to maintenance requests, citing a lack of funding. This resulted in households assuming responsibility for maintenance themselves, to mixed results. The marginal success of the investment can be partly attributed to the relatively low maintenance needs of the systems; however, the review team speculates that a greater degree of sustainability could have been achieved if the fee-for-service model had been maintained. The review team identified no evidence of replication or scaling of this activity during fieldwork.

Case Study 3 – Community PV Irrigation in Bom Jesus and Barra de Corrego (DD, STA): This case study assessed two PV-irrigation installation sites that supported organic agriculture production in the communities of Bom Jesus and Barra de Córrego in the semi-arid northeast region of Ceará State. USAID funds assisted in (1) the installation of the water-pumping and micro-irrigation system, (2) capacity building for farmers in organic agriculture practices, and (3) commercialization support for marketing the produce grown using the irrigation systems (e.g., business planning, credit acquisition).

[70] Founded by Fabio Rosa in 1997, IDEAAS is a Brazilian nonprofit organization that develops and pilot-tests models for delivering rural electrification and the use of renewable energy sources to low-income rural populations.

Conclusions: The installations in Bom Jesus and Barra de Córrego were able to operate for two to three years as a result of beneficiary engagement and sufficient training to maintain the systems for a period. However, the water-pumping system eventually began to malfunction. The model utilized Danish parts and was expensive and time-consuming to repair. By the time of the review team's visit the operation had ceased entirely. Beneficiaries also cited difficulties in marketing the organic products produced at the sites. The review team identified no evidence of scaling or replication of this activity.

Case Study 4 – Biofuel Power Production in Quixeramobim (DD): This case study assessed the outcomes of a biofuel-based electricity production plant on Fazenda Normal, a demonstration farm managed by Empresa de Assistência Técnica e Extensão Rural – Ceará (EMATERCE),[71] near the town of Quixeramobim in central Ceará State that provided electricity to Serrinha de Santa Maria, a rural community. The biofuel plant at Quixeramobim was a proof-of-concept pilot led by a consortium of companies called "CENP Energia"[72] in partnership with the Secretariat of Agriculture and Livestock (SEAGRI). USAID, through its implementing partner IDER, supported coordination and administration of the activity. The activity also received financial support from the firms that constituted CENP-Energia, as well as the state government of Ceará. The biofuel pilot at Quixeramobim was initiated in 2003.

Conclusions: The biofuel plant ceased operation in 2007. No evidence was available to suggest that the pilot scaled or replicated. Contributing factors to the pilot's lack of sustainability include: (1) main-grid extension to the community and (2) the Brazilian government's prioritization of soybean based biofuel as opposed to the pilot's use of castor oil.

Case Study 5 – Enalter Solar Hot Water (CG): Enalter is a Brazilian commercial enterprise that received a 2007 loan through the E+Co/Shorebank global loan portfolio guarantee scheme described above. The $26,000 loan was for the purpose of expanding Enalter's operations budget and its marketing mechanisms for its solar water heating systems. While these heating systems are not meant for electricity generation, this case was selected because it represents a contrasting commercial approach relative to the other cases. At the time of USAID's investment, Enalter was mainly serving middle-class customers; however, in the intervening years, Enalter has contracted with multiple state-sponsored programs to provide solar water heating systems to lower-income clients.

Conclusions: Enalter representatives cited receipt of the USAID-backed loan as a contributing factor to their success in attracting further sources of financing. The review team concluded that the Enalter case was the most sustainable in the sense that it is a growing business with a gradually increasing customer base and strong maintenance and customer service reviews. Contributing to Enalter's success is national and state policies that mandate that 0.5 percent of utilities revenue be reinvested in energy efficiency programs, hence Enalter's participation with state-sponsored distribution schemes to lower-income customers.

[71] EMATERCE is the government agency in charge of agricultural extension services in Ceará State.
[72] CENP Energia was itself a partnership of five independent power producers: Ceará Gerador de Energia (CGE), Cummins Power Generation, Parnamirim Energia, ENGEBRA, and TEP Potiguar.

Cross-Case Conclusions

Public Support for DE

Supportive national and/or state policies with respect to DE are necessary but not sufficient for sustained outcomes. At the time of the 2010 census, fewer than one million households lacked grid access, indicating a relatively successful push in the 2000s to massively extend the grid for those near population centers. But for those in remote areas without access, respondents cited national and state polices for creating an enabling environment for DE. This public support can take the form of a government unit contributing to the procurement of DE installations and partnering with NGOs and international donors to build community capacity to maintain and utilize energy access for livelihoods improvements (such was the case in Cachoeira do Aruã). This can also take the form of the case in Quixeramobim, where grid access was extended to the community, taking away the underlying need for DE solutions. In essence, contextual factors relating to public policy investment choices can improve the likelihood of sustained DE outcomes but can also shift underlying assumptions making previous investments obsolete.

Community Engagement

The circumstances for community engagement varied considerably across the five cases. For the Cachoeira do Aruã mini-grid, the site's implementation model was predicated on community engagement. The entire system is managed by the community and would not have functioned had the community not been engaged from the start. In Maripá and Santí, the fee-for-service model was designed to meet specific needs of these communities in terms of energy demand and ability to pay. While the Maripá and Santí model was only moderately successful due to the failure of a key component (the fee-for-service model), community engagement at the beginning of support ensured that the systems were well designed and that the communities had sufficient sense of ownership to take responsibility for the systems after IDEAAS pulled out. In contrast, Enalter's commercial model does not require such engagement. The firm's growth is subsidized with funds that originate from state utilities, motivated by national-level energy policies, and facilitated by state-level programs for low-income housing. Thus, the review team concludes that community engagement is an important contributor to sustainability for community based, mainly DD, investment types; however, is less vital for commercial investments similar to that of Enalter's credit guarantee.

