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POWER TO THE PEOPLE

Investing in Clean Energy for the Base of the Pyramid in India

FOREWORD

India is facing a severe energy crunch. Roughly four hundred million rural inhabitants – more than the entire U.S. population – still lack electricity, making energy access a development imperative. At the same time, economic growth is sending national energy requirements soaring. India's GDP is on pace to grow by 8% in 2010, and domestic energy demand is predicted to more than double by 2030.

The energy shortage is most acute among India's rural poor, the majority of whom rely on relatively inefficient, polluting and health-threatening fuels such as kerosene and firewood for their lighting and cooking needs. As India's government and energy sector seek to provide more modern and reliable heating and lighting services to these communities, a fledgling market in cleaner, more efficient energy products is emerging. This huge and under-served rural Indian market offers significant opportunities for investors looking to support the sustainable energy solutions of the future.

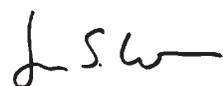
In recent years, a number of domestic companies have developed clean energy products and services specifically targeting India's rural "Base of the Pyramid" population – the 114 million households who spend less than US\$75 a month on goods and services. About 45 percent of these families do not have reliable access to electricity and rely on kerosene for lighting, while over 85 percent largely rely on firewood and dung for cooking. Successful (though small scale) business models such as solar-based home electricity systems and lanterns, energy-efficient cookstoves, and electricity services generated from decentralized sources such as micro hydro and biomass gasifiers are increasingly finding a market among such households.

India's government has also facilitated the emergence of this rural clean energy sector by supporting distributed generation in the form of community-based, self-sufficient biomass and solar power. The recently launched National Solar Mission seeks to achieve 20 gigawatts of solar power by 2022, in part through the installation of rooftop photovoltaic systems. It also sets the specific goal of providing 20 million solar lighting systems in place of kerosene lamps to rural communities within the next dozen years. Such measures serve the government's dual objectives of providing electricity to rural areas and reducing the trajectory of India's greenhouse gas emissions. Several Indian states, including Andhra Pradesh, Gujarat and Haryana, are also encouraging development of the clean energy sector by instituting statewide renewable portfolio standards. These mandate that a certain percentage of electricity is generated by solar, wind or other renewable, non fossil, fuels.

Against this encouraging backdrop, this report by India's Centre for Development Finance at the Institute for Financial Management and Research (CDF-IFMR) and the World Resources Institute's New Ventures Program, seeks to enhance understanding of the investment potential of the clean energy industry serving India's rural poor. Based on extensive field work with clean energy companies and rural BoP consumers as well as rigorous secondary research, the report showcases eleven companies selling innovative products and services to sustainably meet the energy needs of the rural poor. It also analyzes both the market opportunities and the challenges to scale up that the industry faces.

WRI and CDF-IFMR hope that these research findings and recommendations will help investors – both in India and abroad – better understand the enormous potential of this market. We believe the expansion of this sector is highly achievable through the development of more efficient business models, additional favorable national policies, and increased, targeted capital. The potential opportunity for investors is significant. We estimate the aggregated potential market for clean energy consumer products and services to be INR 97.28 billion or USD 2.11 billion per year.

Realizing this potential would be a win-win for investors, for India's people and for the global climate: profit-making clean energy solutions bringing light to millions of India's poorest households.



Jessica Seddon Wallack
Director, Centre for Development Finance



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PHOTO CREDITS

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DEDICATION

This publication is dedicated to Professor C.K. Prahalad (1941-2010), one of the founders of the Base of the Pyramid concept and a long time and greatly valued member of the World Resources Institute's Board of Directors. His 2004 book, 'The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profit' – named one of the best books of the year by the Economist - laid the foundation for the concepts incorporated in this report.



With funding support from:



ICICI Foundation:

ICICI Foundation for Inclusive Growth (ICICI Foundation) was founded by the ICICI Group in early 2008 to give focus to its efforts to promote inclusive growth amongst low-income Indian households. It is committed to making India's economic growth more inclusive, allowing every individual to participate in and benefit from the growth process. The ICICI foundation does this by supporting strong independent organisations which work towards empowering the poor to participate in and benefit from the Indian growth process.

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Executive Summary

Box 1: What is the Base of the Pyramid?

The Base of the Pyramid (also referred to as the Bottom of the Pyramid) refers to the estimated 4 billion people around the world who are poor by any measure and have limited or no access to essential products and services such as energy, clean water, and communications. Globally, people in this socioeconomic group earn US\$1 to US\$8 in purchasing power parity (PPP) per day. Yet these households often pay higher prices than wealthier consumers do for lower-quality goods and services because of uncompetitive markets.^a

Since this report focuses specifically on rural India, we define the rural Indian BoP market as households in the bottom four expenditure quintiles (based on data from the National Sample Survey Organization) that spend less than INR 3,453 Indian rupees (US\$75) on goods and services per month. This definition represents a market of 114 million households, or 76 percent of the rural population.^b

Notes: ^a A. Hammond, B. Kramer, et al., *The Next 4 Billion: Market Size and Business Strategy at the Base of the Pyramid* (Washington, DC: World Resources Institute, 2007).

^b CDF-IFMR analysis, National Sample Survey Organization (NSSO) 2004/2005, round 61.

India, a rapidly emerging economy with the world's second largest population, is facing a surging energy demand. Its rural Base of the Pyramid (BoP) consists of 114 million households, representing 76 percent of India's rural residents and almost 60 percent of the country's total population (see box 1)¹. Despite their low income, these households constitute a significant consumer market for the energy services and products required to provide daily necessities such as cooking and lighting. Using the most recent available expenditure data (2004/2005), we estimated that India's rural BoP consumers spent INR 224 billion (US\$4.86 billion) per year on their energy needs².

In 2005, approximately 45 percent of India's rural BoP households still did not have reliable access to electricity and relied on kerosene for lighting, and more than 85 percent of rural BoP households mostly used conventional free or inexpensive sources of fuel, such as firewood and dung, for cooking³. These fuel sources, however, are not only harmful to users' health⁴ but also contribute to pollution and environmental degradation.⁵

A growing number of Indian companies see a market opportunity in providing rural BoP households with access to alternative cooking and electricity solutions and consequently are developing clean energy products and services for this market. "Clean energy" refers to products and services that produce energy from renewable resources and emit fewer greenhouse gas emissions than does energy from conventional fuel sources. The lack of a reliable supply of power from the electricity grid and the availability of free and inexpensive fuels, such as wood and kerosene, are key influences on this market. In this report, we focus on two areas in this growing, high-potential market: clean energy electricity systems and clean energy cooking and light products. We examined a representative selection of companies selling solar lanterns, solar home systems, energy-efficient cookstoves, and electricity generated from decentralized sources, including small hydro power plants and biomass gasifier systems (see box 2).

ABOUT THIS REPORT: INFORMING INVESTORS

The goal of this report is to inform investors about the market potential of the clean energy industry serving India's rural BoP market, by looking at its opportunities, challenges, and potential paths to growth. The purpose of our report is to present an overall picture of these growing clean energy sectors, rather than to provide investment advice on individual companies (see box 2).

Box 2: Information and Data Sources

CDF-IFMR and WRI collected secondary data on forty-five companies from India and abroad and selected eleven Indian (from a total of twenty-three Indian clean energy companies identified as targeting rural BoP clean energy markets) and four global companies for in-depth analysis based on technology, product or service, business model, value proposition for the BoP, and potential to scale.

The information and data used for this publication were derived from three sources: (1) field research conducted by CDF-IFMR and WRI in India and globally, to collect quantitative and qualitative data from companies through a survey, interviews with company leadership and field staff, and focus group discussions with more than 240 rural BoP consumers; (2) data from the National Sample Survey Organization's (NSSO) sixty-first round of the Consumer Expenditure Survey, conducted in 2004/2005; and (3) peer-reviewed secondary sources.

The potential opportunity for investors in the Indian clean energy market for the rural BoP is significant. We estimated the aggregated potential market for the four sectors studied in this report to be **INR 97.28 billion (US\$2.11 billion) per year, including INR 94.06 billion (US\$2.04 billion) for decentralized renewable energy services and INR 3.22 billion (US\$70.1 million) for energy products per year** (see box 3 for our method of calculation).

Our analysis shows that clean energy services and products may require an upfront investment three to ten times greater than that for conventional energy sources such as kerosene and firewood, which often are subsidized or free to India's rural consumers. Yet despite these and other drawbacks, the average annual gross revenue of the companies profiled in this report has grown 36 percent since 2004⁶.

TARGET SECTORS

CLEAN ENERGY ELECTRICITY SYSTEMS

We found that the need for a dependable supply of electricity for multiple uses was the primary driver of the demand for clean energy products and services. Installed in either the household or the community, clean energy products and services can supply enough electricity for several different uses, such as providing lighting, running fans, charging mobile phones, and operating radios and small appliances.

- » **Decentralized renewable energy enterprises (DRE)** are energy companies that supply clean power for a community in a specific geographic region. These systems supply rural BoP consumers with electricity services generated from renewable sources of energy (primarily small hydro and waste biomass) through existing grids or company-owned distribution systems. Based on the most recent available data (2004/2005), we estimated the potential market value of the DRE sector for India's rural BoP segment at **INR 94.06 billion (US\$2.04 billion) per year**. DRE constitutes more than 95 percent of our total market forecast.
- » **Solar home systems (SHS)** are solar-based electricity-generating and storage systems designed to provide power to individual households. These systems use photovoltaic panels to generate electricity, combined with a battery and a controller to regulate charging and discharging. These systems are typically purchased on credit by individual households and are customized to meet their specific electricity requirements. Based on the most recent available data (2004/2005), we estimated that the SHS sector's potential market value for India's rural BoP segment is **INR 1.26 billion (US\$27.39 million) per year**.

Box 3: Methodology for Estimating the Potential Annual Market Value of India's BoP Clean Energy Sector

The following formulas were used to estimate the potential market for clean energy sectors:^a

Decentralized Renewable Energy (Clean Energy Services)

Average annual household expenditure on electricity^b * (Number of households not connected to the grid^c – Average number of households connected to the grid each year)^d

Solar Home Systems, Solar Lanterns, and Energy-Efficient Cookstoves (Clean Energy Products)

(Price of least expensive clean energy product currently available in the market^e * Number of households * Observed adoption rate for the clean energy product^f) / Average Product Life Span^g

Using these formulas, we calculated the potential annual market for each product/service as illustrated in the following table. For further explanation, please see the rest of the text.

	Decentralized Renewable Energy Services	Solar Home Systems	Solar Lanterns	Energy-Efficient Cookstoves
Number of Households	75 million	18 million	51.3 million	29.6 million
Lowest Product Price/ Annual Expenditure	INR 1272 (annual expenditure)	INR 7,000	INR 500	INR 150
Life Span	N/A	10 years	3 years	3 years
Adoption Rate	98.6% (discounting for rate of rural electrification)	10%	10%	75%
Potential Annual Market Value	INR 94.06 billion (US\$2.04 billion)	INR 1.26 billion (US\$27.39 million)	INR 855 million (US\$18.58 million)	INR 1.11 billion (US\$24.13 million)
Potential Annual Clean Energy Market Value for the Rural BoP = INR 97.28 billion (US\$2.11 billion)				

Notes: ^aThroughout this report, we distinguish between clean energy electricity systems that can supply power for a variety of uses, and single-use cooking and lighting solutions. However, clean energy electricity systems, such as solar home systems, are sold as products and are installed in individual households, whereas DRE providers sell electricity as a service. Therefore we use different formulas to calculate the potential market estimates.

^b CDF-IFMR, WRI analysis, NSSO 2004/2005, round 61.

^c Ibid.

^d Ibid.

^e CDF-IFMR-WRI field research, 2009.

^f Ibid.

^g Ibid.

COOKING AND LIGHTING SOLUTIONS

Alternative cooking and lighting products such as solar lanterns and energy-efficient cookstoves provide cleaner substitutes for conventional, highly polluting products like traditional cookstoves and kerosene lanterns. But there is not a strong demand for clean energy lighting and cooking products at their current prices, which put them out of reach of the majority of rural BoP households. Many BoP consumers also are not aware of the health benefits of these cleaner alternatives.

We also analyzed the two main types of clean energy cooking and lighting products in India.

- » **Solar lanterns** are portable LED lanterns that are powered by solar panels and can provide light for four to eight hours, replacing polluting and inefficient kerosene lanterns and supplying basic lighting for BoP households. Based on the most recent available data (2004/2005), we estimated the solar lantern market is worth **INR 855 million (US\$18.58 million) per year**
- » **Energy-efficient cookstoves** are fixed or portable cookstoves that burn solid-biomass cooking fuels 20 to 65 percent more efficiently than traditional stoves do. Energy-efficient cookstoves can replace traditional polluting stoves that cause indoor air pollution and severe respiratory problems in women and children. Based on the most recent available data (2004/2005), we estimated the energy-efficient cookstove market is worth **INR 1.11 billion (US\$24.13 million) per year**.

Table 1 summarizes our analysis of each of the four sectors. Next we offer more detailed analyses of each sector.

Table 1. Clean Energy for the rural BoP in India: Sectoral Analysis

	Decentralized Renewable Energy: Biomass and Small Hydro	Solar Home Systems	Solar Lanterns	Energy-Efficient Cookstoves
Potential Market Value (per year)	INR 94.06 billion (US\$2.04 billion)	INR 1.26 billion (US\$27.39 million)	INR 855 million (US\$18.58 million)	INR 1.11 billion (US\$24.13 million)
Average Pricing	INR 8 to 13 /kWh (biomass) INR 2 to 2.5 /kWh (small hydro)	INR 7,000 (US\$150) to INR 20,000 (US\$450)	INR 500 (US\$ 11) to INR 1,600 (US\$ 35)	INR 150 (US\$3) to INR 1,100 (US\$24)
Competitive Advantage	Biomass and small hydro have higher levels of operational reliability compared with other DRE technologies; low upfront cost for consumers; and sized to meet demand.	Customized electricity solution based on individual requirements.	Long-term cost savings for rural households currently using kerosene.	Reduced cooking fuel costs; health benefits from lower emissions of pollutants.
Business Model	Biomass: Provided through company-owned minigrids; electricity priced to existing fuel expenditure levels. Small hydro: Supplied to villages using existing underutilized grid infrastructure; paid at government-determined tariffs.	Sold on credit, in partnership with local banks. Users typically pay 10 to 25 percent upfront and the rest in installments.	Bulk sales to corporate, NGO, and microfinance institution (MFI) partners; sold directly to consumers through local retailers.	Sold through multiproduct rural distributors and retailers; partnerships with microfinance institutions (MFIs), and NGOs.
Challenges	Biomass: Correctly estimating demand to optimize plant size and load. Small hydro: Highly dependent on regulation tariffs set by government; requires negotiation of power purchase agreement (PPA).	Pricing is currently too expensive for the larger market of low-income groups; adequate maintenance is difficult in remote rural areas.	Government subsidies for kerosene use dissuade consumers; charitable distribution schemes distort the local market.	Pricing is currently too expensive; product design does not always meet users' needs and habits; little awareness of health benefits among consumers.
Opportunities	Government subsidies can reduce expenditures; carbon credits can generate new revenue sources; PPAs in grid-connected regions can minimize demand risk by allowing companies to sell power to the state electricity board (SEB).	Leasing options for solar home systems may be tried out, as in Brazil and the United States.	Industry group can be formed to represent companies' interests to policymakers, provide service resources to reduce product misuse, and implement pay-per-use business models that mirror purchasing patterns and income streams.	Partnerships with MFIs and NGOs can reduce financing and marketing costs; market exists for products that meet users' needs.

Source: CDF-IFMR and WRI analysis.

INVESTMENT THEMES

In our analysis of the primary and secondary data, we observed several key themes for each sector relevant to investors interested in this market, which are outlined in the following box.

