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INNOVATING FOR EMERGING MARKETS
Novel business models to supply energy to the rural poor

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INNOVATING FOR EMERGING MARKETS
Novel business models to supply energy to the rural poor

Abstract

A quarter of the world's population does not have access to electricity, and relies on expensive, hazardous, and polluting alternatives for basic needs such as lighting. A framework that combines perspectives from the strategy, entrepreneurship and organization science literature is used to analyse the business models of 47 organizations, which deliver modern energy services to this mostly poor, rural population. The research seeks to understand the marketing innovations and multi-level collaborations that theory suggests are essential for the success of social entrepreneurs. Vivid illustrations of such work are found. The data suggest that the returns associated with serving this population are low and multinational corporations play a small and indirect role. The poor also pay significantly more for basic energy services than the better-off. As such, even though the organizations studied are often more effective than the state at providing basic energy services, it is essential that state and non-state actors collaborate to deliver energy to the poor in manner than ensures greater efficiency and equity.

Sara Ruto relies on her mobile phone to receive money from and talk to relatives in the city. To charge it, she needs to walk two miles out of her village in Kenya, hire a taxi, and make a three-hour journey to the nearest town. Here, she drops her phone off at a shop, which charges it for the equivalent of 30 US cents. The demand for the shop's services is so large, that the phone can't be returned to Sara on the same day. She must make another costly and arduous journey, and return for it three days later (Rosenthal 2010).

Over 1.5 billion people - over a fifth of the world's population - do not have access to grid electricity. Well over three quarters of these people live in rural or peri-urban areas (The Economist 2010).

Comparing national data, Modi (2004) shows that for low levels of energy use, a small increase in per capita energy consumption is correlated with a dramatic rise in wellbeing, as measured by the Human Development Index. Poor households spend 20-30% of income on kerosene for lighting, and access to electricity could reduce or eliminate this expenditure (The Economist 2010; Adkins et al. 2010). Mills (2005) estimates that 77 billion litres of fuel are used each year for lighting, equivalent to 1.3 million barrels of oil per day, or 1.5% of total oil consumption (BP plc 2010). This leads to 190 million metric tonnes of CO2 emissions annually, equivalent to a third of the UK's emissions. In India, 2.5 million people (Schultz et al. 2008) suffer severe burns each year due to overturned kerosene lamps; and 200,000 die annually (Peck et al. 2007) due to burn accidents involving flame-based appliances.

The United Nations estimates that investments of $30-40 billion per year are required annually up to 2030 to ensure universal access to grid electricity. Such

investments are not being made. On current trends, the absolute number of people who do not have grid access will not change by 2030, when a sixth of the world's population will remain off the grid (The Economist 2010).

Chakrabarti and Chakrabarti (2002) have shown that for remote villages in India – where over 400 million (Page 2009) people do not have access to electricity - decentralised power generation using renewable energy sources can be economically more attractive than grid extension. Renewable sources of energy can also be more attractive than existing alternatives to the grid. In the case of a Millennium Village in Malawi, Adkins et al. (2010) show that most families spend between $2-4 per month on kerosene for lighting. Clean, bright, solar lanterns[1] - costing as little as $10 (Unnithan 2010) - would eliminate kerosene consumption, and therefore pay for themselves in a few months. Miller (2010) observes that diesel generators, a common alternative to grid electricity, are under-utilized by rural households. As a result, the monthly, amortized cost of operating them in India exceeds the cost of operating a small photovoltaic power generation system.[2]

An opportunity exists to economically displace traditional alternatives to grid electricity. This dissertation is a study of how enterprises - ranging from for-profit businesses to charitable non-government organizations (NGOs) - reach the people who are forced to use primitive energy sources and provide them with environmentally and economically sustainable alternatives.

[1] These consist of light-emitting diodes (LED) or compact fluorescent lamps, and are powered by a battery, which is charged by a small solar panel.

[2] Such a system consists of a solar panel, battery, and a charge controller to manage the charging and discharging of the battery. It typically generates enough power to operate a few lights, and a radio or black and white television.

RESEARCH QUESTION AND CONCEPTUAL BACKGROUND

There is an extensive literature on the techno-economics of the extension of energy services to the rural poor (Banerjee 2006; Nouni et al. 2006; Nouni et al. 2008; Nouni et al. 2007), as well as on the successes and failures of policies put in place to achieve universal electrification (Modi 2005; Martinot et al. 2002; Bekker et al. 2008; Miller & Hope 2000; Sen & Jamasb 2010). In contrast, the present research seeks to answer the following question.