Partnerships

Each of the activities that achieved a degree of sustainability exhibited successful partnerships between donor, government agencies, businesses, and/or local service providers. For international donors especially, these partnerships are vital to developing the positive stakeholder networks necessary to maintain DE systems after the end of support. Such partnerships were largely absent in the two activities that were not sustained and prominent components of the three that did exhibit sustained outcomes. For the activities in Pará State (Case Studies 1 and 2), a strong local NGO with vital community ties was the key element of the partnership. In these cases, the local partner helped beneficiaries overcome obstacles that might have stunted the sites' relative sustainability. Especially in the case of Cachoeira do Aruã, the activity was designed with community ownership as a key component and resulted in full responsibility for system operations and maintenance to be passed to community members in conjunction with continued support from local NGOs that remained in the area. While the nature of Enalter's solar hot water systems is quite different from the Cachoeira do Aruã case, this report draws a similar conclusion about the collaboration in that case: multiple agencies came together to create a sustainable DE dissemination program that Enalter would likely not have accomplished alone.

Technology Choice

DE solutions are only possible if the technology chosen is an appropriate match for the context in which it is deployed. For the cases that were not sustained, the technologies that were chosen presented challenges that could not be surmounted (e.g., failure of costly irrigation pumps in Ceará and low oil yields and energy inefficient processing at Quixeramobim). In successful cases, parts were manufactured regionally and could be replaced with ease or be serviced by local technicians. Above all, simple technologies requiring less costly and less frequent maintenance were more likely to be sustained.

ANNEX E: TANZANIA PORTFOLIO REPORT EXECUTIVE SUMMARY[73]

Portfolio Review of USAID Decentralized Energy Activities

This document presents and compares three Tanzanian case studies that inform a wider portfolio review of USAID decentralized energy (DE) investments that began between 2004 and 2012. DE in this context refers to interventions supported by USAID that generate limited wattage, serve a small number of customers per system/installation, are off-grid, and utilize clean energy technologies. USAID DE investments take the form of sectoral technical assistance, credit guarantees, enterprise support, and direct delivery modalities. Examples of the technologies supported include solar powered micro-grids, household energy systems, micro-hydro generators, and biomass installations supported by a range of business models, financing mechanisms, public policy arrangements, and capacity-building assistance for system operations and maintenance (O&M).

The range of activities representing the entire USAID DE portfolio includes 31 unique investments in 12 countries, including 2 global credit guarantee facilities. Based on criteria developed collaboratively with USAID, three countries were selected for in-depth study: Tanzania, Brazil and India. Therefore, primary data were collected for applicable DE investments in these 3 countries, which together represent 13 case studies.[74] In a separate Synthesis Report, these case studies – the 3 Tanzania cases of which are summarized in this document – along with a literature review, summary of related performance evaluations, and descriptive statistics relating to the entire 31-activity portfolio are used to answer the review's three research questions:

1. To what extent and under what conditions have USAID-supported decentralized energy systems been sustainable after USAID assistance ended?
2. To what extent and under what conditions have USAID-supported decentralized energy systems been replicated or scaled up after USAID assistance ended?
3. What decentralized energy implementation models and processes have been most effective at achieving sustainability, scale, or replication?

USAID-DE Investment Modalities

Global USAID-DE investments fall into four overarching categories, which are:

Credit Guarantees (CG): Through the Development Credit Authority (DCA), USAID uses partial credit guarantees to mobilize local financing, by covering 50 percent[75] of the principal in loans to projects that advance the Agency's development objectives. This risk-sharing mechanism encourages commercial banks and other lenders and creditors to expand credit to sectors and industries they currently do not serve, or to lend with less collateral than previously required. The expectation is that during the guarantee period, the lender will get to know the industries and associated risks so that in the future, the lender will have the confidence to issue comparable credit without enhancements.

[73] The full Tanzania report is available here: http://pdf.usaid.gov/pdf_docs/pbaaf012.pdf.
[74] Five in Brazil. Five in India. Three in Tanzania.
[75] The large majority of CG activities cover 50 percent of the loan principle; however, there are exceptions. For example, a loan portfolio guarantee to a Nigerian financial institution covered up to 80 percent for loans disbursed for renewable energy promotion.

Direct Delivery (DD): USAID activities or activity component(s) in which USAID or other donors invest the majority of the capital and other associated costs for repairing, procuring, and/or installing one or multiple DE systems. In addition to paying for capital costs, these projects may provide training, capacity building or other technical support for the installation and/or operation of the DE system.

Enterprise Support (ES): USAID grants made directly to clean energy enterprises to support testing and/or scaling of breakthrough technologies and solutions. This may include complementary technical assistance and training to the enterprise for such purposes as business acceleration, improved management, equipment sourcing, and increased access to financing. This category includes Development Innovation Ventures (DIV) grants and grants under contracts or larger umbrella mechanisms.

Sectoral Technical Assistance (STA): USAID project or project component(s) that strengthen the enabling environment for enhancing access to clean energy services in off-grid areas. This may include, for example, developing new policies, legislation, and/or regulations, strengthening relevant government agencies and higher education facilities, and training of financial institutions on off-grid clean energy lending.