Decentralized Renewable Energy Enterprises	<p>Increasing consumer demand: Consumers want solutions comparable to grid electricity in cost, convenience, and capability.</p> <p>Forecasting is key to successful supply/demand management: DRE companies that set up their own mini community-focused grids and charge rural consumers directly for their services need strong forecasting abilities to accurately assess local consumers' demand for power and to build appropriate, cost-effective facilities.</p> <p>Available options to offset demand risk: DRE companies that operate in regions with existing grid infrastructure but poor local power availability can sell electricity directly to the state electricity board (SEB), which can then be routed to underserved local communities through the existing underutilized grid. SEBs are required to purchase power from independent renewable energy providers, making this an attractive option for DRE companies to offset demand risk.</p>
Solar Home Systems	<p>Demand for multiuse electricity solutions: Consumers want multiuse electricity solutions that mimic grid-based electricity, which has largely driven the demand for solar home systems among the BoP's higher-income groups.</p> <p>Reductions in upfront costs and improvements in after-sales service likely to drive consumer demand: Consumers are currently deterred by high prices and companies' poor after-sales maintenance. SHS companies can reduce the upfront product cost by developing leasing options, providing various financing options for users, and developing other sources of revenue, such as after-sale service contracts.</p>
Solar Lanterns	<p>Limited demand that could grow as prices fall: High prices and subsidies for traditional energy sources have limited the demand for solar lanterns. While bulk purchases from charitable programs currently drive the market, solar lantern companies are starting to produce cheaper lanterns that are more affordable for individual BoP consumers.</p> <p>Financing and partnerships critical to lowering upfront prices: Solar lantern companies can lower the upfront purchase price through tight controls on value chains' distributor and retailer margins and partnerships with microfinance institutions to provide consumer-financing options. They also can reduce their marketing and distribution costs through partnerships with nonprofit organizations.</p>
Energy-Efficient Cookstoves	<p>Demand restricted to higher income levels: The relatively high price of most energy-efficient cookstoves in the market and the unclear value proposition (since most consumers collect firewood for free and do not receive a direct monetary gain from the improved fuel efficiency) have made it difficult for companies to sell these products to lower-income groups.</p> <p>Creating markets through partnerships and design: In the near to mid term, companies in this sector should work with nonprofit market development organizations (see section VII) to raise awareness of the significant health benefits of their products and to build a market for energy-efficient cookstoves. Companies should also lower the upfront price by designing simpler products using low-cost materials, which mimic the ease of use of traditional stoves; or by providing product financing to penetrate the considerably larger, but as yet untapped, lower-income BoP market.</p>

Source: CDF-IFMR and WRI analysis.

ROLE OF GOVERNMENT POLICIES

The potential growth of this market is significant, but the government's role is critical to the development of clean energy services and technologies for India's rural BoP population. The government provides many incentives for renewable energy projects, including capital subsidies of up to 90 percent, tax holidays, accelerated depreciation, and low-interest loans. In addition, state electricity boards (SEBs) are required to buy power from independent power producers, and states are required to set targets for renewable energy generation⁷. But some of India's current policies undermine the demand for clean alternatives. For example, government programs that distribute solar products for free often make users less inclined to purchase these products at cost, and the availability of highly subsidized kerosene distorts the market for competing alternatives like solar lanterns.⁸

Our report concludes that the investors and clean energy firms serving this market should work together to advocate policies that achieve the dual objectives of increasing access to clean energy and stimulating the industry's growth. The improved implementation of existing regulations by the states, combined with new favorable policies such as considering clean energy products and service providers a priority lending sector for Indian banks would help achieve both objectives. We make three policy recommendations:

- » Shift the existing subsidy for kerosene to a subsidy based on lighting, to enable BoP consumers to choose their own lighting source while stimulating innovations related to solar lanterns and other clean technologies and business models.
- » By streamlining the application process, make the current subsidies and incentives more easily accessible to existing and potential DRE providers.
- » In accordance with the lending guidelines of the Reserve Bank of India, promote clean energy and energy efficiency companies as priority sectors for Indian banks.

THE INVESTMENT POTENTIAL OF THE INDUSTRY

Despite the great opportunities for growth in India's nascent clean energy market for the rural BoP, our detailed analysis of the industry, described in the rest of this report, shows that significant obstacles remain. The DRE sector is the most mature and appears ready to absorb mainstream investment. Although consumer demand in the other sectors is currently limited, it could grow considerably if the upfront prices were reduced through a combination of tighter control over distributor and retailer margins, cheaper manufacturing, lower marketing and distribution costs through strategic partnerships, and the availability of consumer-financing options.

Investors seeking to supply capital to this industry require patience and pragmatic expectations regarding their initial returns. Two of the eleven Indian companies we profiled have received investment; four others have received grants and donor capital; and three have received both investment and grants. In addition, four companies complained about the general lack of availability of short-term debt financing for small companies.

Impact investors, who seek to use their investments to generate positive social and environmental impacts, can have a significant effect on the industry at this stage by supplying firms with patient capital and non-financial resources such as management expertise and access to their business networks. Patient capital and guidance from impact investors will help companies in this industry overcome market challenges and provide rural Indian consumers at the base of the pyramid with clean sources of energy.

I. Introduction and Scope

Meeting the energy needs of India's 114 million rural "Base of the Pyramid" (BoP) households is a growing and urgent challenge⁹. While rural areas' access to the country's electricity infrastructure continues to increase, the majority of India's rural BoP population still meets their basic energy needs through an array of harmful sources, such as burning kerosene, firewood, and dung. These traditional fuel sources are inefficient and often unreliable, create health risks,¹⁰ and contribute to pollution and environmental degradation.¹¹ As a result, there is an urgent development need for clean, reliable, safe, and low-cost energy services and products. Detecting a market opportunity in this underserved consumer segment, a growing number of companies are selling clean energy products and services to India's rural BoP households. In 2009/2010, recognizing the importance of this industry in the social venture space, the Institute for Financial Management and Research's Centre for Development Finance (CDF-IFMR) and the World Resources Institute (WRI) analyzed the clean energy market for India's rural BoP consumers. This analysis involved on-the-ground research in both India and other countries where rural households use clean energy products and services.

Our goal is to inform investors about the market potential of the clean energy industry within India's rural BoP segment by reviewing the opportunities, challenges, and potential paths to growth based on an analysis of companies already operating in the market. By examining the business models of these companies and the overall landscape, we provide a firsthand perspective of the industry's investment potential, including:

- » The current scale of activity in India's rural BoP clean energy market.
- » The energy-related consumption and expenditure habits of India's rural consumers.
- » The market value of four clean energy alternatives:
 - Decentralized renewable energy enterprises
 - Solar home systems
 - Solar lanterns
 - Energy-efficient cookstoves
- » Government policies and initiatives affecting the rural BoP clean energy industry.
- » The role of nonprofit market development organizations.

METHODOLOGY

CDF-IFMR and WRI first collected secondary data on forty-five companies (twenty-two Indian companies and twenty-three global companies) offering solar lighting, decentralized renewable energy, micro-wind, biofuels, energy-efficient agricultural machinery (irrigation pumps, solar dryers), and energy-efficient cookstoves. We did so through an online search, using both company published and third-party sources. Fifteen of these forty-five companies (eleven Indian and four global) were then selected for a detailed analysis based on the companies' technology, product, or service; business model; value proposition for the rural BoP; and potential to scale. The companies we selected based on these criteria were in the solar lighting (solar home systems and solar lanterns), DRE, and energy-efficient cookstove sectors. In addition to these technologies and business models, we also examined newer technologies and business models that were not yet fully implemented but may affect this sector in the future (see appendix IV). The relatively small sample of companies serving these markets reflects the sector's early stage of growth.¹² Although even newer companies have recently entered the market, we believe our sample is representative of the sector and illustrates the wide range of its business models, challenges, and opportunities (for more on our selection process and field research, see appendix II).

We used conservative assumptions throughout the report. Observed adoption rates and the lowest-priced clean energy products and services available (based on field research), combined with market size estimates (based on national energy expenditure data), determine the size of the potential market for each sector.

The information and data used for this publication were derived from the following three sources:

» **Field Research**

The WRI and CDF-IFMR teams conducted field research at the fifteen selected clean energy companies and rural BoP consumers in seventeen cities and twenty-six small towns and villages in India and four other countries: Bangladesh, Brazil, Cambodia, and Kenya (see figure 1). The interviewees were a wide range of clean energy company staff, including executives, middle managers, and field staff, as well as their retail and financial partners. The research team also organized forty focus groups made up of more than 240 rural BoP users and nonusers of the clean energy products and services. Additional financial data were collected through an online survey from fifteen Indian companies, including the eleven case study businesses, to estimate the state of the market for each of the four sectors.

» **National Energy Expenditure Data**

A key source of information for market estimates was the National Sample Survey Organization's (NSSO) sixty-first round of the Consumer Expenditure survey.¹³ Conducted in 2004/2005, the NSSO survey is based on a sample size

of 79,298 rural and 45,346 urban households, representing more than 207 million households across India, including 150 million rural households. The survey uses the household as the primary unit of analysis, which more accurately reflects the level at which energy purchases are made by India's rural BoP consumers. While we recognize that energy usage patterns may have changed since the data were collected, the 2004/2005 survey is the most recent national and authoritative level data source available (see appendix III).

» **Secondary Sources**

Our report used only peer-reviewed or government sources for secondary research. A full list of sources can be found in the notes.

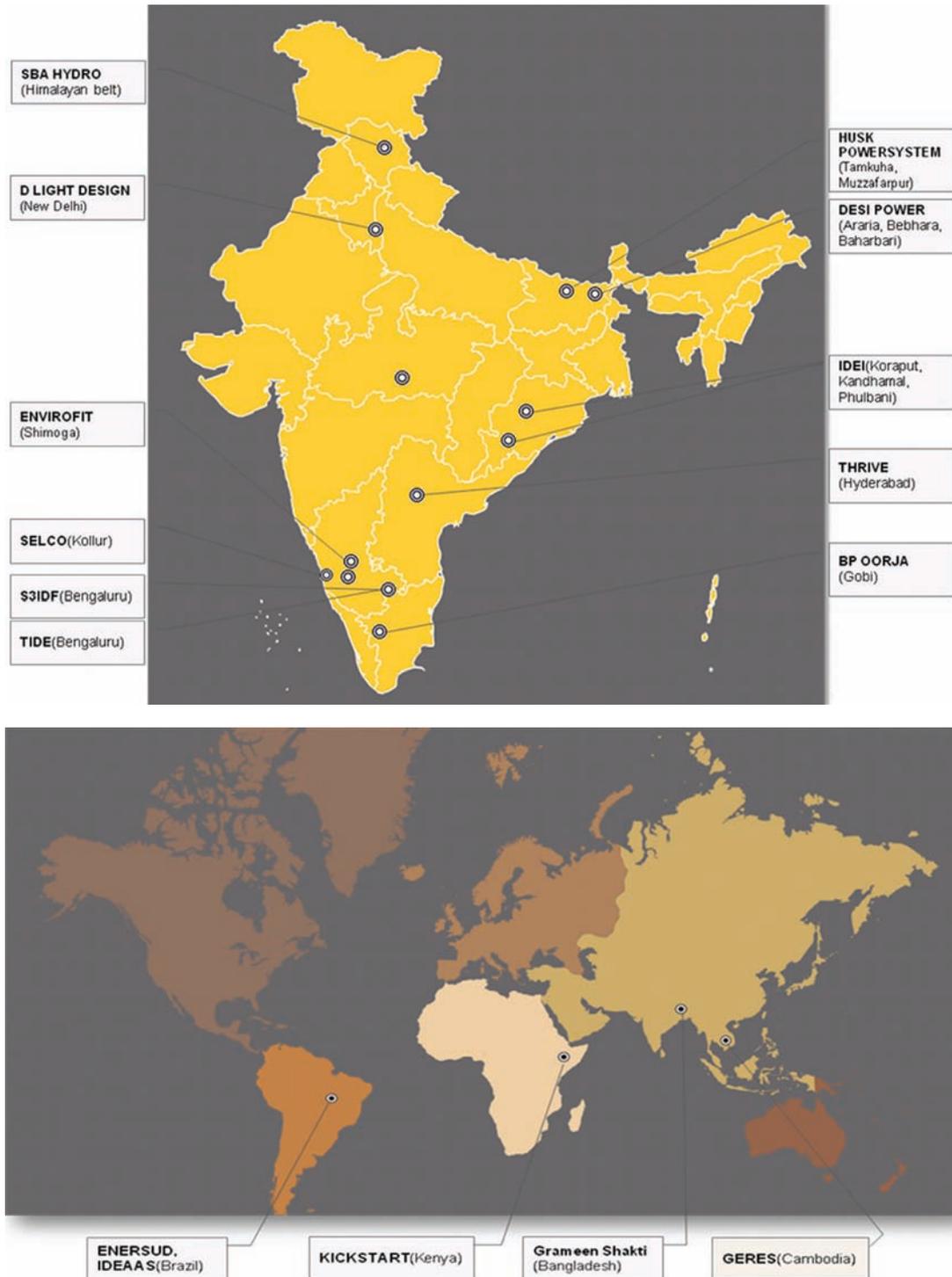
SCOPE OF THE STUDY

Only 55 percent of rural households are electrified in India, compared with more than 92 percent of urban households. Similarly, more than 85 percent of rural households rely on traditional cooking fuels such as firewood and dung, compared with only 30 percent of urban households.¹⁴ Therefore, our report focuses on the rural BoP energy market's current consumption patterns and industry behavior as the indicator for the potential market for clean energy products and services. It is not feasible to directly estimate demand for clean energy products and services because most rural BoP users have not been introduced to clean technology products and services, and thus their preference cannot be measured. As a result, rigorous empirical research on rural BoP consumers' preference for clean energy is extremely limited.

To estimate the rural BoP energy sector's current consumptive patterns and industry behavior, we

- » **Assessed current consumption and expenditures for specific energy sources.** We analyzed consumers' current fuel consumption and expenditure patterns to estimate the market size for clean energy alternatives. We did not, however, look at consumers' willingness to pay for, or to shift to, new technologies or service models.
- » **Assume that ticket price, users' life-cycle costs, and the associated health benefits will be the key demand drivers for consumers.** We omitted from our analysis the demand for conventional products used by rural BoP consumers, such as kerosene lanterns and traditional cookstoves, because they currently are considerably cheaper than clean energy alternatives and thus cannot be used to accurately measure the demand for this sector.
- » **Examine only household expenditures rather than include the commercial and agricultural energy markets.** While we recognize the significance of the commercial and agricultural energy markets, analyzing the potential demand for commercial and agricultural energy at the specific village level is not feasible because of the lack of aggregate research and is outside the scope of

Figure 1. Locations of Indian and Global Companies Studied (Source: CDF-IFMR, 2009)



Source: CDF-IFMR, 2009.

this study. However, we do briefly examine the common agricultural and commercial use of electricity.

- » **Present conclusions based on our analysis of the most recently available authoritative data on the behavior and trends of India rural BoP consumers and existing clean energy companies.** Although we recognize that fuel usage patterns may have changed since 2004/2005, fuel usage patterns for cooking and lighting did not change significantly between 1999/2000 and 2004/2005*. Therefore, we believe our estimates still indicate the current market size.
- » **Analyze the business models of specific companies to illustrate the industry and sector levels.** This report does not purport to assess the investment quality of the individual companies highlighted. Also, the report does not predict future consumer behavior or introduce new business models for the rural BoP clean energy market.

Business and investors should conduct their own market research to derive demand and growth projections for technologies and services in specific areas in India. India is a geographically diverse country with respect to food, culture, politics, and socioeconomic development. As a result, national statistics do not adequately reflect the actual clean energy products and services market in different regions of the country. For example, state-level data on lighting and energy usage highlight the substantial geographical variety of energy use patterns, underscoring the unique individual situations and the need for customized research.

* Changes in primary fuel usage in rural areas between 1999/2000 and 2004/2005 are as follows: (1) firewood and dung usage (for cooking) declined by 1 percentage point, from 87 to 86 percent; (2) kerosene usage (for lighting) declined by 7 percentage points, from 51 to 44 percent; and (3) electricity usage (for lighting) thus increased by 7 percentage points, from 48 to 55 percent (CDF-IFMR, WRI analysis, NSSO 2004/2005, round 61).