> *How do organizations seek to deliver - in an environmentally and economically sustainable way - energy services to the poor, rural populations that do not have access to the electric grid?*

Opportunities at the Bottom of the Pyramid (BoP)

Hammond et al. (2007) estimate that people at the BoP, with annual incomes of less than $3000, have a combined purchasing power of $5 trillion. At $433 billion, the market for energy at the BoP is the second largest after food ($2,895 billion). Christensen et al. (2001) recommend that developed-world firms grow by competing against the non-consumption at the BoP. Hart and Christensen (2002) hypothesize that the niche requirements of such customers could inspire disruptive innovations. Tracey and Phillips (2011) argue that institutional uncertainty in emerging markets can act as both a barrier to, and source of, opportunity for entrepreneurs. Entrepreneurs have been able to enter the market for energy services in developing countries at least in part because services provided by the state are often poor or non-existent (Modi 2005).

Marketing to the BoP

Prahalad (2009) asserts that firms can sell to the poor profitably; and by doing so, contribute to their well-being, and give them the means to lift themselves out of poverty.

Scholars (e.g., Warnholz 2007) have refuted these claims by arguing that the collective purchasing power of the poor is much smaller than Hammond et al. claim; that the firms that Prahalad extols serve customers who – though poorer than their western counterparts - are not at the BoP; and that many firms that have tried to serve the poor have found it difficult and unprofitable to do so. Karnani (2007) suggests that business alleviate poverty by buying from the poor instead of merely selling to them. Munir et al. (2010) review the evolution of theoretical perspectives on business at the BoP, as well as the empirical evidence that has informed the debate.

Institutional work and innovations needed to reach BoP customers

A business model is the "underlying logic that explains how we can deliver value to customers at an appropriate cost" (Magretta 2002). Morris et al. (2005) suggest that a business model describes an organization at two levels. At a 'foundational' level, it describes how the founders intend to create value, and for whom. In the context of organizations that serve very poor customers, the objective of the founders may be to create positive social outcomes. At a 'proprietary' level, the model explains the enterprise's unique approach to one or more of the foundational components.

Products, awareness, accessibility, affordability and sustainability

Prahalad (2009) suggests that firms need to devise innovative ways to make products *accessible* to BoP customers, who may be geographically dispersed and difficult to reach. They must be priced so that consumers who live on less than $2 per day, have scant access to credit, and have erratic incomes, can *afford* them. Customers who may often be illiterate and live in media 'dark' areas must be made *aware* of the product. The *product* itself may need to be modified to meet these goals, or the specific needs of the poor. Dacin et al. (2011) observe that social enterprises must generate

enough economic value to continue to finance the generation of social value: business models must be commercially *sustainable*.

Macro, meso and micro collaborations

Tracey et al. (2011) suggest that bridging two different types of institutional logic[3] –the logic of social and economic value creation – requires institutional work at three levels: micro, meso and macro. At the micro level, entrepreneurs frame the problem in a unique way, recognize that existing institutions are incapable of solving it, and apply counterfactual thinking to solve it themselves. At the meso level, new organizational forms need to be created. At the macro level, legitimacy must be conferred on the new organizational form, which must tap into "broad discourses…that are widely understood and broadly accepted in society."

Spear (2006) found that the success of the enterprise required "closely and essentially involved" external stakeholders. Sánchez and Ricart (2010) argue that "interactive" business models perform better than "isolated" ones. Seelos and Mair (2007) stress the importance of "multiple partnerships" to market creation at the BoP.

Combining these perspectives, it is suggested that in addition to doing institutional work, social entrepreneurs must form collaborations at the macro, meso and micro levels. In a study of subsistence consumer-merchants in India, Viswanathan et al. (2010) find that such micro-entrepreneurs work hard to sustain relationships at various levels: with their vendors, customers and extended family. For the purposes of this research, we define the micro level as consisting of individuals, or small, self-organizing groups of individuals (e.g., self-help groups). The meso level is defined as consisting of relatively

[3] Greenwood et al. (2009) present several definitions of *institutional logic*, including "the formal and informal rules of action, interaction, and interpretation that guide and constrain decision makers."

large organizations, ranging from NGOs to multinational companies. The macro level consists of national governments, and international organizations (e.g., the United Nations).