DE in Tanzania

Tanzania has low rates of electricity access, particularly in rural areas. While roughly 20 percent of Tanzanians have access to electricity, only 3 percent of rural Tanzanians have grid connections. Grid extension has been a priority for Tanzania's Rural Energy Agency (REA), and in recent years REA has extended the grid to hospitals, clinics and schools in rural areas, with plans to connect a larger number of households to the grid over the next few years. Currently, grid connections are unavailable or unaffordable for most rural Tanzanians and a growing number of off-grid energy companies have begun to market energy services to rural Tanzanians. Each case study profiled in this report markets its products to a different income-group. This range first illustrates the ubiquity of energy poverty in rural Tanzania, but these cases also provide instructive lessons for expanding energy access to a broad base of rural residents.

USAID-DE Investments in Tanzania

Tanzania hosted only 1 of the 31 distinct activities that make up the review's inventory; however, 2 additional investments were included as case studies due to their comparability with contexts and themes exhibited elsewhere in the portfolio.

The activity formally included in the wider portfolio was a DIV grant in 2012 to Engineering Global Growth (EGG) – Energy. EGG serves as Case Study 2 in this report and is discussed below.

The other two cases, Off-Grid Electric/M-Power and Zara Solar, also provide instructive lessons. Off-Grid Electric/M-Power received a DIV grant in 2013 but has been operating in Tanzania since 2011. Zara Solar, on the other hand, received support from the USAID FENERCA[76] activity. FENERCA was a USAID cooperative agreement held by E+Co initiated in 2000 and ended in 2005. FENERCA's objective was to promote the development of renewable energy enterprises and projects, while increasing the capacity of financial institutions, entrepreneurs, and NGOs. FENERCA operated mainly in Latin America but was later expanded to Sub-Saharan Africa, including Tanzania. While this global STA investment is not included in the review's formal inventory, it extended loans to Tanzanian firm Zara Solar which is included as a Case Study 1 and discussed below.

[76] Increased Use of Renewable Energy Resources Program – (Financiamiento de Empresas Energéticas en Centroamérica) (Award #: LAG-A-00-00-00008-00)

USAID Investments Selected as Cases

Cases were selected based on initial desk research and through a collaborative process with USAID. All of the cases represent ES-type investments.

Case Study 1 – Zara Solar/Mona-Mwanza Electrical and Electronics (MMEE): Zara Solar is related to the older company Mona-Mwanza Electrical and Electronics (MMEE). MMEE/Zara received three loans from FENERCA's implementer E+Co[77] in 2001, 2004, and 2005 to build its expertise and offerings in the solar market. Starting in 2000, MMEE became increasingly interested in selling solar home systems and began working with solar experts in East Africa, including E+Co. The 2001 loan of $50,000 allowed MMEE to expand its retail business to include solar PV systems. E+Co provided technical assistance to help MMEE complete a business plan and in 2004 disbursed a second loan for $100,000. The second loan enabled MMEE to purchase solar PV components in bulk. As a condition of the third loan ($200,000), MMEE split its operations into two; opening Zara Solar, Ltd. MMEE/Zara maintained the same owner, location, and business model, but Zara exclusively provided customers with high-quality solar PV systems targeted to relatively well-off rural residents of the Mwanza region.

Conclusions: The review team found Zara to be the most successful in terms of sustainability among the three cases. A major contributing factor to Zara's sustainability is its strategic partnerships with a Tanzanian Government-UNDP collaboration that trains solar technicians and maintenance workers in the region. At least in part due to the solar training scheme, the region enjoys a sophisticated understanding of solar products, which supports demand for Zara's offerings and allows savvy consumers to easily tap into technician networks to maintain purchased systems. Zara's upfront pricing reduces risk and financing costs for the company, but also limits its customer base to those who can afford the system in full. Zara's systems provide sufficient power to meet household needs for lighting and television and can support small-scale entrepreneurial activity. The firm has experienced substantial growth in recent years; although it has not expanded beyond the Mwanza Region. Because of Zara's business model, strategic partnerships, and Mwanza's structural advantages, the review team speculates that scaling the firm's offering outside of Zara's home region would require significant adaptation.

Case Study 2 – Engineering Global Growth-Energy (EGG-Energy): EGG-Energy is a commercial firm providing energy services to rural Tanzanians. Founded in 2009, EGG's original offering was solar powered battery-charging hubs. In 2012, EGG received a $100,000 DIV grant in 2012 to test the viability of this model. Over the course of this grant period, EGG recognized that its hub approach to disseminating energy services was found to be inconvenient by customers. The firm then switched its focus to rent-to-own solar systems for household/small business use (systems generating between 50 and 200Wp). EGG also tapped into agriculture networks as a key customer outreach tool when it switched its operations away from its base in Iringa, towards Tanga. The 2013 DIV grant (also $100,000) was provided to improve EGG's data infrastructure, which linked mobile money systems with the company's customer service records; developed data applications to track logistics, inventory, and customer management; and trained staff to use new software systems.

[77] E+Co faced liquidation in 2012 due to unpaid loans and its Africa operations were restructured as Persistent Energy Partners, a for-profit energy company operating in Ghana and Tanzania.