II. India's rural BoP clean energy market

The potential annual market value for the four clean energy products and services in India's rural BoP is INR 97.28 billion (US\$2.11 billion).

The potential annual market value for the four clean energy products and services in India's rural BoP is INR 97.28 billion (US\$2.11 billion). This market includes INR 94.06 billion (US\$2.04 billion) for energy services from decentralized renewable energy and INR 3.22 billion (US\$70.1 million) for energy products per year and therefore could represent as much as 43 percent of India's total current rural BoP energy market of INR 224 billion (US\$4.86 billion).*

While the development of the clean energy market is being driven by the lack of a reliable supply of power from the electricity grid, one of the main obstacles is the availability of free or inexpensive "dirty" fuels, such as wood and kerosene. Clean energy firms are trying to provide environmentally and user-friendly energy solutions that reduce health problems, lower air pollution and lower fuel costs while at the same time offering additional public benefits such as lower greenhouse gas emissions. Clean energy products, however, often cost more than traditional rural energy sources.

Despite this challenge, the demand for clean energy products at the rural BoP is increasing; with the average gross revenue of the fifteen firms we surveyed increasing 36 percent per year since 2004.¹⁵

MARKET VALUE

Despite the huge variability across geographic regions and income levels in India, our analysis estimates that India's rural BoP households spend an average of INR 163 (US\$3.50) per month on cooking, lighting, and energy needs.¹⁶ Table 2 is an overview of rural households separated into quintiles based on their monthly expenditure on fuel. For this report, we define the rural BoP as the bottom four quintiles (quintiles 2, 3, 4, and 5) of the population based on monthly household expenditure, which represents approximately 114 million households, or 76 percent of the rural population. Using the most recent available data (2004/2005), we estimate this market in terms of actual spending to be INR 224 billion (US\$4.86 billion) per year.†

* Based on the most recently available data from 2004/2005; see CDF-IFMR, WRI analysis, NSSO 2004/2005, round 61

† Our market value, based on the household's actual financial expenditure on energy, is as follows: Average monthly expenditure (INR 163.25) * Number of rural BoP households (114 million) * Number of Months (12) = Annual market estimate INR 224 billion.

Table 2. Monthly Household (MHH) Energy Expenditure in Rural India, by Expenditure Quintile, 2004/2005

	Monthly household expenditure on Fuel (INR)	Percentage of rural households in each Quintile (%)
Q1 (top)	362.92	24
Q2	291.99	21
Q3	264.06	19
Q4	239.08	18
Q5 (bottom)	195.78	17

Source: CDF analysis, NSSO 2004/2005, round 61.

MARKET DRIVERS

Rural household energy expenditure is driven by the lack of access to a reliable electricity grid and the availability of free and inexpensive fuels, such as wood and kerosene. Approximately 100,000 of India's 600,000 inhabited rural villages are off the country's electricity grid. Of these 100,000 off-grid villages, 20,000 are located in remote areas that cannot be reached by extending the traditional grid.¹⁷ India also has one of the world's highest rates of transmission and distribution (T&D) losses, with more than 30 percent of generated electricity lost through weak networks and theft. For the 500,000 rural villages with potential access to the electricity grid, more than 50 percent have an erratic, low-voltage power supply and frequent power outages.¹⁸

To meet their lighting and cooking needs, Indian rural households use a variety of fuels, such as firewood, kerosene, dung cakes, and liquid petroleum gas (LPG) for which many households pay below-market value because of government subsidies. For example, more than two-thirds of Indian rural households buy some of their kerosene at subsidized prices (about 30 percent of the market price), making it a fairly inexpensive fuel.¹⁹

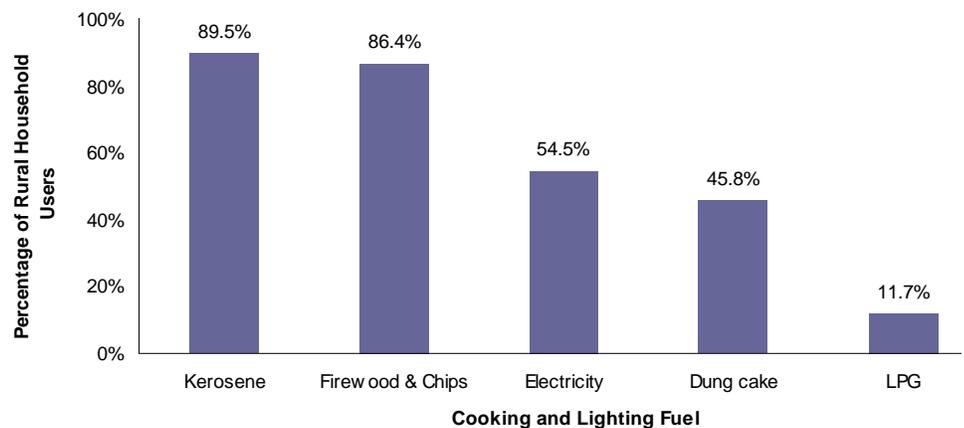
Moreover, only 27 percent of rural households reported paying for firewood, and the remaining 73 percent of households grew, collected for free, or bartered for their firewood.²⁰ Thus, if we include the value of the free firewood consumed by rural BoP households, the annual economic value of the fuel consumed (not including subsidies) would be INR 380 billion (US\$8.3 billion), compared with the INR 224 billion (US\$4.86 billion) that is actually spent.* Understanding what the rural BoP actually spends on fuel, rather than the value of the fuel itself, is an important distinction that has strong implications for sizing the potential BoP clean energy market.

* Households acquire goods through purchase, free collection, gifts, or home production. The value of fuel recorded in the NSSO survey is the sum of the total monetary expenditure on fuel plus the imputed market value of fuel that was not purchased. We used the identification codes in the original data to differentiate between purchased fuel and freely acquired fuel. Therefore, our market estimates are based on actual monetary expenditures and exclude the imputed values (CDF-IFMR analysis, NSSO 2004/2005, round 61).

Rural BoP consumers, including those with access to the electricity grid, meet their cooking, lighting, and energy needs through multiple sources. Our field research found that rural BoP consumers with access to the electricity grid continue to use kerosene for lighting during the frequent power outages or for igniting their wood-burning stoves.²¹ These findings also coincide with the NSSO survey, which found that while only 44 percent of rural households use kerosene as their primary lighting source, nearly 90 percent report using it in some capacity²² (see figures 2, 3, and 4).[†]

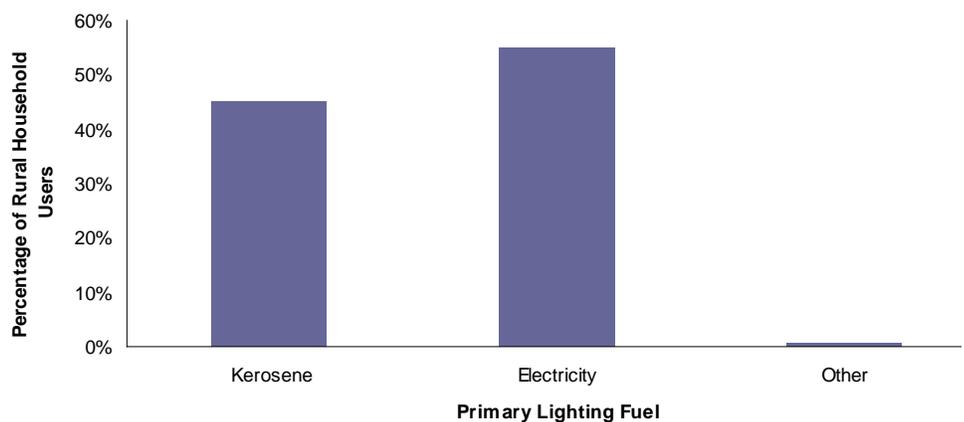
Figure 2: Rural Cooking and Lighting Fuel Use by Energy Source in India, 2004/2005

Percent of Rural Households Consuming Each Fuel Type



Source: CDF-IFMR analysis, NSSO 2004/20005, round 61.

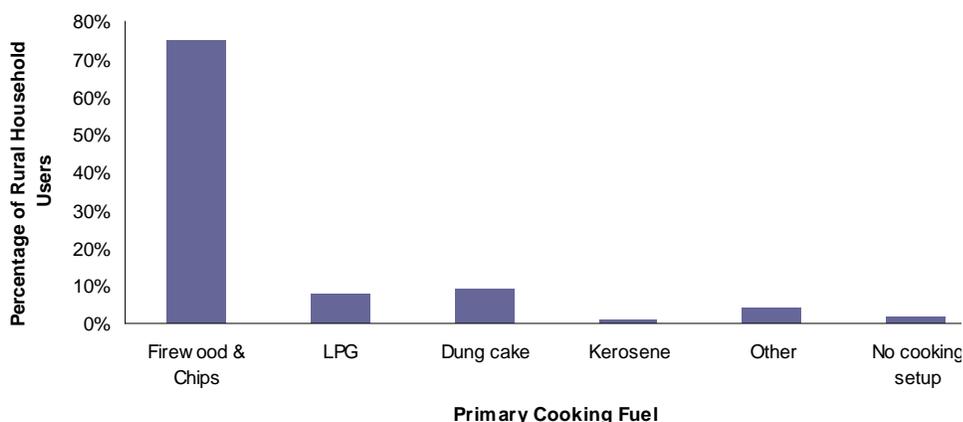
Figure 3: Primary Rural Lighting Fuel Use by Energy Source in India, 2004/2005



Source: CDF-IFMR analysis, NSSO 2004/20005, round 61.

[†] The data described in figures 2, 3, and 4 refer to all rural households, not only rural BoP households. We define the rural BoP as the bottom four expenditure quintiles, representing 76 percent of the rural population.

Figure 4: Primary Rural Cooking Fuel Use by Energy Source in India, 2004/2005



Source: CDF-IFMR analysis, NSSO 2004/20005, round 61.

OPPORTUNITIES AND CHALLENGES

Clean energy products have competitive advantages over conventional products because they can help rural BoP users improve their health and reduce their long-term fuel costs while at the same time gaining public benefits such as less pollution and lower greenhouse gas emissions. Households that use firewood, kerosene, and dung cakes as their energy supplies are exposed to dangerous toxins and pollutants such as respiratory particles, carbon monoxide, nitrogen and sulfur oxides, and benzene.²³ Studies have found that indoor air pollution from the combustion of traditional cooking and lighting fuels contributes to approximately 500,000 deaths annually and 4 to 6 percent of all disease-related deaths in India.²⁴ Additionally, cleaner fuels or energy efficient devices can help households reduce fuel costs over time. Users of solar lanterns who previously relied on kerosene for lighting can recover their investment in as little as five months, and households that purchase firewood for cooking can recover the cost of an energy-efficient cookstove in as little as two to three months. These devices also help the Indian government's efforts to reduce greenhouse gas emissions, making some of these sectors eligible for government incentives and subsidies (see sec. V).

Despite the serious negative health impacts of conventional energy sources, clean energy products and services continue to have difficulty penetrating the market because of their significantly higher relative costs. The prices of clean energy products and services are three to ten times higher than those for conventional products and services. In addition, complex clean energy products like solar lanterns and solar home systems often require careful and regular maintenance, which deters rural BoP consumers.²⁵

Not all these benefits attract rural BoP consumers. Clean energy products and services can offer many public and private benefits, such as less indoor air pollution, lower greenhouse gas emissions, better quality of electricity and lighting, and less deforestation, as well as long-term cost savings. Although some BoP consumers do value these benefits (such as less indoor pollution, cost savings, and improved lighting), many do not value these environmental benefits (summarized in table 3). This undervaluation thus presents a marketing and communications challenge for companies operating in this space.²⁶

Table 3. Environmental Attributes of Clean Energy Technologies Studied in This Report

Clean Energy Technology	Environmental Benefits
Decentralized Renewable Energy	Natural resources (water, waste biomass) are used sustainably to generate electricity at a community level.
Solar Home Systems and Solar Lanterns	Solar lanterns replace polluting kerosene lanterns, and solar home systems provide renewable electricity generation for multiple purposes.
Energy-Efficient Cookstoves	Traditional fuels like firewood are burned more efficiently, resulting in less indoor air pollution for households.

Source: CDF-WRI analysis, 2009.

Nonetheless, the average annual revenue of clean energy firms in the rural BoP household market we sampled has risen 36 percent since 2004. Even though many of these firms are small in size (averaging INR 50 million, or US\$1.08 million, in gross annual revenues), their growth rate demonstrates that rural BoP users are purchasing environmentally friendly energy products and services. The number of companies in the industry is increasing as well; with more than 75 percent of the companies we surveyed having started operations in 2006 or later. Much of this initial growth can be attributed to the early stage of the market, during which companies have been able to target specific sections of the rural BoP population. Companies will need to overcome the challenges discussed in this report and penetrate the larger rural BoP market in order to continue to grow at high rates.

III. Clean energy electricity systems

Clean energy electricity systems installed in either the household or the community can offer rural BoP consumers a reliable source of power for several uses, such as providing lighting, operating fans, charging mobile phones, and operating small appliances. The technologies studied in this report (small hydro, biomass gasification, and solar photovoltaic) are relatively mature and proven, and transmission and distribution (T&D) losses can be minimized because of the proximity of power generation to usage. We profile two main types of clean power production systems: decentralized renewable energy (DRE) enterprises, energy companies that supply power for a community in a specific geographic region; and solar home systems (SHSs), solar-based electricity-generating technologies designed for the individual household. Our analysis suggests that the desire for a reliable supply of energy for multiple uses is driving the demand in this market segment.

SUMMARY OF INVESTMENT THEMES

The estimated potential market value of DRE enterprises is INR 94.06 billion (US\$2.04 billion) per year, representing more than 95 percent of the clean energy potential market estimates for the rural BoP in India.

- » Consumers increasingly want power sources comparable to grid electricity in cost, convenience, and capability.
- » Forecasting the demand for energy is key to successful supply/demand management for DRE companies setting up their own community-focused mini-grids.
- » Options to offset demand risk are available in some regions that already have local transmission and distribution infrastructure.

The estimated potential market value of solar home systems is INR 1.26 billion (US\$27.39 million) per year.

- » The demand for multiuse electricity has largely driven the growth of solar home systems among the BoP's higher-income groups.
- » Lower upfront costs and improvements in after-sales service are likely to attract consumers to solar home systems.

A. DECENTRALIZED RENEWABLE ENERGY ENTERPRISES

Decentralized renewable energy (DRE) enterprises are energy companies that use technologies such as biomass-gasifiers and small hydro-electric turbines.* These technologies supply power either to communities outside the electricity grid or to those connected to the grid but vulnerable to severe power shortages. The three companies examined in this sector have average gross revenues of INR 36 million (US\$0.78 million) and have grown an average of 12 percent annually from 2004 to 2008.

MARKET VALUE

Approximately 55 percent of rural Indian households lack access to grid-based electricity, representing a potential market of 75 million households for electricity services.† Rural households report spending INR 106 per month (INR 1,272 per year) on electricity, and those without access to a reliable electricity grid often spend more by buying their electricity from diesel generator-based operators or using car batteries to power small appliances.²⁷ While this report focuses on the household electricity usage, some DRE providers also supply electricity for agricultural and commercial usage (see table 4 and the profile of DESI Power).²⁸

Table 4. Rural BoP Consumer Energy Needs in India

Market Segment	Energy Use	Energy Supply
Household	Lighting (3 to 4 hrs/day) TV, radio, CD/Cassette players (3 to 4 hrs/day) Mobile recharge (once a week)	Kerosene lanterns and lamps (2 to 3 L/month) Diesel-based generator sets Rechargeable batteries Mobile recharge (INR 2 to 5 per charge)
Agricultural	Irrigation needs: typically 3 kW, required for about 90 to 100 days a year Harvesting and processing: 3.5 kW to 7 kW, varies seasonally.	Irrigation from diesel- or electric-based water pumps Pedal pumps or manual labor-based pumps (used by very small landholding farmers, < 0.3 to 0.5 acres) Diesel-powered processing units
Micro and Small Enterprises	Machinery operation: 2 kW to 3.5 kW Lighting: less than 1 kW	Own diesel engines to run machinery Lighting from diesel generator (small shops)

Source: CDF-WRI field research, 2009.

* In our initial scan, we examined companies using four technologies for DRE: biomass gasification, small hydro, community-level solar photovoltaic, and micro-wind. We decided to focus on biomass gasification and small-scale hydro power technology for this study, which we found to be the most mature and scalable at this time. As technologies and business models evolve, other companies may become more promising (see app. IV).

† This estimate includes BoP and non-BoP rural households, since DRE providers operating in a particular community can provide services to richer households as well as poor households that need electricity

Rural household electrification has been slow in India: 55 percent of rural households used electricity in 2004/2005, compared with 48 percent in 1999/2000 (a yearly change of 1.4 percentage points). Discounting the annual rate of rural household electrification, we estimate the annual market for DRE services is 98.6 percent of 75 million households willing to pay INR 106 per month for electricity services. Using these assumptions, we estimate a potential annual market of INR 94.06 billion (US\$2.04 billion) for DRE electricity services in rural India.*

PRICING

Biomass gasifiers produce electricity through the gasification of solid-biomass fuel, such as wood chips or crop residues. Their generating capacity ranges from 25 kW to 100 kW and is well suited to villages with 500 to 1,200 households or a group of small hamlets located within a radius of two to three kilometers. The production price is INR 8 to 13 / kWh, depending on the type of feedstock, capacity of the power plant, and plant load factor (PLF).

Small-scale hydro plants generate electricity using micro-turbines along mountain streams, with minimal impact on the environment. Their generation capacity ranges from 100 kW to 1,000 kW, with the power fed primarily into the existing electricity grid for distribution. The production price is INR 2 to 2.5 /kWh.

COMPETITIVE ADVANTAGE

DRE technologies use local labor and resources and have demonstrated relatively high levels of operational reliability in field conditions.²⁹ As a result, DRE enterprises can increase the economic productivity of the communities they serve beyond providing a more comprehensive electricity solution comparable to grid electricity.

DRE technologies can be more price competitive than conventional, grid-based electricity. Several studies suggest that biomass and small hydro technologies are less expensive for remote areas than conventionally generated (coal or large hydro), grid-based electricity when the full cost of transmission and distribution is taken into account. Grid extension increases the cost of supplying electricity by approximately INR 1/kWh for every additional kilometer from the point of generation.³⁰ State electricity boards currently supply power to remote rural areas at subsidized prices of INR 3 to 5 per kWh, although the true cost of supplying electricity to these regions is actually INR 9 to 15 per kWh.³¹ The cost savings of large-scale power generation is offset by the high cost of distributing it to remote locations, making decentralized power generation a desirable alternative.³² Table 5 compares the two DRE technologies studied in this report.

* The DRE annual potential market value is calculated as follows: Average annual electricity expenditure (INR 1272) * [Potential addressable market (75 million households) – Annual rate of rural household electrification (1.4% of 75 million)].

Table 5. Comparison of Biomass Gasifiers and Small-Scale Hydroelectric Plants

	Biomass Gasification	Small-Scale Hydro
Generation Capacity	25 kW to 150 kW	100 kW to 1000 kW
Raw Material	Crop residue, woody biomass, fuel wood	Run-of-the-river generation
Distribution Model	Direct supply to end users or to small entrepreneurs distributing to end users through a company-owned and -operated grid.	Leverages grid infrastructure to supply electricity to grid; usually does not directly supply end user.
Cost of Production	INR 8 to 13 per kWh	INR 2 to 2.5 per kWh
Range of Distribution	Within 2- to 3-km radius of plant	Dependent on local grid infrastructure
Cost of Fuel	Dependent on fuel type (see table 6)	No fuel cost

Source: CDF-WRI field research on Husk Power, DESI Power, and SBA Hydro, 2009.

BUSINESS MODELS

Biomass DREs employing biomass gasifiers commonly set the price of electricity for low-income rural BoP consumers according to their target market segment's current expenditure on energy. By pegging the price to the existing expenditure for directly comparable service, such as kerosene for lighting or diesel generator-based electricity, companies can tap consumers' demonstrated ability and willingness to pay. For example, the price of kerosene lighting is as low as INR 9 per liter (when subsidized), and diesel generator-based electricity prices range from INR 8 to 12 per kWh. DRE electricity providers that sell electricity directly to consumers usually provide customized electricity services, depending on the household's ability to pay (see the profiles of Husk Power and DESI Power).

The fees for electricity services are DRE providers' main source of revenue, although some biomass-based DREs have successfully registered their projects under the global carbon-trading scheme Clean Development Mechanism (CDM) or in the voluntary carbon-trading market. As a result, they earn additional revenues from selling certified emissions reductions (CERs) or voluntary emissions reductions (VERs) (see the profiles of DESI Power and Husk Power).*

Some small-scale hydro DREs operate as independent power producers and set their prices based on government-determined rates. Pricing is determined by the preferential tariffs set by India's central and state governments in India, and these tariffs have become increasingly attractive in some states (for example, Himachal Pradesh increased its tariffs by 15 percent in 2009). Although pricing is outside the DREs' control, companies can generate additional revenue by increasing the scale of their operation and can drive down the cost of production through technological innovation (see the profile of SBA Hydro).

* The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries or companies committed to lowering greenhouse gases to invest in ventures that reduce emissions in developing countries as an alternative to more expensive emission cuts in their own countries. While some Indian DRE companies have been able to sell emission reduction credits, the majority of entrepreneurs consider the registration process and transaction costs too complex and expensive for small companies. Also, with the uncertainty surrounding the future of the CDM, which is due to expire in 2012, companies and investors largely consider CDM revenue as a useful "bonus" but not a core source of revenue. We suggest that investors consider bundling emission reductions from several companies or projects to reduce the transaction costs and take advantage of this potential source of revenue.

COST CENTER

Feedstock, the raw biomass material used for fuel, makes up 60 percent of biomass gasifiers' operating costs. Biomass power plants typically source their raw material (usually waste from crop processing like rice husk) from the local village or neighboring villages in which they operate. The availability of feedstock can vary widely depending on type and source. The supply can also be disrupted by seasonal fluctuations and severe weather, like droughts and floods. Table 6 gives the costs and sources of raw biomass material.

Table 6. Raw Material Costs and Sources for Biomass-Based Plants Serving Rural BoP in India

Raw Biomass Material	Cost (including transportation)	Supplier	Source
Ipomeas	INR 0.40 to 0.75/kg	Villagers	Local weed
Dhaincha	INR 1.4 to 1.6/kg	Villagers	Cultivated on waste lands
Fuel Wood	INR 2.5 to 3.0/kg	Local fuel wood dealers	Procured from open market
Rice Husk	INR 0.6 to 0.75/kg	Villagers / mill owners	By-product of rice processing

Source: CDF-WRI field research, Husk Power, DESI Power, 2009.

Small-scale hydro plants have relatively high construction costs. Small hydro plants can incur capital costs ranging from INR 50 million to 65 million, as they often are built in remote and mountainous regions and require six to twelve months to plan. To build such facilities, small hydro companies must conduct extensive geological and hydrological studies, recruit skilled labor for construction, and transport heavy machinery to remote construction sites.

CHALLENGES/OPPORTUNITIES FOR SCALING UP DREs IN RURAL INDIA

Challenges

Accurate assessment of users' demand

Companies that sell electricity services directly to consumers must estimate local demand accurately. In order to be profitable, plants must run at projected plant-load factors (PLFs). Miscalculation of demand can result in the construction of plants that cannot reach the PLFs and thus will incur operating losses.

Lack of qualified personnel

Skilled labor is required to operate and maintain DRE plants. But such workers can be difficult to find in rural BoP communities and therefore must be trained by the company, which often is expensive.

Government intervention

Because the government acts as the sole electricity purchaser of some DRE power companies, independent power producers rely on government infrastructure and policies. In addition, the government requires small hydro projects to obtain the same planning clearances as large hydro plants, such as particular voltage requirements, which can lead to delays in planning and construction.

Opportunities

Existing grid can be leveraged

DRE enterprises can use the existing grid infrastructure to provide much needed supplemental power to electrified villages. In addition, DREs can sell their electricity to on-grid power utility companies.

Reducing costs through government subsidies

State and central governments offer generous subsidies for renewable energy, ranging from preferential feed-in tariffs to accelerated depreciation to extended tax holidays. However, many companies are not aware of the full suite of subsidies for which they may qualify.

Generating new revenue sources through carbon credits

Reduced greenhouse gases resulting from DRE technologies enable DRE firms to sell carbon credits to domestic and international carbon-trading mechanisms, which can provide additional income.

INVESTMENT THEMES

Increasing consumer demand: The demand for DRE-produced electricity at the rural BoP is growing because users want a power source that is comparable to grid-based electricity in convenience and capability.

Forecasting is key to successful supply/demand management: DRE companies that set up their own community-focused grids and charge rural consumers directly for their services need to be able to accurately forecast the local demand for power and accordingly build the appropriate, cost-effective facilities.

Options to offset demand risk are available in some regions: DRE companies that operate in regions with existing grid infrastructure but poor local power availability can sell electricity directly to the state electricity board (SEB), which then can route it to underserved local communities through the existing underutilized grid. SEBs are required to purchase power from independent renewable energy providers, making this an attractive option for DRE companies to offset demand risk.

DRE COMPANY PROFILES**HUSK POWER SYSTEMS**

Husk Power Systems constructs and operates biomass-based power plants in India's rice belts (Bihar and Uttar Pradesh) and, since 2008, has been supplying electricity to rural households not connected to the electricity grid. In 2009, the company was operating in eight villages, constructing its own "minigrid" in each village.

» Product and Assembly

Husk Power has developed biomass gasifiers that operate on rice husk, a common agricultural waste product in many northern Indian states. The gasifiers are custom built by a local manufacturer and typically have a capacity of 35 kW to 100 kW. The power plants use between 25 kg and 50 kg of rice husk per hour, which is procured from local rice mills at INR 0.60 per kg.

» Distribution and Sales

When starting operations in a village, the company conducts a basic energy audit by means of household surveys to determine the electrical load that a cluster of houses will require. The company then installs a distribution network of insulated overhead wires in each village and charges the individual households a monthly fee for electricity, based on usage. The company uses inexpensive LED circuit breakers that allow both the users and the company to monitor power consumption.

» Marketing

Husk Power does not carry out specific marketing activities but actively engages the local village government bodies (panchayats) when setting up operations, to ensure sufficient demand.

» Pricing and Financing

The company has various pricing models that can be adapted to local conditions. In general, they try to price electricity at a level comparable to the households' monthly expenditure on kerosene, which is between INR 40 and 75. They charge a monthly fee based on the number of lightbulbs and other appliances that the household uses, and the company uses circuit breakers to ensure that the households do not exceed their monthly limits. For small shops, Husk Power charges around INR 80 to 500 per month, depending on the size of the operation.

Source: CDF-WRI field research, 2009.

DESI Power

DESI Power provides electricity to off-grid villages via biomass-based power plants and has been operating in Bihar since 2005. The company supplies power to households and small village businesses, such as shops and flour mills that can use electricity to generate additional income from their businesses.

» Product and Assembly

DESI Power uses gasifiers of 25 kW to 100 kW, manufactured by its sister company, Netpro. It uses locally available waste biomass such as rice husk and common weeds like Ipomea and Dhaincha, procured for INR 0.40 to 1.6 per kg from farmers.

» Distribution and Sales

The company builds a power plant and sells electricity through a local entrepreneur responsible for sales, billing, and collection. DESI Power entrepreneurs determine their own pricing model and fee structure and charge a monthly rate based on the number of bulbs each household or shop uses. The entrepreneur installs a circuit breaker to ensure that the households do not exceed their monthly limits.

» Marketing

DESI Power does not conduct any direct marketing activities and mainly relies on local distributors to promote its services to potential consumers.

» Pricing and Financing

DESI Power sets up the power plants but relies on the local entrepreneurs to determine their pricing model, which varies from village to village. In general, the entrepreneurs charge consumers based on the type and number of appliances they operate. Irrigation pump users are charged INR 50 per hour, which is comparable to diesel pump operators, and households are charged INR 120 to 150 per month. In addition, DESI Power's first plant successfully registered under the Clean Development Mechanism (CDM) and has sold certified emissions reductions (CERs) to a Swiss buyer.

Source: CDF-WRI field research, 2009.

SBA HYDRO

SBA Hydro constructs and operates micro-hydro power plants in several districts in the Himalayas and has been in operation since 2001. The company has two projects that are currently operating in Himachal Pradesh, and it plans to develop a series of 100-kW projects along the small rivers and streams in the region. These micro-hydro projects supply power to nearby communities, with minimal impact on the environment.

» Product and Assembly

SBA Hydro has developed customizable hydroelectric turbines that can operate under various conditions of water availability and speed, and it currently operates two micro-hydro power plants of 800 kW and 1 MW. Owing to the difficult terrain, the power plants take more than a year to plan and construct. Since they run continuously, the plants require twelve to fifteen people to operate them.

» Distribution and Sales

SBA Hydro supplies power to nearby communities through the existing electricity grid by selling its power to the state electricity board (SEB), which distributes it to villages in the region. The SEB is required by the Electricity Act of 2003 to purchase power from independent power producers at a rate set by the state electricity regulatory authority. The SEB pays SBA Hydro on a monthly basis, based on the amount of power generated, and supplies it to the villages through their grid. Since SBA Hydro's power plants are located near rural users, rural communities are supplied with the electricity first, and the residual power is transmitted to other locations through the grid.

» Marketing

The company sells electricity to the state board and therefore does not have any direct contact with consumers.

» Pricing and Financing

The SEB purchases electricity from SBA Hydro at INR 2.87 per unit. The plants cost approximately INR 50 million to 65 million to construct, and operating costs are approximately 5 to 7.5 percent of capital costs.

Source: CDF-WRI field research, 2009.



B. SOLAR HOME SYSTEMS

Solar home systems (SHS) are solar-based electricity-generating technologies designed to meet the power needs of individual households. Although they are used principally to supply power for lighting, SHS can also provide power for other household needs, such as operating televisions and radios, running solar water heaters, and charging mobile phones. The SHS company in this sector that we examined, SELCO, is one of the largest companies operating in this space, with annual gross revenues of INR 170 million (US\$3.7 million) and an annual growth rate of 6 percent between 2004 and 2008.

MARKET VALUE

The potential market value for solar home systems is INR 1.26 billion (US\$27.39 million) per year.

Solar home systems are relatively expensive, costing from INR 7,000 to 20,000. We found that most SHS users were in the higher-income bracket (upper quintile) within the rural BoP population, or 36 million households. Approximately 50 percent of these households lack reliable access to electricity, representing a potential market of 18 million households.

Assuming a conservative adoption rate* of 10 percent and taking into account the SHS's average life span of ten years, this results in an annual market of approximately 180,000 households.† The cheapest solar home system on the market costs INR 7,000, which results in a potential market of INR 1.26 billion (US\$27.39 million) per year.‡

* Our field research in rural southern India suggests that about 10 percent of targeted BoP customers purchase solar home systems.

† While the market for solar home systems is mainly limited to higher-income groups at the BoP, it may overlap with the DRE market for electricity services.

‡ The SHS annual potential market value is calculated as follows: [Potential addressable market (18 million households) * Observed rural BoP adoption rate (10%) * Lowest priced product available (INR 7,000)] / Product life span (10 years).

PRICING

Solar home systems are constructed from small-size solar panels and rechargeable batteries and cost from INR 7,000 for a single light system up to INR 20,000 for a four- to five-unit light system.

Solar Home Systems: Key Features

- » Mimics traditional grid-based lighting by providing electricity to the entire home.
- » Generates electricity via a photovoltaic panel placed on the roof of the house, with a rechargeable battery that can store generated electricity.
- » Produces from 10 to 35 watts of power: A standard SHS can power up to four compact fluorescent lamps (CFL) and a high-capacity SHS can power eight to ten lights and one fan for about four hours on full charge.
- » Batteries are designed to maintain a standard voltage across the lightbulbs being used in the house in order to maintain a consistent power supply.