Conclusions: USAID support for EGG-Energy has only recently ended; however, the adaptability of the firm provides instructive lessons in flexible commercial approaches to DE programming. EGG's original battery-charging hubs remain operational, but exposed the firm to non-payment risks which became evident early in the 2012 grant's implementation. The revised approach will likely be more sustainable based on several promising improvements: (1) EGG provides financing options to customers based on a rent-to-own scheme, widening its customer base and encouraging customers to payoff systems instead of losing accumulated equity. (2) EGG now uses Global System for Mobile Communication (GSM) applications to switch off systems that have outstanding payments. This reduces the need to repossess units unless payment remains delinquent for extended, and un-communicated, periods (EGG is flexible with seasonal workers with unsteady incomes). (3) Partnerships with agricultural organizations have shown to be a successful way to market offerings to target customers and conduct basic customer-credit inquiries. This report concludes that EGG's model has the potential to scale; however, EGG employees claimed that poor access to capital is a constraint on the firm's growth. Staff also stated that USAID early-support has been instrumental in attracting the financing the firm has been able to secure. Further, EGG's model requires a critical mass of customer penetration in any given region to make viable its O&M model; making rapid expansion to new regions challenging. Grid expansion also poses a medium to long-term challenge; EGG's CEO stated that grid-connected customers typically remain interested in off-grid solutions due to reliability concerns; yet, nonpayment is more common within this demographic.

Case Study 3 – M-Power (Off-Grid:Electric): Off-Grid:Electric, known in Tanzania as M-Power, is a clean-energy start-up that began selling low-cost lighting and cellphone charging services at prices competitive with kerosene. The firm's Tanzanian offshoot was founded in 2011 and uses Arusha as its base of operations. The company has since expanded with offices in 11 districts throughout Tanzania. M-Power's basic systems feature three lights and a mobile phone charger and costs users approximately $1.25 per week. M-Power has received two USAID DIV grants. The first in 2013 was for $100,000 and assisted with operating costs and was meant to facilitate company growth from roughly 500 installations to 1,500 installations. The second, in 2014, also for $100,000, was designed to test the firm's model at scale in new locations and with new approaches to agent training and compensation. While USAID's first investment in M-Power is outside of the review's 2004 to 2012 period of interest, it was selected because M-Power's founding date was several years prior and was recognized from desk review as the most successful case to achieve scale within the Tanzania portfolio.

Conclusions: At the time of the review team's visit, M-Power reports having installed over 60,000 systems with a repossession rate of approximately three to four percent. A key component of M-Power's success is that it has been able to provide an offering that is competitive with kerosene and uses advanced software systems to track company performance and customer usage statistics. The firm has created a four-week academy that trains potential M-Power employees in basic business practices and M-Power's technical offerings. This training program has allowed M-Power to staff its rapidly growing number of offices spread out over 11 districts in Tanzania. A customer compliant is that M-Power uses a fee-for-service approach with no option for customer buyout of the system. Grid expansion poses risks because low-usage customers (those using less than 50kWh per month), are eligible to receive a subsidy from the national utility that would effectively offer low-quantities of energy at a third of M-Power's weekly rate. Accessing this subsidy of course requires the grid's presence in one's community (and $20 connection fee). For households consuming more than 50kWh, M-Power's offering remains competitive; although M-Power's services typically cater to basic needs. Despite these medium to long-term challenges, M-Power has achieved a remarkable degree of beneficiary and geographic coverage and shows strong potential to sustain its operations it if is able to adapt to Tanzania's rapidly changing set of regulatory and economic contexts.

Cross-Case Conclusions

Policy/Regulatory Uncertainty

In Tanzania, the expansion of the grid, especially close to major population centers in the near and medium-term, has the potential to reduce commercial DE company sales through the gradual shrinking of the customer base. This is especially true for firms that could compete directly with the grid. Interviews with Zara Solar and EGG indicate that grid extension contributes to either a drop in sales or increased periods of nonpayment. This suggests that Zara and EGG's higher-end products may compete directly with the grid; whereas M-Power's lower-cost offerings target customers who likely would be unable to afford the grid's current upfront connection fee, or would be unable to utilize the current low-user subsidy. These policies are subject to change however.

Based on the three case studies, this report concludes that commercial DE actors that find ways to compliment or accommodate grid expansion, or are flexible enough to change service territories when the grid expands, will be better positioned to provide sustainable access to electricity while remaining financially viable.

Access to Capital

Macroeconomic conditions, particularly access to capital, affected all three firms. All reported that access to capital was crucial for growth and expansion, but found that lenders perceive their businesses as high-risk. Zara Solar found that an influx of capital early on in its solar PV venture was sufficient. EGG and M-Power, however, require continued financing to (1) provide flexible payment options to their customers and (2) fund new offices and floor space. M-Power has received sufficient investment funding and grants to open 10 new offices in the past year and a half; EGG plans to expand to new regions once it obtains sufficient investment funds. Both EGG and M-Power noted that early USAID-DIV funding was crucial in attracting additional financing from donors and private investors; however, domestic debt is difficult to attract. This is at least in part due to the finance sector's unfamiliarity with start-ups employing innovative business models, especially those using relatively new DE technologies.

Community Engagement

The Tanzanian cases profiled in this report worked within or grafted themselves onto existing community structures in innovative ways. Zara Solar was able to greatly increase its customer count by capitalizing on other donor support mechanisms, specifically a partnership between the Ministry of Energy and Minerals and the UNDP. The UNDP-MEM program has contributed to a relatively sophisticated regional user base in terms of solar technology near Mwanza. This in turn has increased demand for Zara's products and established a large pool of qualified technicians to maintain the systems. In this environment, Zara has achieved deep penetration into the regional market; but reliance on this structural advantage limits Zara's ability to replicate elsewhere.