COMPETITIVE ADVANTAGE

SHSs can provide a customized supply of electricity tailored to the consumer.

SHSs are configured according to the household's energy requirements and ability to pay and can be modified if the household's energy needs increase.

BUSINESS MODEL

More than 90 percent of consumers buy their SHS on credit, with the SHS firms forming partnerships with banks to provide financing. Customers pay 10 to 25 percent of the total costs up front and the remaining balance in installments. Banks can charge SHS customers interest rates as high as 17 percent on the outstanding loan, but banks receiving government subsidies charge lower interest rates.

COST CENTER

SHS components, such as solar panels and batteries, account for 70 percent of the total production price. The main reason for their high cost is the high price of good-quality solar panels. Although cheaper imported components are available, they tend to be of low quality.³³

CHALLENGES/OPPORTUNITIES FOR SCALING UP SHSs IN RURAL INDIA

Challenges	Opportunities
<ul style="list-style-type: none"> » Solar home systems are currently too expensive for the larger market of lower-income groups. Without more attractive financing options, the market for solar home systems will be confined to high-income rural households, which comprise a smaller market. » Ensuring adequate servicing and maintenance of solar home systems is difficult in rural areas. Previous experiences with poorly maintained, government-provided SHS have made rural customers hesitant to purchase new systems without assurances of regular, affordable maintenance. 	<ul style="list-style-type: none"> » Leasing-based business models for solar home systems have been tried in countries like Brazil (see box 4) and may be an attractive option for Indian SHS companies to explore. » After-sales service contracts will improve product quality, build customer loyalty, and serve as a new revenue stream for SHS companies.

INVESTMENT THEMES

Demand for multiuse electricity solutions: Consumers want multiuse electricity solutions that mimic grid-based electricity, which has largely driven the demand for solar home systems among the BoP's higher-income groups.

Lower upfront costs and improvements in after-sales service are likely to attract consumers: Consumers are currently deterred by companies' high prices and poor after-sales maintenance. SHS companies can reduce the upfront cost by offering leasing options, providing various financing options, and separating sales from after-sales service contracts (which can be offered at an additional cost).

COMPANY PROFILE**SELCO**

SELCO builds and sells photovoltaic (PV) solar home systems (SHS) to low-income and middle-income households in rural areas with poor access to the electricity grid. Since starting operations in 1996, SELCO has established twenty-five energy service centers in Gujarat and Karnataka and has sold and financed more than 95,000 solar systems.

» Product and Assembly

SELCO offers a wide range of solar home systems, ranging in price from INR 7,000 to 20,000, depending on the capacity and the number of lights the system will power. The company sources its solar panels from Tata BP Solar, and the CFL lights and batteries from local dealers. SELCO employees assess the energy needs and paying capacity of potential customers to develop a customized energy solution for each household, which is then installed at the user's home.

» Distribution and Sales

SELCO has developed partnerships with nine Indian banks that have branches in rural areas, to offer loan financing for its solar home systems at interest rates between 12 and 17 percent. SELCO's network of energy service centers has dedicated sales and customer support staff. SELCO also has local sales agents who seek potential customers and are paid a 5 percent commission on the sales they make.

» Marketing

The company has set up regional sales and service centers in rural areas, and SELCO sales executives promote their products through wall paintings, banners, and demonstration vehicles in remote villages and at local fairs. Each regional center allots approximately 5 percent of its sales revenue for marketing purposes.

» Pricing and Financing

SELCO's solar home systems range in price from INR 7,000 to 20,000, with more than 90 percent of the products purchased on credit through financing agreements with local banks. The relatively high prices of these systems are currently out of reach of the BoP's lower-income groups.

Source: CDF-WRI field research, 2009.

Box 4: International SHS Lessons

Solar home systems also have been sold to BoP consumers through innovative business models in other countries like Bangladesh and Brazil. We examined some of the successful practices by Grameen Shakti and IDEAAS that could be adopted by Indian companies.

GRAMEEN SHAKTI: Bangladesh

Grameen Shakti is a nonprofit organization started in 1996 by the cofounders of Bangladesh's largest microfinance institution, Grameen Bank, to provide clean energy solutions to rural households without access to grid electricity. Grameen Shakti sells clean energy technology such as solar home systems, energy-efficient cookstoves, and biogas systems through a micro-credit model, making it affordable for the BoP in Bangladesh. The company now has offices in all sixty-four districts of the country and has sold more than 220,000 solar home systems, 30,000 cookstoves, and 4,000 biogas plants. The SHS program broke even in 2001 and has been profitable since. The revenue has been used to start Grameen Shakti's other programs. These findings are based on our visits to the Mymensingh and Phulpur districts in Bangladesh.

Successful Practices

- » *Aggressive expansion strategy is based on extensive market research and financial modeling.* Despite competition from at least thirteen other commercial and nonprofit firms, Grameen Shakti controls more than 60 percent of the SHS market in Bangladesh. According to the firm, much of its success can be attributed to its methodical expansion strategy, involving extensive surveys to determine the market potential of each region before opening a local sales and service office. In addition, it performs detailed financial projections, such as predicted costs of capital, monthly operating costs, and working capital, to estimate the targeted sales and "break even" period for each local office. Each office has monthly sales targets and, on average, sells about nine to ten SHSs each month. The local staff is in charge of marketing the products to villagers, as well as sales, installation, maintenance, and management of the credit system. Therefore, despite being a nonprofit entity, Grameen Shakti ensures that it is financially sustainable and able to invest additional revenue in new programs for energy-efficient cookstoves and biogas plants.

Close customer relationships are key to customer satisfaction. Grameen Shakti employees install the solar systems and manage the microcredit program instead of working with local banks, as other organizations do. Employees visit customers every month to collect payments and to listen to feedback on the product. These regular visits increase customers' confidence in the company's after-sales service.

Challenges

- » *Procuring and transporting staff and materials to remote areas is difficult and expensive.* Many remote areas in Bangladesh lack adequate transport infrastructure, making operations extremely expensive in these regions. Because these local operations are often not financially sustainable, they are cross-subsidized by operations in other districts.

Institute for Development of Natural Energy and Sustainability (IDEAAS): Brazil

IDEAAS is a nonprofit organization that works on a number of clean energy-related projects in Brazil, including energy access to rural areas and energy efficiency. Founded in 1997, IDEAAS leases customized solar home systems to rural households that do not have access to the grid in Brazil's southernmost state of Rio Grande do Sul.

Successful Practices

- » *Renting solar PV equipment lowers costs for customers.* IDEAAS's main product is a solar home system that varies in size and capacity and costs between US\$1,500 and 1,800. The company collects detailed financial information about each of its customers, such as occupation, approximate income, and location, to determine a monthly rental fee for its solar equipment (on average, US\$19, enabling IDEAAS to recover its costs in about seven years). Customers sign a contract with IDEAAS confirming the terms of service, which include regular maintenance, a battery change after five years, and replacement of the solar panels after their life cycle is completed (fifteen years). IDEAAS has partnerships with local banks that collect the monthly fees for a 5 to 10 percent charge. As a nonprofit, IDEAAS received initial funding from donors, and the monthly fees cover only capital and operating costs. The model of leasing solar home systems and providing electricity as a service, rather than selling a product, has allowed IDEAAS to make its business very affordable for rural Brazilian households.

Challenges

- » *IDEAAS's NGO status has hampered its growth and expansion.* As a nonprofit, IDEAAS still operates on a case-by-case basis, without a methodical expansion strategy. The organization is largely dependent on grant funding for its own operations and has found it difficult to expand its network and scale up.

Source: CDF-WRI Field Research, 2009.

IV. Clean energy lighting and cooking solutions

Solar lanterns and energy-efficient stoves can provide environmentally friendly substitutes for traditional, inefficient cooking and lighting options. Our research finds that there is a market for these products among some segments of rural BoP consumers, including those who have access to grid-based electricity and liquid petroleum gas for cooking. Although the demand for these products has been relatively limited, our field research provides some insight into consumer preferences for solar lanterns and energy-efficient cookstoves that will be useful for companies (see box 5).

SUMMARY OF INVESTMENT THEMES

Solar Lanterns: The estimated potential market value of solar lanterns is INR 855 million (US\$18.58 million) per year.

- » Although the demand currently is small, it could grow as more affordable lanterns enter the market.
- » Financing and partnerships with nonprofits and microfinance institutions can help lower upfront purchase prices.

Energy-Efficient Cookstoves: The estimated potential market value of energy-efficient cookstoves is INR 1.11 billion (US\$24.13 million) per year.

- » The demand is largely restricted to higher-income levels at the BoP.
- » A market for lower-income groups at the BoP could be created through partnerships to raise awareness of energy-efficient cookstoves' health benefits and improve their design to incorporate users' preferences.

SOLAR LANTERNS

Solar lanterns provide light from a battery that is charged by sunlight through a photovoltaic module. Between 2006 and 2008, the two companies examined in this report had average gross revenues of INR 70 million (US\$1.5 million) and annual growth rates of more than 300 percent.

MARKET VALUE

The potential rural BoP market for solar lanterns is estimated at INR 855 million (US\$18.58 million) per year.³⁴

Forty-five percent of rural households in India use kerosene as their primary lighting source, relying on homemade wick lamps and kerosene lanterns to light their homes. We assume that the demand for the cheapest solar lanterns will be largely by those who rely primarily on kerosene for lighting, or 51.3 million rural BoP households.

Using the observed adoption rate of 10 percent,^{*} we estimated the market for solar lanterns to be 5.13 million households. Since the average life span of a solar lantern is approximately three years, this equates to a market of INR 855 million (US\$18.58 million) per year.[†]

PRICING

The price of a solar lantern ranges from INR 500 to INR 1,600 per unit. Basic models provide only lighting, whereas more expensive models also have features such as mobile phone chargers and bicycle mounting brackets (see table 7).

Table 7. Key Features of Solar Lanterns

Basic Features	» Mobile; encased in damage resistant plastic.
	» One- to two-watt light-emitting diode (LED) bulb.
	» Provides electricity for up to eight hours at low intensity and three to four hours at maximum intensity on a single charge.
Recharging Options	» Can be charged by (1) a solar panel supplied to the end user (which increases the overall price of the lantern by INR 250), (2) solar panels on the body of the lantern, or (3) electrical sockets.
Additional Features	» Multiple uses, such as a mobile phone charger.
	» Bicycle mounting brackets.

Source: CDF-WRI field research, THRIVE, d.Light design, 2009.

* Our field research in rural southern India suggests that about 10 to 15 percent of BoP households use solar lanterns.

† The solar lantern annual potential market value is calculated as follows: [Potential addressable market (51.3 million households) * Observed adoption rate (10%) * Lowest-priced product available (INR 500)] / Product life span (3 years).

COMPETITIVE ADVANTAGE

Solar lanterns can offer long-term cost savings for rural households using kerosene. On average, Indian households spend from INR 50 to 100 on kerosene each month, and rural households that rely heavily on kerosene are likely to spend more. Households that replace kerosene lanterns with the cheapest lanterns, priced at INR 500 (see the company profile of d.Light) could recover their investment in as little as five months and eliminate future lighting-fuel costs.³⁵

Solar lanterns significantly reduce health and fire risks and provide safer, better-quality lighting. Kerosene lanterns release unhealthy fumes, provide low-quality light, and often pose a fire risk.³⁶ According to one five-year research study at an Indian hospital, nearly 50 percent of burn-related injuries were caused by accidents related to kerosene.³⁷ Another study suggests that indoor kerosene fumes may increase the risk of contracting tuberculosis.³⁸ In comparison, solar lanterns do not emit any fumes and provide lighting through LEDs that is two to three times brighter than that of kerosene lanterns.³⁹

BUSINESS MODEL

Solar lighting companies distribute their products through retail sales, either directly to the end user or through local retailers to the end user; or through bulk sales. Most bulk sales are made to government agencies, charities, and corporate social responsibility programs that distribute solar products at below cost or free to rural households.⁴⁰ Companies that sell directly to consumers may offer financing options through local microfinance institutions. Some lanterns are sold without the solar panels, and the firms work with local entrepreneurs to set up electricity charging stations for LED lanterns. End users who buy LED lanterns without the solar panels pay these charging stations INR 5 per week to charge their lanterns (see the profiles of d.Light and THRIVE).

COST CENTER

Manufacturing costs account for 70 percent of the solar lanterns' total cost. The product components are manufactured in India and elsewhere, mainly China. Good-quality solar panels are relatively expensive and account for the most of the manufacturing cost.

Box 5: Solar Lanterns: Users' Insights

Despite the economic, health, and safety benefits of solar lantern products, in the areas we studied, only 10 to 15 percent of rural BoP households used them. Our field research, which included focus group discussions with more than forty rural BoP households, including both solar lantern users and non-users, explained this low adoption rate.

Users view solar lighting as a temporary lighting solution for grid-based electricity. Overall, compared with kerosene lanterns, users value the higher quality of light and additional safety features offered by solar lanterns. However, the majority of users interviewed considered solar lanterns as an intermediate step before gaining access to grid-based electricity, thereby making them hesitant to invest in the product. Some users relied on solar lanterns as backup lighting sources during power outages.

Users' errors have led to negative product experiences. Untrained in how solar panels function, consumers often place them with the photovoltaic side facing away from the sunlight, so the battery cannot charge. Others use lantern batteries to run additional small electrical appliances, which greatly shortens the battery's life. Some users charge lantern batteries through motorcycle engines and other methods that also reduce the battery's life and charging capacity.

Users value solar products that meet multiple electricity and lighting needs. During the evening hours, households engage in simultaneous activities that require lighting. As a result, consumers revealed a strong preference for products that provide multidirectional lighting, which not all solar lanterns do. BoP consumers also want energy solutions that provide more than just lighting, preferring comprehensive options that can charge mobile phones and run small appliances like fans.

Relatively high prices deter the majority of BoP consumers. In relation to BoP household incomes and the current level of lighting expenditure, solar lanterns remain an expensive lighting solution. According to the companies we profiled, the target BoP market segment for solar lanterns ranges from households with monthly incomes of INR 1,500 to 4,000, putting the higher-end solar lanterns out of their reach.

Short warranty periods deter users from making a purchase in order to gain life-cycle benefits.

To be attractive to users, the payback period for solar lanterns must be within the warranty period. Currently, the majority of higher-priced solar lanterns come with a one-year warranty, which is less than the anticipated payback period for the more expensive solar lantern models.

Source: CDF-WRI field research, 2009.

CHALLENGES/OPPORTUNITIES FOR SCALING UP SOLAR LANTERNS IN INDIA**Challenges**

Balancing costs with high quality standards is difficult. Manufacturers procure components from a variety of suppliers, which can result in varying levels of quality. Products sold to rural BoP consumers often need to operate in harsh conditions, so must be reliable and sturdy.

Government subsidies for kerosene use dissuade consumers. Rural households are allocated between two and twenty-two liters of subsidized kerosene per month, depending on the size of their family, their income level, and their state of residence. About 80 percent of rural households report having access to subsidized kerosene through the public distribution service, although they also purchase some kerosene at market rates.^a

Charitable distribution schemes distort the local market. Consumers who have previously received solar lanterns for free or at subsidized rates (as low as INR 100) from government or philanthropic programs were unaware of the true cost of solar lanterns and were reluctant to purchase them at full cost. Most charitable programs also did not provide any maintenance services, and the lanterns often stopped functioning after a year, leaving users wary of their quality.

Opportunities

Affordability can be increased by maintaining tighter cost controls over distributors' and retailers' margins. Companies can work with nonprofit organizations that promote clean energy use at the rural BoP to reduce distribution and marketing costs. These nonprofit organizations can help raise awareness of products or sell them through their rural networks, thereby reducing companies' marketing and distribution costs.

Misuse of products can be reduced through active before- and after-sales service. Users should have regular access to trained and skilled individuals who can install, repair, and maintain solar products. Follow-up visits with customers can help detect and correct users' errors after purchase.