EGG on the other hand uses community agriculture associations to market its products. This marketing serves two purposes: first, EGG is introduced to a whole network of potential users; and second, these associations are seen as a good way to attract clients with sufficient means to make regular payments. Somewhat similarly, M-Power tends to train and hire local employees across its large and growing number of outlets in order to utilize staff's intimate knowledge of target regions and communities.

Between these cases, this report concludes that knowing one's customer and the context in which they plan to consume energy is helpful for commercial approaches to scale. Yet, sustaining systems has more to do with building (or tapping into) O&M procedures that responds to customer maintenance needs and is flexible enough to adapt to changing circumstances.

Fee Collection and Maintenance

Each of the cases presented in this report developed fee-collection strategies that mitigated the risk of nonpayment. Zara represents the highest-end product offering of the three. The firm targets customers of sufficient means to pay upfront installation costs which is out of reach for a wide range of rural residents. In turn, Zara's financial risk is quite low and local technicians provide routine maintenance at reasonable fees contracted by the customer. EGG provides a two-year warranty and the firm continues to own the system as customers pay a regular fee. The fee is designed as a rent-to-own payment resulting in the eventual cessation of payments, which customers found advantageous. EGG mitigates risk by using GSM-based applications able to switch off installation generating capacity in the event of non-payment. For short term non-payment this makes repossession unnecessary and contributes to system maintenance monitoring. Customers generally found EGG's two-year warranty to be well implemented. M-Power on the other hand provides a fee-for-service model and maintains ownership of the installation indefinitely. Customers appreciate the affordability of M-Power's systems; however, would prefer to be able to gradually purchase it outright. At least in part to M-Power's rapid expansion, customers reported delays in receiving system maintenance.

Gender Empowerment

USAID's investments in the three cases profiled in this report were supportive of existing enterprises and thus were not designed to specifically address gender inequities. That said, extending energy access naturally has the potential contribute to gender empowerment. Across the cases, end-user interviews confirmed that energy needs differ between men and women, and low-capacity solar home systems are of limited benefit to females. Near the sites visited by the review team, the team found that men typically make decisions about where lights will be placed (low-end systems only support two to three lights) and rarely locate them in the kitchen, where women would benefit most. Relatedly, female respondents expressed interest in energy generation for ironing, cooking, and refrigeration, which require larger (and more expensive) solar power systems. Despite a greater overall need for electricity, women in the sites visited by the review team were commonly excluded from decision-making about energy systems and often expressed limited understanding of how the systems work. Although there were instructive exceptions.

During one set of interviews with Zara Solar beneficiaries in Sengerema, and during another set of interviews with EGG customers in Tungalamenga, the review team spoke to multiple female beneficiaries who were the primary users of their systems. These women expressed sophisticated understanding of their system's capacity and maintenance needs. In both cases, this higher-than-normal level of familiarity seemed to be a combined function of favorable socio-economic conditions and a local technician who had made a special effort to educate and empower women to utilize and care for solar power systems.

ANNEX F: INDIA PORTFOLIO REPORT EXECUTIVE SUMMARY[78]

Portfolio Review of USAID Decentralized Energy Activities

This document presents and compares five Indian case studies that inform a wider portfolio review of USAID decentralized energy (DE) investments began between 2004 and 2012. DE in this context refers to interventions supported by USAID that generate limited wattage, serve a small number of customers per system/installation, are off-grid, and utilize clean energy technologies. USAID DE investments take the form of sectoral technical assistance, credit guarantees, enterprise support, and direct delivery modalities. Examples of the technologies supported include solar powered micro-grids, household energy systems, micro-hydro generators, and biomass installations supported by a range of business models, financing mechanisms, public policy arrangements, and capacity-building assistance for system operations and maintenance.

The range of activities representing the entire USAID DE portfolio includes 31 unique investments in 12 countries, including 2 global credit guarantee facilities. Based on criteria developed collaboratively with USAID, three countries were selected for in-depth study: India, Brazil, and Tanzania. Therefore, primary data was collected for applicable DE investments in these 3 countries, which together represent 13 case studies.[79] In a separate Synthesis Report, these case studies – the 5 India cases of which are summarized in this document – along with a literature review, summary of related performance evaluations, and descriptive statistics relating to the entire 31-activity portfolio are used to answer the review's 3 research questions:

1. To what extent and under what conditions have USAID-supported decentralized energy systems been sustainable after USAID assistance ended?
2. To what extent and under what conditions have USAID-supported decentralized energy systems been replicated or scaled up after USAID assistance ended?
3. What decentralized energy implementation models and processes have been most effective at achieving sustainability, scale, or replication?

USAID DE Investment Modalities

Global USAID DE investments fall into four overarching categories, which are:

Credit Guarantees (CG): Through the Development Credit Authority (DCA), USAID uses partial credit guarantees to mobilize local financing, by covering 50 percent[80] of the principal in loans to projects that advance the Agency's development objectives. This risk-sharing mechanism encourages commercial banks and other lenders and creditors to expand credit to sectors and industries they currently do not serve, or to lend with less collateral than previously required. The expectation is that during the guarantee period, the lender will get to know the industries and associated risks so that in the future, the lender will have the confidence to issue comparable credit without enhancements.