Note ^a: S. Gangopadhyay et al., *Reducing Subsidies on Household Fuels in India: How Will It Affect the Poor?* (Gurgaon: India Development Foundation and Indian Statistical Institute, 2004)

INVESTMENT THEMES

Although the demand is small now, it could grow as prices fall: High prices and subsidies for traditional energy sources have limited the demand for solar lanterns. While bulk purchases from charitable and government programs currently drive the market, solar lantern companies are starting to produce cheaper lanterns that are more affordable for individual BoP consumers.

Financing and partnerships can lower upfront prices: Solar lantern companies can lower the upfront price by means of tight controls on value chain margins and partnerships with microfinance institutions to provide consumer-financing options. They also can reduce their marketing and distribution costs through partnerships with nonprofit organizations.

COMPANY PROFILES**D.LIGHT**

D.Light is a solar-powered LED lantern company that entered the Indian market in February 2008 and sells three models of solar lanterns with various features. D.Light designs and manufactures solar-powered LED lanterns for middle- and low-income groups in rural India that traditionally relied on kerosene lanterns. The company mainly operates in Uttar Pradesh and Maharashtra.

» **Product and Assembly**

D.Light sells three models of solar lanterns, the Kiran, the Nova, and the Solata, which can provide four to seven hours of light on a full charge. The solar panels generate 1.3 watts and can charge the batteries in eight hours. The lanterns are mobile, with a 1 W to 2 W LED bulb and encased in damage-resistant plastic. Some models also incorporate mobile phone-charging slots and bicycle mounting brackets. D.Light has a manufacturing base in China, which results in lower manufacturing costs but higher import duties.

» **Distribution and Sales**

D.Light partners with distributors to sell to the end customer. The distributors also provide customer and market feedback, which D.Light integrates into new product designs. The firm's customers are commercial buyers and household consumers. The company also partners with corporate foundations on philanthropic programs to donate solar lanterns to the poor.

» **Marketing**

D.Light uses basic promotional material such as posters and leaflets and has recently entered into a partnership with a marketing company to launch an advertising campaign targeted at rural Indian consumers.

» **Pricing and Financing**

D.Light's three models of solar lanterns range in price from INR 500 to 1,250 and can be charged using solar panels or AC power. The lanterns are manufactured in China, which adds about 11 percent import duties to the cost.

Source: CDF-WRI field research, 2009.

THRIVE

THRIVE is an enterprise focused on developing solar lighting products for people at the BoP. The company sells its products to NGOs and corporate foundations, which then distribute the lanterns to users. THRIVE has been operating in the solar lantern market since 2003.

» **Product and Assembly**

THRIVE's main product is an LED solar lantern, which can be set to different levels of luminosity. While the company initially purchased off-the-shelf parts from China and assembled them in-house, it now has its own research-and-development lab and testing unit in Hyderabad to improve the technology and bring down production costs. The company has also improved the lanterns' design by incorporating user feedback and has brought down costs by partnering with rural workers to assemble the lanterns.

» **Distribution and Sales**

THRIVE relies mainly on institutional sales to NGOs, corporate foundations, and the government, which then distribute the lanterns to users. THRIVE uses government and other aid-based funding resources to sell large orders of lanterns at a discount to NGO partners, which then donate, sell, or rent the products to BoP consumers. The company has working agreements with seven government agencies, and six microfinance institutions.

» **Marketing**

THRIVE does not directly sell its lanterns to consumers, and so it does not conduct any direct consumer-marketing activities. It mainly promotes its products to funding institutions like governments and foundations, applying for government tenders and marketing to corporate foundations.

» **Pricing and Financing**

THRIVE lanterns cost about INR 600 to 650 to produce, and they sell for about INR 800 to 900, although the company sometimes provides discounts for bulk orders. Those users who purchase the lanterns pay between INR 900 to 1,400. Many NGOs and foundations purchase lanterns from THRIVE and distribute them for free. THRIVE also collaborates with NGOs to provide a consumer-financing scheme for end users, who pay INR 350 up front and approximately INR 30 per month over the term of the loan.

Source: CDF-WRI field research, 2009.

B. ENERGY-EFFICIENT COOKSTOVES

With their improved design and construction, energy-efficient cookstoves burn solid-biomass cooking fuels 20 to 65 percent more efficiently than traditional stoves do (see table 8).⁴¹ From 2006 to 2008, the companies in this sector that we examined had average gross revenues of more than INR 82 million (US\$1.8 million) and average annual growth rates of 65 percent.

MARKET VALUE

The potential market value for energy-efficient cookstoves for India's rural BoP is INR 1.11 billion (US\$24.13 million) per year.

Only 27 percent of rural households that use firewood as their primary source of cooking fuel report actually paying for it. Therefore, we assume the rural BoP market for energy-efficient cookstoves will be largely limited to the 29.6 million households that pay for firewood and can therefore derive economic benefits from the increased fuel efficiency.

The cheapest energy-efficient cookstove in the market is the fixed, natural draft mud-and-brick stove that costs INR 150, sold by micro-entrepreneurs trained by the nonprofit organization TIDE.* Although rural BoP adoption rates for expensive stoves have been low, at 10 to 15 percent, we observed that, where available, inexpensive TIDE stoves had adoption rates of 75 to 80 percent. Therefore, we assume a relatively high adoption rate of 75 percent for the cheapest stove, which has an average life span of about three years. We estimate the potential market for energy-efficient cookstoves to be INR 1.11 billion (US\$24.13 million) per year.†

PRICING

Energy-efficient cookstoves vary in design, portability, and the type of fuel used, with prices ranging from INR 150 for basic, single-burner stoves constructed from mud and brick, to INR 1,100 for portable models with metal and ceramic construction and electric fan–assisted air flow, known as forced draft cookstoves. More-advanced stove models use biomass pellets as fuel, sold by the company for INR 30 for a one-week supply for the average household, which adds to the cost of operation. In contrast, other stove designs use the same fuel as traditional stoves do (firewood).

* TIDE is a nonprofit organization that trains rural micro-entrepreneurs to construct inexpensive, energy-efficient cookstoves. Although TIDE is not a for-profit company, we analyzed its technology in this report alongside for-profit companies, because these cookstoves are considerably more affordable for rural BoP consumers, owing to the cheaper materials used, as suggested by the high adoption rate of 75 percent.

† The energy-efficient cookstove annual potential market value is calculated as follows: [Potential addressable market (29.6 million households) * Observed adoption rate (75%) * Lowest-priced product available (INR 150)] / Product life span (3 years).

Table 8. Key Features of Energy-Efficient Cookstoves

	Portable, Forced Draft	Portable, Natural Draft	Fixed, Natural Draft
Company	First Energy / BP Oorja (for-profit)	Envirofit (for-profit)	TIDE (nonprofit)
Design and Construction	Outer layer of cast iron and inner ceramic chamber for insulation; regulated fan continuously blows draft of air for more efficient combustion; fan uses rechargeable batteries; tray at the bottom collects unburned pellets and ash.	Cylindrical structure with two layers of fire kiln brick material, which increases heat retention; inlets allow better air circulation, relies on natural draft.	Mud-and-brick construction resembles traditional cookstoves; insulation, a cast iron grate, and a chimney; chimney removes smoke from the kitchen and increases fuel efficiency; installed at user's home (fixed).
Fuel	Pellets made from agricultural waste (which cost INR 30 for a one-week supply); small amount of kerosene (30 ml to 40 ml) required to light the pellets.	Relies on fuel wood, chopped into small pieces because of small size of inlet.	Fuel wood or dung.
Advertised Emission Reductions and Benefits	71 percent reduction in CO ₂ emissions; 34 percent reduction in suspended particulate matter; 98 percent reduction in CO emissions. Combustion efficiency of 40 to 80 percent.	Fuel consumption reduced by 50 percent; cooking time reduced by 40 percent; toxic emissions reduced by 80 percent.	Fuel consumption reduced by 30 percent for household models; 40 to 50 percent for larger stoves.
Typical Price Range	INR 1,050	INR 750 to 1,150	INR 150 to 300

Source: CDF-WRI field research, 2009.

COMPETITIVE ADVANTAGE

Energy-efficient cookstoves can reduce cooking-fuel costs. Rural BoP households who pay for firewood spend an estimated INR 100 to 300 on firewood per month, depending on whether they use it as their primary fuel or as a supplement to other sources.⁴² As a result, users who buy firewood (about 27 percent of rural households) can recover their costs in as little as two months with the TIDE stoves and, on average, within seven to ten months.

Energy-efficient cookstoves reduce exposure to indoor air pollutants. Cookstove smoke contributes to about 500,000 respiratory disease–related deaths per year.⁴³ In an ongoing study by MIT's Poverty Action Lab, energy-efficient cookstoves are linked to a lower incidence of air-pollution-related sicknesses.⁴⁴

BUSINESS MODEL

Energy-efficient cookstoves are sold through rural distributors and retailers that sell other items like kerosene and LPG stoves and/or through partnerships with microfinance institutions and NGOs that distribute the stoves directly to users. To promote and demonstrate their cookstoves, companies send sales people to retail stores that sell other energy products such as kerosene and LPG stoves. Although this strategy allows access to the market without significant investment, it also reduces

the companies' control over pricing, since retailers choose their own margins for the stoves. Some companies also partner with microfinance institutions, which allow their members to buy cookstoves at lower prices. Cookstove companies may partner as well with NGOs to use their local network to sell their products (see the profiles of Envirofit and First Energy).

COST CENTER

Components for expensive energy-efficient cookstoves may make up more than 60 percent of the product's cost. High-end cookstoves, such as portable forced draft, use electric fans and rechargeable batteries to increase their fuel efficiency. As a result, these components, combined with relatively expensive materials like iron and ceramic, can increase the price of some fuel-efficient cookstoves by as much as ten times more than that of conventional stoves sold on the market. In comparison, simple, fixed, energy-efficient cookstoves are constructed of cheaper materials like mud and bricks, but they are more labor intensive.

Box 6: Energy-Efficient Cookstoves: Users' Insights

Although there are several models of energy-efficient cookstoves on India's rural BoP market, we observed that advanced models of stoves were bought by as few as 10 percent of potential users. Moreover, the majority of these stoves were mainly being sold to higher-income groups at the BoP, many of whom already had LPG stoves and used the biomass cookstoves as a backup. Our field research, which included focus group discussions with thirty rural BoP users and nonusers, provides insight into the low adoption rate.

The high price deters many potential consumers using cheaper alternatives. Traditional stoves may be constructed by the users themselves either at no expense or a cost up to INR 90. In comparison, the majority of energy-efficient cookstoves cost between INR 500 and INR 1,100. Also, because most BoP households do not pay for their cooking fuel (firewood), they do not value the improved fuel efficiency. Simple, inexpensive, energy-efficient cookstoves that cost between INR 150 and INR 300 (see table 9) have been considerably more successful in penetrating the rural BoP market, with adoption rates of more than 75 percent.

Many BoP consumers already use liquefied petroleum gas (LPG) for cooking and use cookstoves only for secondary activities. Focus group discussions suggest that more than 75 percent of the higher-priced energy-efficient cookstove users already have LPG connections and use their energy-efficient cookstoves only for heating water for bathing or cooking rice. LPG stoves are more energy efficient than traditional stoves, but the fuel is considerably more expensive and can be hard to obtain in rural areas, so LPG stove owners often use these firewood stoves as a backup for other activities.

Users of more advanced energy-efficient cookstoves report disruption to their traditional cooking practices. While users appreciated the flexible use, constant heat, reduced cooking times, and lower smoke emissions of portable fixed and natural draft cookstoves, they complained that refueling procedures were inconvenient and time-consuming. The need to replenish fuel pellets from the top stove inlet and chop wood into smaller pieces because of the different design resulted in time away from cooking.

Source: CDF-WRI field research, 2009.

Challenges	Opportunities
<p>» Cookstoves from for-profit firms are currently too expensive. Consumers see greater value in the lower-priced fixed-draft stoves (see table 9), priced comparably to traditional cookstoves. Companies will have to cut costs to enable them to lower prices and become more competitive.</p> <p>» Products require customers to change their cooking habits. Many customers are reluctant to purchase cookstoves with specialized functions that disrupt their traditional cooking practices and are viewed as more time-consuming.</p>	<p>» Market exists for products that meet users' needs. Simple-to-use cookstoves that require no change in cooking habits have been relatively successful among lower-income groups. Our research found consumers willing to pay about INR 300 for these kinds of cookstoves, providing companies with a benchmark for the pricing required to attract this larger market.</p> <p>» Partnerships and financial products can lower costs. Nonprofit development organizations and NGOs can help energy-efficient cookstove producers cut their marketing and distribution costs by using their local rural networks, while consumer-financing options, such as extended-payment plans can lower upfront costs for consumers who want to purchase more advanced cookstoves.</p> <p>» Government is offering new cookstove initiatives. In 2009, the Indian Ministry of New and Renewable Energy announced a new initiative to provide rural BoP households, through public-private partnerships, with energy-efficient cookstoves that are affordable, easy to maintain, and conform to local cooking habits. As this initiative develops, it may present new opportunities for cookstove companies to sell their products to lower-income households.^a</p>

Note: ^a Ministry of New and Renewable Energy, Press release, National Biomass Cookstove Initiative, December 2009.

INVESTMENT THEMES

The demand is restricted to higher-income levels: The relatively high price of most energy-efficient cookstoves on the market and their often unclear value (most consumers collect firewood for free and do not receive a direct monetary gain from the improved fuel efficiency) have made it difficult for companies to sell energy-efficient cookstoves to lower-income rural BoP consumers.

The market can be created through partnerships and improved design: In the near to midterm, companies in this sector should work with nonprofit market development organizations (see sec. VI) to raise awareness of the significant health benefits of their products and to build a market for energy-efficient cookstoves. Companies should also lower their prices by designing simple products that mimic the ease of use of traditional stoves or by providing product financing to penetrate the considerably larger, but as yet untapped, lower-income BoP market.

COMPANY PROFILES

FIRST ENERGY

First Energy (formerly BP Oorja) produces low-cost, portable, smokeless stoves for rural Indian households and has been in operation since 2007. The company began as a partnership between BP's Emerging Consumer Market program and the Indian Institute of Science. In 2009, a consulting company based in Pune bought and relaunched BP Oorja as First Energy. Since then, it has sold more than 250,000 cookstoves in Maharashtra, Karnataka, and Tamil Nadu, with gross revenues in 2009 estimated to be more than INR 200 million.

» Product and Assembly

First Energy manufactures portable cookstoves fueled by pellets made from agricultural waste. The stoves have an outer layer of cast iron and an inner ceramic chamber, along with a regulated fan to provide a continuous draft of air for more efficient combustion. The company manufactures its stoves in Maharashtra and relies on small entrepreneurs to produce the fuel pellets.

» Distribution and Sales

First Energy distributes its stoves through profit-sharing partnerships with Indian NGOs like Samruddhi, Adharam, and Sakhi Retail. It does not advertise or directly sell its cookstoves to end users. NGOs purchase the stoves and use their networks of local entrepreneurs, known as “village-level entrepreneurs” (VLEs), to sell the stoves.

» Marketing

First Energy relies predominantly on its NGO partners for its marketing and promotional activities. With funding from First Energy, NGOs conduct live cooking demonstrations, distribute usage information pamphlets, and occasionally underwrite television and newspaper advertisements.

» Pricing and Financing

First Energy's cookstoves cost INR 1,150, and the fuel pellets cost INR 30 per bag. Additional parts such as the fan, the rechargeable batteries required to operate the stove, and the ongoing cost of fuel pellets make the stoves seven to ten times more expensive than traditional cookstoves. The company earns profits of approximately 9 percent from its sales of stoves and pellets to the NGOs. The NGOs then resell them at markups of 9 percent through its VLEs, with which they share the profits.

Source: CDF-WRI field research, 2009.

ENVIROFIT India

Envirofit India produces portable, energy-efficient cookstoves in the southern states of Karnataka, Tamilnadu, and Andhra Pradesh and has been in operation since 2007. The company was started as part of the U.S.-based, nonprofit organization Envirofit International and has subsequently sold more than 100,000 cookstoves. The estimated gross revenues for 2009 were more than INR 40 million.