[78] The full India report is available here: http://pdf.usaid.gov/pdf_docs/pbaaf011.pdf.
[79] Five in Brazil. Five in India. Three in Tanzania.
[80] The large majority of CG activities cover 50 percent of the loan principle; however, there are exceptions. For example, a loan portfolio guarantee to a Nigerian financial institution covered up to 80 percent for loans disbursed for renewable energy promotion.

Direct Delivery (DD): USAID activities or activity component(s) in which USAID or other donors invest the majority of the capital and other associated costs for repairing, procuring, and/or installing one or multiple DE systems. In addition to paying for capital costs, these projects may provide training, capacity building or other technical support for the installation and/or operation of the DE system.

Enterprise Support (ES): USAID grants made directly to clean energy enterprises to support testing and/or scaling of breakthrough technologies and solutions. This may include complementary technical assistance and training to the enterprise for such purposes as business acceleration, improved management, equipment sourcing, and increased access to financing. This category includes Development Innovation Ventures (DIV) grants and grants under contracts or larger umbrella mechanisms.

Sectoral Technical Assistance (STA): USAID project or project component(s) that strengthen the enabling environment for enhancing access to clean energy services in off-grid areas. This may include, for example, developing new policies, legislation, and/or regulations, strengthening relevant government agencies and higher education facilities, and training of financial institutions on off-grid clean energy lending.

DE in India

The Government of India has set ambitious goals for extending electricity access to all communities by 2020. The boldness of this plan is underscored by findings from the 2011 census, whereby 33 percent of Indian households lack access to a reliable energy source (approximately 400 million people). The vast majority of these households are in rural India. A combination of great distance, less dense populations, and lower ability to pay makes electrifying all of rural India using the central grid unlikely in the near-term. The government has identified over 20,000 villages where grid extension is cost prohibitive; and these are earmarked for electrification using DE sources. However, the scope for application of decentralized technologies is potentially much greater than that for two reasons. First, meeting the ambitious targets for extension of the grid system within the government's proposed timeframe will be challenging, and, in the meantime, decentralized technologies may play a role in providing electricity. Second, India's grid system has both insufficient generating capacity and distribution problems (poor infrastructure leading to high losses) that result in regular power cuts and power quality problems. These issues are particularly acute in rural India, where grid-connected households may only receive power for a few hours per day. Decentralized technologies provide an alternative source for households in the face of an unreliable grid system.

The magnitude of energy poverty in India requires scalable solutions to achieve the ambitious goals the government has set out. Thus commercial firms have entered the market to capitalize on the potential of recent DE-related technological advancements, such as cost-competitive solar photovoltaic (PV) systems and innovative financing and fee collection structures; pay-as-you-go household financing (see the case study on Simpa Networks); or group-oriented fee collection schemes (see the case study on Mera Gao Power). Further, DE solutions are also linked to women's empowerment and livelihood generation opportunities. An example of this is Swayam Shikshan Prayog's training of more than 1,000 women entrepreneurs in Maharashtra and Bihar. These entrepreneurs were trained in the use and basic maintenance of clean energy technologies and given business and entrepreneurial training in order to establish their own clean energy distribution businesses.

USAID DE Investments in India

India hosted 6 of the 31 activities that make up the review's inventory, making it the portfolio's most active host country. These are:

1. Mera Gao Power (MGP);
2. Humana People to People – India (HPPI);
3. W-Power/Swayam Shikshan Prayog (SSP);
4. South Asia Regional Initiative for Energy (SARI/E) – Phase 2;
5. SARI/E – Phase 3; and
6. Orb Energy Portable Credit Guarantee.

In addition, Simpa Networks, which received a DIV grant in 2013, was included as a case study for this country report due to its comparability with other ES activities in India and among the wider global portfolio.

Activities Selected as Cases

This report summarizes then compares five of the investments noted above. Cases were selected based on initial desk research and through a collaborative process with USAID.

Case Study 1 – MGP (ES): MGP received a USAID ES grant in 2011 as part of the Global Development Lab's DIV competition designed to support breakthrough, scalable solutions for intractable development challenges. DIV grant funding was provided to (1) build off previous pilot-testing and test the commercial viability of MGP's solar micro-grid technology and (2) assess the development impact of these micro-grids on the lives of customers. Activities were concentrated in Uttar Pradesh. MGP reports having reached 20,000 households across 1,073 villages with its micro-grid operation.

Conclusions: MGP operates an unsubsidized-driven business model and has witnessed rapid growth. MGP's success to date has been on account of its standardized micro-grid technology that caters to basic energy needs at an accessible price with prompt and hassle-free service. This service includes a customer service line that logs customer complaints and dispatches an MGP trained technician to address maintenance issues. MGP's fee collection approach has been effective; where a weekly fee is collected from community customer groups that hold individuals accountable. Another critical factor that has contributed to MGP's growth has been its focused operations within a limited geography, which has contributed to efficiencies in operations. The main threat to MGP's business model is from the arrival of the main grid into communities it is currently serving, but 100 percent household connectivity and reliable energy service provision through the main-grid appears unlikely in the medium term. A factor that will determine MGP's future growth is its ability to develop innovative solutions to meet the increasing aspiration levels of their customers.

Case Study 2 – HPPI (DD): From 2009 to 2011, HPPI utilized a grant investment from USAID and in-kind support from the Tata Energy Research Institute (TERI) to directly provide 100 solar lantern changing stations (with 60 lanterns each) for use in western Uttar Pradesh. The activity had a women's empowerment component that supported women's self-help groups. These groups were geared towards pooled savings plans that assisted women in times of personal shocks (e.g., a family health crisis), micro-investments (e.g., to start a commercial activity), and encouraged female entrepreneurs to start up solar lantern rental businesses to support the larger community's lighting access needs. Female entrepreneurs were provided the lanterns in-kind and were usually selected from within the existing self-help group structures. Lanterns were then rented out to community members for a fee (ranging from a per night basis in some communities to as long as a month).

Conclusions: At the time of the review team's visit in 2015, it was estimated that between 50 and 60 percent of the solar lanterns were still in working order, which given the typical life-span of similar products, was in line with expectations. There is no mechanism in place to replace the donated lanterns or continue servicing them to extend their already stretched lifespan. An indirect achievement was a noticeable increase in demand for solar products in the communities HPPI served, according to residents. "Saur Urja shops" are entering the market displaying a number of solar products with increasing sophistication. A concern for these shop keepers however is that their more expensive, higher-quality products, compete with cheap, low quality imported torches which are more accessible to the low-income communities that make up the bulk of the energy poor in western UP. The female entrepreneurs renting out the HPPI lanterns noted that their small-business ventures contributed to an increase in their household's income and increased their agency within the community. The review team concluded that HPPI's model was successful in empowering specific female entrepreneurs and the women's groups it works with; however, the technical products it provided are unlikely to be sustained or replaced in the long-term and its model is unlikely to scale due to its reliance on donor support.

Case Study 3 – SSP (STA): From 2012 to 2015, SSP received USAID grant support for the purpose of strengthening DE distribution pathways in Maharashtra and Bihar. These funds, which reflect an STA investment approach, were provided through the Partnership on Women's Entrepreneurship in Clean Energy (W-POWER) program in India. USAID funds were used to train female entrepreneurs to sell clean energy products through associated distribution schemes. To generate demand, efforts were made to promote clean energy generation technologies at the community level through promotional materials (e.g., extension efforts to rural market stalls, community group meetings, and wall murals), and the establishment of an "energy hub" where nearby residents could assess various products and speak with knowledgeable suppliers. The energy hub also served as the training space for the initiative's female entrepreneurs. At the end of the activity, 1,010 entrepreneurs were trained, selling solar lanterns to an estimated 40,000 households.

Conclusions: USAID support for SSP has only recently ended, making an assessment of sustainability provisional. This report speculates that while existing systems have been sustained, long-term funding systems are not in place to ensure the sustainability of the SSP entrepreneurial-training model, nor the long-term operations of the energy-hub. Social benefits of the program included an uptake in solar lamp usage to replace kerosene across communities the entrepreneurs operated in and, according to the entrepreneurs themselves, stronger household decision-making authority because of the income they were bringing into the home. Without continued donor support, it is unlikely that the SSP model will achieve scale beyond its current network.

Case Study 4 – Simpa (ES): Founded in 2010, Simpa Networks sells solar power through a process similar to mobile credit purchasing. In 2013 the firm obtained a USAID-DIV ES grant to test their model at scale. Specifically, the grant was designed to (1) rollout Simpa's model to 12,000 households mainly in Uttar Pradesh and (2) measure the social impact and financial viability of the approach in order to attract additional private investment. While the portfolio review's period of interest are USAID-investments that began between January 2004 and December 2012, Simpa's earlier sites were installed before the cutoff date, thus its inclusion in the overall portfolio. Further, Simpa has attracted an array of donor backed and commercial financing to support its scaling vision and provides instructive lessons for the wider-portfolio.

Conclusions: A major contributor to Simpa's success has been its ability to attract low-cost, long-term debt in order to finance its expansion plans and offer low usage fees to its customers. The nature of its fee collection scheme is innovative, using a pay-as-you-go model that allows energy poor households to access comparatively sophisticated solar home systems without the up-front costs that would be associated with purchasing a system on their own. This pay-as-you-go system with buyout options requires Simpa's continued engagement in the regular maintenance of its products (they continue to own the system), until the user is able/chooses to pay-off the system or return it. While Simpa has attracted an impressive degree of additional financing for its expansion, its plans for 10 percent month on month growth is ambitious. Simpa, like MGP, appears secure in the medium term but uncertainty with respect to public subsidies for solar home lighting systems that may compete with its unsubsidized models, along with uncertain grid-expansion plans, pose risks for the firm's long-term viability.

Case Study 5 – Orb Energy (CG): Orb Energy is a private limited enterprise selling distributed solar PV and solar thermal water heaters. In 2012 Orb obtained access to a portable loan guarantee backed by USAID's Development Credit Authority (DCA). Orb aimed to scale up its operations to establish 500 branches within 3 years (ending in 2016). Under this arrangement, Orb at the time of the review team's visit had obtained $1 million from Deutsche Bank with the support of the CG. This first tranche was for backward integration within its solar water heater vertical, i.e., towards setting up a manufacturing facility for solar water heaters with an eventual capacity of 1,500 systems per month, which would result in greater cost efficiencies and improved margins. This Bangalore-based facility was formally inaugurated in September 2015.