» Product and Assembly

The Envirofit stove has a cylindrical structure and two layers of fire kiln brick material, which better retain heat, as well as fuel inlets that rely on a natural draft to provide better air circulation. The stove operates on the same fuel, wood, as do traditional stoves. Envirofit originally imported stoves from China but recently shifted its production to Maharashtra, thereby eliminating import costs.

» Distribution and Sales

Envirofit sells its stoves through existing regional retailers and has an employee in each store to demonstrate its products. The company also sells cookstoves through a partnership with the microfinance institution Grameen Koota, whose members receive a significant discount on the purchase price.

» Marketing

Envirofit directly markets its products through existing retail channels and uses demonstration vans and print and media ads. Distributors and retailers accompany the vans to remote areas in order to attract more consumers. Envirofit's regional offices have monthly marketing budgets of approximately INR 60,000.

» Pricing and Financing

Envirofit's basic stove model sells for an average of INR 750, with more expensive models priced at INR 1,100. Compared with other products such as kerosene and LPG stoves, retailers and distributors report lower sales volumes of energy-efficient cookstoves, but extremely high margins of 33 to 66 percent, compared with 10 to 15 percent for kerosene stoves. Distributors purchase the stoves for INR 360 to 450, and retailers buy them for INR 600 each. The company is currently selling the stoves at a loss in order to gain initial market share and has no control over dealers' markups, since it relies on the existing distributor and retail networks. Retailers earn margins of around 25 percent on the stoves.

Source: CDF-WRI field research, 2009.

Box 7: International Lessons from Energy-Efficient Cookstoves

The Groupe Energies Renouvelables, Environnement et Solidarités (GERES) has been successful in selling energy-efficient cookstoves to BoP households in Cambodia. We looked at some of the lessons it offers for Indian companies:

GERES The Groupe Energies Renouvelables, Environnement et Solidarités (GERES) is a nonprofit market development organization based in France that supports small energy-efficient stove producers in Cambodia. Through the Cambodian Fuelwood Saving Project managed by its Cambodian office, the organization promotes the development and design of cookstove models that use 22 to 30 percent less charcoal than do traditional Cambodian stoves. In addition, GERES trains local producers of traditional stoves to manufacture improved cookstoves and establishes distribution networks by connecting the producers to distributors and retailers. As a result of its efforts, GERES estimates that these producers have sold more than 700,000 energy-efficient cookstoves since beginning operation in 2001.

Successful Practices

Working with existing value chains

By training traditional stove producers to manufacture energy-efficient cookstoves, GERES has raised awareness of the benefits of improved cookstoves within the industry's existing value chain.

Adapting to local habits and competitive pricing

GERES models use a more efficient design and better materials while retaining the basic shape and characteristics of the traditional stove. As a result, users do not need to change their cooking habits. Although GERES stoves are priced two to three times higher than traditional stoves, users recover the higher costs in two months through their lower fuel expenditures.

Securing revenue streams via carbon credits

While initially funded through a grant by GERES-France, GERES Cambodia now finances more than 60 percent of its operations through the sale of carbon credits on the voluntary carbon-trading market. They are able to secure carbon credits because of the meticulous information GERES Cambodia collects at each stage of the improved cookstove distribution process, as well as the extensive laboratory and field tests conducted by its monitoring and evaluation teams.

Challenges

Maintaining quality control is difficult, and poor-quality stoves and counterfeits affect brand equity

Despite extensive education from GERES, some improved cookstove producers do not maintain the quality of production that achieves the expected energy efficiency. With the emergence of several cookstove producers, external quality control and extensive monitoring are required continuously to maintain standards. In addition, several poor-quality cookstove counterfeits have damaged GERES's brand equity of quality and energy efficiency.

Source: CDF-WRI field research, 2009.

V. The role of government

Meeting the energy needs of India's rural population is an urgent challenge and a priority for the Indian government. The demand for energy is soaring while much of the rural population still must make do without electricity. Even though the rural population's access to the country's electricity infrastructure is increasing, most still meet their basic energy needs through harmful sources, such as by burning kerosene, firewood, and dung. Besides these supply and health imperatives, the third driver of the government's rural energy policy is mitigating climate change. Now that India has pledged in international negotiations to curb its growth of greenhouse gas emissions, the government is likely to promote the development, deployment, and increase of clean, reliable, safe, and low-cost energy services and products.

Given the rural clean energy industry's fledgling state, government policy is critical to its future development. The government already provides many incentives for renewable energy projects, including capital subsidies of up to 90 percent, tax holidays, accelerated depreciation, and low-interest loans through the Indian Renewable Energy Development Authority (IREDA).⁴⁵ In addition, state electricity boards (SEBs) are required to buy power from renewable energy independent power producers (IPPs), and states are required to set targets for renewable energy generation.⁴⁶ In July 2010, the government unveiled its national solar mission, whose target is to achieve 20 gigawatts of solar power nationwide by 2022. Of specific relevance to this report, the mission also has set a goal of installing 20 million solar lighting systems to replace kerosene lamps by 2022.⁴⁷

Although some government policies are designed to help the rural BoP population gain access to clean energy, other policies may undermine demand by supporting the use of conventional polluting products, such as kerosene. In addition, many beneficial regulations promoting clean energy have not been successfully implemented at the state level.⁴⁸ Investors and firms serving this market could work together to encourage public-sector policies and actions that can achieve the dual objectives of increasing energy access and stimulating the growth of the clean energy industry. Better state-level implementation of existing regulations, combined with new favorable policies such as promoting clean energy products and service providers as priority lending sectors for Indian banks, would help meet both objectives.

POLICY LEVERS

To this end, we present the following three major policy recommendations that would have a significant impact on the industry:

- » **Shift the existing kerosene subsidy to a lighting-based subsidy that will enable BoP consumers to choose their lighting source while encouraging**

innovations related to solar lanterns and other clean technologies and business models.

Kerosene is heavily subsidized in India as a cooking and lighting fuel and is widely available through both public and private distribution systems. Households are allotted several liters of subsidized kerosene a month (the number varies widely by state, poverty status, household size, and access to LPG).⁴⁹ Several studies, however, suggest that more than 30 percent of the kerosene intended for the public distribution system is diverted to the black market and sold at market rates of INR 35 to 40 per liter, making the subsidy considerably less effective.⁵⁰

While subsidized kerosene plays a significant role in providing basic lighting for the poor, affordable solar lanterns can replace kerosene lanterns by supplying rural BoP users with safer, better-quality light. The government is considering a proposal to divert 10 percent of the amount spent on kerosene subsidies to procure solar lanterns for households below the poverty line.⁵¹ Although this is a promising shift in focus, our field research suggests that consumers have not been satisfied with previous government efforts to distribute solar lanterns, owing to the lack of after-sales maintenance. Distributing free or heavily subsidized solar lanterns also makes it difficult for companies to penetrate the market and sell these products directly to consumers.⁵² We therefore recommend gradually replacing the kerosene subsidy with a lighting-based subsidy that would allow rural BoP households to select their lighting source from a list of competing eligible choices and would encourage solar lantern and other clean energy providers to develop appropriate and affordable lighting solutions to meet this consumer demand.

» **Encourage targeted attempts to make current subsidies and incentives more easily accessible to existing and potential DRE providers.**

The Ministry of Power intends to supply rural areas with electricity by extending the grid and centralizing large-scale power generation, which is heavily subsidized (often free) to rural BoP households.⁵³ Although the grid has been slow to expand,* the government has given it priority over off-grid solutions.⁵⁴ Clean energy sources like biomass and small hydro, however, can often compete with unsubsidized electricity rates when the full cost of delivery, which includes the basic cost of supply from the grid as well as the cost of grid extension and transmission and distribution, is taken into account.⁵⁵ The government has recognized the potential role of DRE in meeting India's electrification challenges, but its recommendations and policies are often restrictive (rigid eligibility guidelines for subsidies and incentives) or are not fully implemented at the state level.⁵⁶ We recommend that the government streamline the application process for these subsidies and make them more

* The number of electrified rural households increased by 7 percentage points, from 48 to 55 percent from 1999/2000 to 2004/2005 (CDF-IFMR analysis, NSSO 2004/2005, round 61).

easily accessible to a wider range of DRE providers. This approach will not only provide rural households with grid-like electricity services but will also lower the burden on state electricity boards that suffer heavy losses by providing subsidized electricity to remote areas.⁵⁷

» **Promote clean energy and energy-efficiency companies as priority sectors for Indian bank lending.**

The Ministry of New and Renewable Energy (MNRE) currently provides low-interest loans and subsidies for renewable energy projects.⁵⁸ But the rapid growth of the clean energy industry has increased the demand for capital, and many of the companies we studied cited the difficulty of obtaining debt financing.

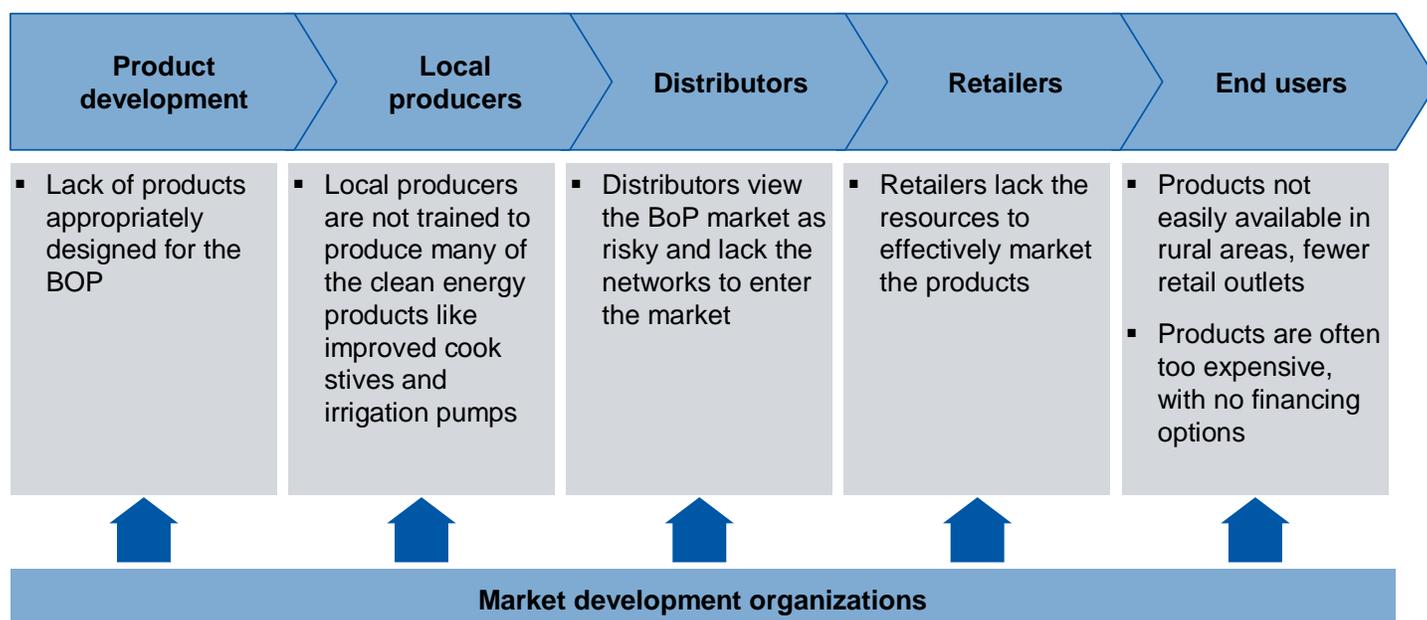
India's central financial regulator, the Reserve Bank of India (RBI) requires Indian banks to allocate a percentage of their lending each year to "priority sectors" such as agriculture, small industries, and education, which deliver spillover benefits to society.⁵⁹ Small- and medium-sized enterprises in India's clean energy sector deliver important social and environmental benefits but face significant credit constraints. Therefore, we recommend that the government consider clean technology (clean energy and energy efficiency) as a priority sector for Indian banks, to help direct more capital to these companies.

VI. The role of nonprofits

Nonprofit organizations that promote the use of a product within a targeted group are known as market development organizations (MDOs) and can help generate demand for clean energy products and services among the rural BoP. Because of the high marginal costs of selling products in the underdeveloped landscape, companies find it difficult to penetrate the rural BoP market and attain financial sustainability, but MDOs can fill some of the gaps in the value chain, as shown in figure 5. MDOs have strong local networks, can raise awareness of the health and economic benefits of clean energy products, and can help companies improve their distribution and marketing, resulting in lower costs, higher profits, and better returns for investors.⁶⁰

Figure 5. Market Development Organizations Bridging the Gaps in the Value Chain

Unmet needs along the supply chain



Source: CDF-WRI field research, 2009.

What Is the Role of Market Development Organizations?

MDOs can use local networks and knowledge to market clean energy products for the rural BoP.

MDOs operate in the rural areas of several states across India and are therefore well equipped to adapt to local cultural and economic conditions. Their knowledge can help clean energy companies build effective distribution and retail networks, assess consumer demand, and raise awareness of their products. This can significantly lower the distribution and marketing costs of clean energy products, making them more affordable for BoP consumers. For example, International Development Enterprises-India (IDE-I) is a market development organization working with various NGOs across India to promote the use of drip irrigation technologies like treadle pumps. IDE-I bears the cost of promotional products and events such as film, banners, and village demonstrations.

Technology development–focused MDOs can train local talent to produce basic clean energy products.

For example, Technology Informatics Design Endeavour (TIDE) is an MDO that trains local micro-entrepreneurs to produce simple, inexpensive, energy-efficient cookstoves. This strategy of using local talent and materials allows the organization to spend more of its resources on distribution and marketing activities.

MDOs can develop new business models that can generate additional demand.

The Small Scale Sustainable Infrastructure Development Fund (S3IDF) is an MDO that provides seed funding and business development services to small-scale enterprises that provide essential services like energy, water, transport, and communication to the rural BoP. One of S3IDF's projects is helping small entrepreneurs build businesses that rent solar-charged lanterns to street vendors in rural areas. S3IDF works with these entrepreneurs to help them develop their businesses, lends them part of the startup capital at reduced interest rates, and offers a partial loan guarantee that enables vendors to access financing from local banks.

How Can Companies and Investors Work with MDOs?

Companies can partner with mission-aligned MDOs to help address current market challenges.

The companies we studied face a variety of challenges in regard to product design, production, distribution, and marketing. MDOs can use local networks to raise awareness of the health benefits and other positive attributes of clean energy products, as well as build distribution channels, train local producers, and experiment with innovative business strategies in partnership with clean energy companies. For example, solar lantern companies can partner with organizations like S3IDF to develop leasing models for solar lanterns. Likewise, cookstove

manufacturers can work with organizations like TIDE to develop simpler, less expensive cookstoves that can be produced locally at a lower cost, and both solar and cookstove providers could partner with MDOs to raise awareness of their products' benefits.

Investors and donors can supply “soft” capital support to MDOs that partner with clean energy firms and help develop the market.

As part of an expansion strategy, clean energy BoP investors can fund MDOs to partner with the clean energy company in which they have invested. This capital for MDOs would help bring down costs for the invested company and move them toward profitability by allowing the company to tap into the MDOs' local networks and knowledge. The support of the MDOs then can be phased out as companies develop their own capacity. This will ensure that companies do not become reliant on grants as a core part of their business.

VII. Conclusion

India's demand for energy is surging, and the government is increasingly promoting clean energy solutions. Despite their low income, India's rural BoP population of 114 million households constitutes a significant consumer market for the energy services and products required to provide daily necessities, such as cooking and lighting. Indeed, we estimate India's potential total rural BoP energy market to be INR 224 billion (US\$4.86 billion) per year.⁶¹

This clear market opportunity has encouraged a growing number of Indian companies to target such households for alternative cooking and electricity sources and to develop clean energy products and services for this prospective customer base. Within the rural BoP market, we estimate the clean energy market for the four categories of products and services studied in this report to be INR 97.28 billion (US\$2.11 billion). However, despite the great opportunities for growth in the nascent clean energy market for the rural BoP in India, significant barriers remain.