Conclusions: Orb has been unable to secure the second half of its CG backed ceiling towards similar backward integration within its solar PV business line. This was due to Deutsche Bank's internal criteria, which limited the bank's exposure to one-third of the net assets of a firm, i.e., for the bank to lend $2 million to Orb, the firm's net assets would need to be in excess of $6 million as opposed to Orb's current $4.9 million. Orb representatives told the review team that they hope for USAID's support in ongoing discussions with Deutsche Bank to relax the criteria, due to the risk sharing nature of the CG. While this report is unable to provide specific conclusions about Orb's sustainability or scaling model because of the uncertainty relating to Orb's ability to access additional credit using the CG, this uncertainty is itself instructive. DCA support can take multiple structures, i.e., a loan guarantee for a specific enterprise and specific lender, a portfolio guarantee for a number of loans provided by specific lender, or (as in this case) a portable guarantee that can be used by the holder (Orb) to "shop around" for lenders. Because CG-type support is demand-driven with respect to lenders, generalizable conclusions from this case are limited. Factors contributing to CG model successes are by their nature relationship, context, and demand specific.

Cross-Case Conclusions

Capital and Policy/Regulatory Uncertainty

Current Government of India policies for electricity access favor grid expansion and regulatory mechanisms provide insufficient guidance on the relationships between DE and grid-service. This raises a number of considerations for DE providers and customers, including:

- How the promise of grid-expansion may impact customer willingness to pay for DE solutions in the short-term;

- What happens to DE investments when grid-access arrives to communities currently not served; and
- How will public utilities integrate micro-grids, among other DE solutions, into the existing grid system?

Uncertainties surrounding these types of considerations pose risks to DE providers, especially commercial actors, and is a factor in decisions being made today both for seekers and providers of capital. Firms like MGP, with its micro-grid model, recovers costs in two to three years, which is a better financial bet than firms that would require capital in greater orders of magnitude to establish more sophisticated off-grid solutions. The greater up-front capital costs and longer terms of repayment exacerbate the risk felt by investors betting on DE initiatives. As seen in the Simpa case, access to large amounts of capital and long-term repayment plans allows the firm to provide pay-as-you-go services to those who would otherwise be unable to afford solar home systems. Clarifying these uncertainties would likely contribute to greater access to capital for firms that seek large-scale social change through commercial pathways.

Also relating to access to capital, repeated interviews with sectoral and case-level informants suggest that the Indian financial sector is largely unfamiliar with DE activities and credit underwriting for these types of investments have benefitted from donor funded grants. These grants, such as those sponsored by USAID-DIV, are instrumental in establishing the business framework and financial records needed to pursue private future sources of private financing. Sectoral informants credit USAID's support in building linkages between the financial sector, policy makers, and DE providers and welcome further assistance to solidify and expand progress. Points of further improvement include shifting credit underwriting for DE investments away from collateral-dominated analysis to cash-flow based reviews better suited to new firms in a new market-sector.

Commercial Pathways

Four-hundred million Indians without energy access is a development challenge that dwarfs the other countries represented in the wider USAID portfolio. Given India's sophisticated capital markets and stable political system, commercial DE firms and investors are well placed to compliment government efforts to massively extend access in the short and medium-term. NGO-driven cases (HPPI and SSP) appear unlikely to be sustained after donor assistance ends and unlikely to be scaled beyond their specific target communities. By contrast, the commercially oriented partners (MGP and Simpa) continue to expand after their grant periods of performance end; however, suggest that employee talent acquisition, access to capital, and the policy uncertainties described above may prove to be challenges to their success.

Gender Equality and Female Empowerment

The NGO-driven cases were designed to contribute to additional objectives beyond those concerned with energy access; most-prominently women's empowerment, and along these metrics HPPI and SSP have been largely successful. Both models trained female entrepreneurs to contribute to the solar lighting value chain (HPPI to rent solar lanterns and SSP across a range of products and distribution schemes) and respondents from both activities suggested that they have experienced increases in their personal agency in the home and in their communities. This is mainly due to the increased income these women are able to generate, but also their roles as a provider of a valuable service to communities that may not have access to other forms of lighting. None of the five-cases examined in this report linked specific female empowerment models with scalable commercial pathways; however, this is examined across the 31-activity portfolio for the review's Final Synthesis Report.

Technology and Maintenance

The cases reviewed included a variety of solar-based technologies offering differing levels of service. None of them followed the same implementation model, and while all targeted rural customers, each targeted a particular customer segment. For example, MGP offered basic household electrification at a low cost, allowing it to serve those at the lower end of the income scale. HPPI's lantern rental model also targeted low-income households and even provided the flexibility to rent on a daily basis. Simpa's pay-as-you-go with purchase option for a single home-based solution targeted a slightly higher income bracket. Each technology-type was viable and well suited to the context in which the implementers were targeting. The larger conclusion is that technology choice should be context appropriate (e.g., Simpa's more expensive solution would likely not have been viable for the users of HPPI's lanterns), but as long as it meets this threshold, it is not a first-order predictor of sustainability or scale. Rather, how these technologies are maintained, and the fee structures that underpin this service are of more direct consequence.

Four of the cases (Orb not being applicable) recognized the need for maintenance and created maintenance support systems for their technology. However, the ability to maintain the systems over time varied and can reasonably be expected to vary into the future. MGP and Simpa, as commercial enterprises that own their hardware, have an incentive to maintain systems in order to continue their revenue steam. These two cases incorporated maintenance into the customer's standard fee, and they have trained personnel and a commitment to quick service. By contrast, HPPI did not appear to have the funding and processes in place to cover replacement lanterns and ensure longer-term service. To conclude, the cases that had strong customer-satisfaction incentives to maintain their products and built in fee structures to replenish resources for continued support resulted in the most widely sustained and scaled approaches.

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