DRE is the largest market by far, accounting for 95 percent of the total potential rural BoP market for clean energy. Some DRE enterprises are relatively mature and ready for "mainstream" capital, but most of the clean energy companies serving this market require patient capital or social-impact investors with more modest return expectations. The demand for solar home systems, solar lanterns, and energy-efficient cookstoves currently is small but could grow significantly as product prices are reduced by means of tighter control over distributor and retailer margins, cheaper manufacturing, lower marketing and distribution costs through partnerships, and the availability of consumer-financing options.

Outlook for Investors

Investors seeking to provide capital to companies selling clean energy products and services to rural BoP customers require both patience and pragmatic expectations regarding their initial returns. Five of the companies we studied have received investments, and seven have received grants and donor capital. Many companies also expressed the need for short-term debt financing rather than pure equity capital. Debt financing is required to free up companies' cash flows so that they can make the necessary investments to expand their business while meeting their working capital needs and minimizing the risk exposure for investors.

Impact investors who want their investments to have a positive social and environmental impact are critical to the early stage of this industry. By supplying firms with patient capital and nonfinancial resources such as management expertise and access to their business networks, they can help lay the groundwork for a profitable, long-term future industry as the country with the world's second-

largest population moves to a low-carbon economy. They also can act as a catalyst to encourage clean energy firms and stakeholders to create an industry coalition prepared to advocate for favorable government policies.

Patient capital is required to help companies overcome these market challenges. If successful, the future rewards are likely to be significant. The social benefit is also considerable: supporting businesses that provide rural Indian consumers at the base of the pyramid with vital clean sources of energy into the future.

Appendices

APPENDIX I: Glossary

AC	alternating current	MIT	Massachusetts Institute of Technology
BoP	Base of the Pyramid	MW	megawatt
CDF-IFMR:	Centre for Development Finance–Institute for Financial Management and Research	NGO	nongovernmental organization
CDM	Clean Development Mechanism	NSSO	National Sample Survey Organization
CER	certified emission reduction	PLF	plant load factor
CFL	compact fluorescent lamp	PPA	purchasing power agreement
CFSP	Cambodian Fuelwood Saving Project	PPP	purchasing power parity
DRE	decentralized renewable energy	PV	photovoltaic
INR	Indian rupees	SEB	state electricity board
IREDA	Indian Renewable Energy Development Agency	SHS	solar home system
Kg	kilogram	T&D	transmission and distribution
kW	kilowatt	US\$	U.S. dollars
kWh	kilowatt-hour	VER	voluntary emissions reduction
LED	light-emitting diode	VLE	village-level entrepreneur
LPG	liquid petroleum gas	WRI	World Resources Institute
MFI	microfinance institution		

APPENDIX II: Sample Selection and Field Research

The CDF-IFMR and WRI collected secondary data on twenty-three Indian companies and twenty-two global companies and organizations in the businesses of solar lighting, distributed renewable energy (various technologies, including microwind, small hydro, and biomass gasification), energy-efficient cook stoves, and biofuels, through an online search using sources published by both companies and third parties (see table 9). We prepared one-page summaries of these companies and selected fifteen from the initial forty-five for detailed analysis based on the companies' technology, product, or service; business model; value proposition for the BoP; and potential to scale. We also collected financial data from fifteen Indian companies to estimate the current state of the market for each of the sectors (see table 10). The methodology used for the study can be divided into the following stages.

Table 9: Companies and Organizations Initially Surveyed

Company Name	Country	Technology/Product
Global companies		
Grameen Shakti	Bangladesh	Cookstoves / solar home systems
GERES	Cambodia	Efficient charcoal stoves
Kickstart	Kenya	Market development
Institute for the Development of Natural Energy and Sustainability (IDEAAS)	Brazil	Off-grid energy and lighting
Enersud	Brazil	Microwind generators
AIDFI	Philippines	Hydraulic ram pumps
Freeplay Energy, Plc	Africa	Off-grid lighting
Humdinger Wind Energy, LLC	United States, Hong Kong	Off-grid energy and lighting
Fruit of the Nile	Uganda	Solar fruit dryers
Solar Trade Corporation	Costa Rica	Solar coffee dryers
Beijing Shenzhou Daxu Bio-energy Technology Company	China	Energy-efficient cookstoves
Full Belly Project	Malawi	Universal nut shellers
Sunlabob	Laos	Off-grid energy and lighting
Trees, Water and People	Honduras	Fuel-efficient stoves
Aprovecho Research Centre	Malawi	Rocket stoves
Lebone Solutions	Tanzania	Microbial fuel cells
Practical Action	Africa	Off-grid energy and lighting
Shaanxi Mothers	China	Biogas digesters
Solux E.V.	Ghana	Off-grid lighting
Africa Biofuel and Emission Reduction Company	Tanzania	Biofuels
Jatropha Africa	Ghana	Biofuels (jatropha)
OSRAM	Africa	Off-grid lighting

Company Name	Country	Technology/Product
Indian companies		
Biotech, India	India	Small biomass plants
Envirofit, India	India	Energy-efficient cookstoves
d.Light, India	India	Off-grid lighting
BP Oorja, India	India	Energy-efficient cookstoves
Husk Power, India	India	Off-grid power
IDEI, India	India	Market development
TIDE, India	India	Energy-efficient cookstoves
THRIVE Energy, India	India	Off-grid lighting
SELCO, India	India	Off-grid lighting
S3IDF, India	India	Market development
SBA Hydro	India	Small hydro power
Nandan Biomatrix	India	Biofuels
Cleanstar Energy	India	Biofuels
Philips	India	Energy-efficient cookstoves
Protos	India	Energy-efficient cookstoves
IT Power	India	Small hydro
Himurja	India	Small hydro
e charkha	India	Micro electricity generators
MPGVM	India	Off-grid lighting
Mighty Light	India	Off-grid lighting
GSBF	India	Off-grid lighting
ARTI	India	Energy-efficient cookstoves
AuroRe	India	Off-grid lighting

Table 10: Companies Profiled, by Sector

Decentralized Renewable Energy	Solar Lighting	Cookstoves	Market Development
DESI Power	THRIVE	Envirofit	IDEI
Husk Power system	d.Light design	First Energy (formerly BP Oorja)	S3idf
SBA Hydro	SELCO	TIDE	TIDE (cookstoves)
Enersud (Brazil)	IDEAAS (Brazil)	Grameen Shakti (Bangladesh)	Kickstart (Kenya)
		GERES (Cambodia)	GERES (Cambodia)
Additional Indian companies that responded to the financial survey			
	Grameen Surya Bijlee	Samuchit	
		Sustaintech	
		Biotech India	

Field Research

The CDF-IFMR and WRI research teams conducted extensive field research for more than four months to assess the investment potential of clean energy for the rural BoP in India and to understand the challenges and innovations of existing companies. We also conducted semi-structured interviews with company officials to understand the company's mission and objective and with field staff to learn about the challenges of daily operations. We talked to product retailers and distributors to find the overall status of the value chain, and we interviewed investors and other financial partners when available.

Focus Group Discussions

The CDF- IFMR and WRI conducted focus group discussions with rural BoP consumers in twenty-six small towns and villages in India, Bangladesh, Brazil, Cambodia, and Kenya, spending three to seven days with each company and its targeted consumers. We conducted focus group discussions with more than 240 consumers (including both users and non-users of the product or service, to understand their experiences and their reasons for not using it). These insights can help companies and investors better understand the rural BoP market in India.

APPENDIX III: National Sample Survey, Sixty-first Round

We obtained our estimates of the market size and the consumption data from the sixty-first round of the National Sample Survey (NSS) conducted by the National Sample Survey Organization (NSSO). The NSSO, part of the Ministry of Statistics and Programme Implementation (Government of India), conducts one of the world's largest quantitative surveys every five years, collecting data on several socioeconomic variables regarding employment, health, and overall consumer expenditures. The NSS data offer the most robust, up-to-date information about the lives of individuals all over rural and urban India.

The NSS, sixty-first round, is the most recent survey on consumer expenditure held in 2004/2005, using a stratified multistage design to obtain a representative sample of Indian households. The breakouts of sample size and weighted populations are shown in Table 11.

Table 11: National Sample Survey, Sixty-first Round Sample Size and Representation

	Sample Size (number of households)	Population Represented (number of households)	Population Represented (number of people)
All India	124,644	207,113,585	981,610,607
Rural	79,988	150,159,755	733,105,506
Urban	45,346	56,953,830	248,505,110

Calculation of Household Expenditure

Households acquire goods by directly purchasing them from the market, as gifts, from free collection (particularly in the case of firewood and dung cake), or by producing them at home. The NSSO's expenditure data include the imputed values of all goods acquired by households. To accurately size the rural BoP market for companies and investors, we excluded the imputed values of goods and calculated the market size on the basis of only the actual monetary expenditure.

We separated the market into quintiles, based on their average monthly per capita expenditure, and then analyzed the total expenditure on fuel and light within these quintiles.

APPENDIX IV: Emerging Technologies and Business Models

The power generation technologies studied in this report (biomass gasification, small hydro-electric, solar photovoltaic) are relatively mature, and their cost and efficiency have improved incrementally in recent years. We examined both a promising emerging technology and an innovative business model with great potential for the Indian rural BoP market.

Thin Film Solar

Although traditional photovoltaic (PV) solar panels are currently being used to supply power to isolated, off-grid regions in developing countries, they still are relatively expensive to manufacture and require careful maintenance. The development of thin film solar is considered particularly relevant to developing countries, owing to the flexibility and comparatively low cost of manufacturing of the cells, which makes them easy to install in remote, off-grid locations.

Photovoltaic panels are made from crystalline silicon, an expensive and scarce resource for which PV manufacturers must compete with the electronics industry. The production of PV solar panels also is extremely energy intensive, and their average conversion efficiency in the market is from 12 to 18 percent. Thin film photovoltaic is an emerging technology that relies on nonsilicon materials, including alternative semiconductors and organic compounds, making the manufacturing process simpler and less expensive while also reducing the reliance on silicon.⁶² The roll-to-roll manufacturing process of producing thin film photovoltaic is similar to the process of printing paper and is much more environmentally friendly than the production of silicon-based solar cells.⁶³

Even though thin film cells are not as efficient as conventional solar cells, their low cost and flexibility make them ideally suited to the rural off-grid market.⁶⁴ The cells are flexible, thin layers that can be installed directly on surfaces like steel, glass, and plastic. Until now, the low efficiency ratings of thin film solar have restricted its use because of the large surface area required to generate a useful amount of power. The technology has advanced rapidly over the past few years, however, and in March 2009, the National Renewable Energy Laboratory at the University

of California at Berkeley achieved a 19.9 percent conversion efficiency with thin film PV, bringing it on par with silicon-based PV. As the technology continues to become more robust and efficient, thin film solar can become a viable source of power for the BoP.

Leasing Rechargeable Batteries: EGG Energy (Tanzania)

EGG Energy is a battery subscription service operating in Tanzania that rents rechargeable lead acid batteries to low-income, off-grid households. Households pay an annual fee of approximately US\$33 for the service and can exchange a depleted battery for a freshly charged one for US\$0.37 at EGG's local centers. The company also sells a variety of LED lights, mobile phone chargers, and other small appliances that can be operated on battery power. The batteries are charged using grid-based electricity where available and can also be charged by off-grid solar, biomass, or small hydro installations.

This innovative approach of electricity products as a service significantly lowers the upfront cost for consumers and also ensures a steady income stream for the company. These rechargeable batteries can provide a viable, cost-effective alternative to rural, off-grid households that require basic electricity services. EGG Energy is introducing this business model near Dar es Salaam and projects selling 12,000 subscriptions by 2011. Solar and DRE companies also should consider introducing a clean energy, charged battery, subscription-based model for rural areas.⁶⁵

Endnotes

- 1 CDF-IFMR analysis, NSSO 2004/2005, round 61.
- 2 Throughout this report, we used a conversion rate of \$US1 = INR 46.
- 3 CDF-IFMR analysis, NSSO 2004/2005, round 61.
- 4 K. R. Smith, National Burden of Disease in India from Indoor Air Pollution, Proceedings of the National Academy of Sciences of the United States of America, November 21, 2000, 13286–93; A. Pokhrel et al., Tuberculosis and Indoor Biomass and Kerosene Use in Nepal: A Case Controlled Study, Environmental Health Perspectives (Washington, DC: National Institutes of Health, U.S. Department of Health and Human Services, 2009).
- 5 World Resources Institute (WRI), World Resources 1994–1995 (Washington, DC: World Resources Institute, United Nations Environment Programme, and United Nations Development Programme (UNDP), 1995).
- 6 CDF-WRI survey of clean energy companies serving the Indian rural BoP market, 2010.
- 7 James Cust et al., Rural Electrification in India: Economic and Institutional Aspects of Renewables, Working Papers in Economics 0763 (Cambridge: Faculty of Economics, University of Cambridge, December 2007), available at <http://www.electricitypolicy.org.uk/pubs/wp/eprg0730.pdf> (accessed January 12, 2009).
- 8 UNDP and World Bank Energy Sector Management Assistance Programme (ESMAP), Access of the Poor to Clean Household Fuels in India (Washington, DC: World Bank, 2003).
- 9 In 2005, India had approximately 150 million rural households. CDF-WRI separated the expenditure data from the National Sample Survey Organization into quintiles (see table 1) to analyze specific segments of the market for different clean energy products. For this report, we estimate the Indian rural Base of the Pyramid market to be the bottom four quintiles, representing 76 percent of the rural population, or 114 million households.
- 10 Smith, National Burden of Disease in India; Pokhrel et al., Tuberculosis and Indoor Biomass.
- 11 WRI, World Resources 1994–1995.
- 12 The companies profiled in the report do not represent an endorsement of either CDF or WRI. We provide analysis on a sector and subsector level and do not evaluate individual company business models or performance.
- 13 The National Sample Survey Organisation (NSSO) is part of the Ministry of Statistics and Programme Implementation of the Government of India, responsible for conducting large-scale socioeconomic surveys.
- 14 CDF-IFMR analysis, NSSO 2004/2005, round 61.
- 15 This rapid growth has been largely driven by the recent entrance of new companies in the space. More than 75 percent of the companies we studied had entered the market in 2006 or later.
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- 17 Ministry of New and Renewable Energy, 2004.
- 18 Narasimha Rao et al., An Overview of Indian Energy Trends: Low Carbon Growth and Development Challenges (Delhi: Prayas Energy Group, September 2009); Cust et al., Rural Electrification in India.

- 19 S. Morris et al., A Scheme for Efficient Subsidisation of Kerosene in India, Working Paper, no. 2006-07-06 (Ahmedabad: Indian Institute of Management, 2006).
- 20 CDF-IFMR analysis, NSSO 2004/2005, round 61.
- 21 Based on focus group discussions conducted with consumers.
- 22 CDF-IFMR analysis, NSSO 2004/2005, round 61.
- 23 The World Health Organization recently estimated that indoor air pollution is responsible for around 1.6 million deaths per year and 2.7 percent of the global burden of disease. See N. Bruce et al., *The Health Effects of Indoor Air Pollution Exposure in Developing Countries* (Geneva: World Health Organization, 2002).
- 24 Smith, *National Burden of Disease in India*.
- 25 Based on focus group discussions conducted with consumers.
- 26 Ibid.
- 27 These users represent approximately 20 to 30 percent of the households we sampled in our field research. These households are among the higher-income levels in the BoP, earning a monthly income of more than INR 5,000. Car batteries cost around INR 3,500.
- 28 This market value does not include electricity consumption from BoP commercial and agriculture activities, even though the agricultural sector is responsible for 24 percent of total electricity consumption and 19 percent of diesel consumption in India. The market value was not assessed because of the difficulty in estimating its size, owing to the wide range of subsidies and the lack of reliable data on actual expenditure. However, table 5 provides estimates of the typical power consumption of some of these commercial and agricultural activities, based on our field experience.
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