METHOD AND DATA

The case study method

Yin (1981) argues that the

> *the distinguishing characteristic of the case study is that it attempts to examine: (a) a contemporary phenomenon in its real-life context, especially when (b) the boundaries between phenomenon and context are not clearly evident.*

Elsewhere Yin (2003) suggests that case research is best suited to questions of the form 'how'. Arguably, the method is well suited to address the research question above.

Case study research is distinct from grounded theory development. In the former, a theoretical framework is part of the research design; in the latter, the theory emerges from the data (Yin 2003). In particular, Yin (1981) recommends that the central questions of the case be identified beforehand. The theoretical framework for the present research draws on the work of Prahalad, Tracey et al., Spear, Seelos and Mair, and Sánchez and Ricart, as discussed above. Applying this framework to the research question, and acknowledging the importance of context, leads to the questions in Figure 1. As Ansari et al. (Forthcoming) point out, "the BoP is still in a pre-paradigmatic state of development as an academic field." It is therefore appropriate that the data are approached with questions, rather than fully formed theories or hypotheses.

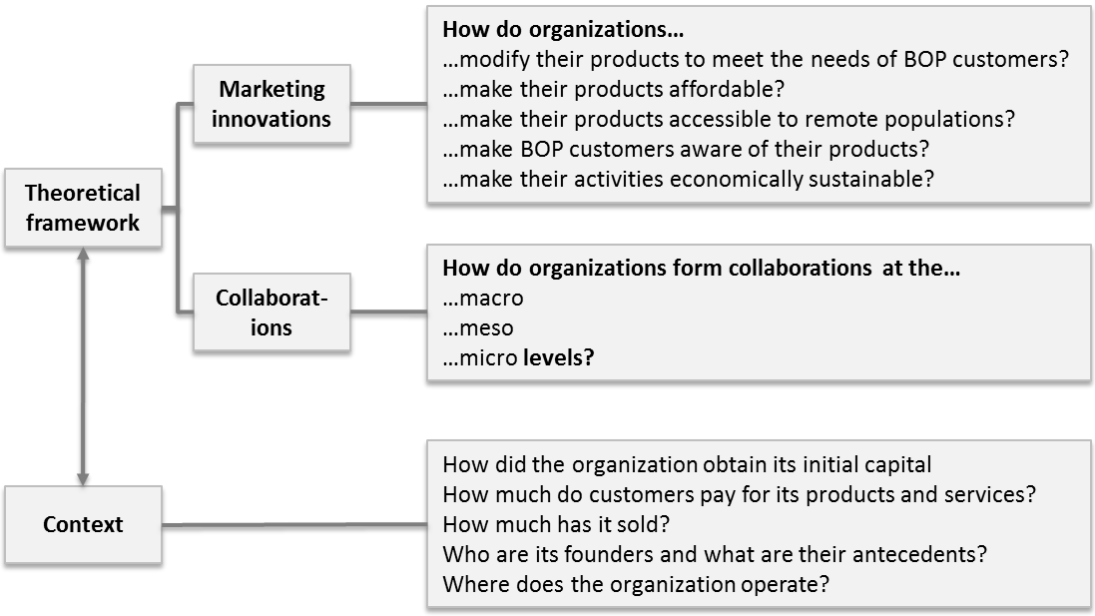

Figure 1: Identifying the central questions of the research

Multiple cases and analytical generalisation

Insights supported by multiple cases are more compelling and robust than those that emerge from a single case (Yin 2003). In order to answer the questions above, 47 organizations are identified, and their business models studied. No attempt is made to select a random, or representative, sample. Following Yin (2003), analytical – rather than statistical – generalisation is sought. Dacin et al. (2011) observe that few studies of social enterprise involve multiple cases, and even fewer undertake a systematic comparison of cases.[5] Furthermore, they observe a "lack of large-scale databases and the use of quantitative data analysis techniques by social entrepreneurship scholars." By studying a large number of cases, and structuring the findings according to a pre-defined framework, this research aims to close that gap.

[5] In the context of delivering energy services to the poor, for example, Yadoo and Cruickshank (2010) studied the case of a co-operative that provides electricity to remote communities in Nepal. Miller (2010) studied three cases of entrepreneurs seeking to sell solar home systems in India, Indonesia and Sri Lanka.

Scope

Services such as lighting, irrigation and space heating are included. Most products or services involve the decentralised generation of electricity. Some products use solar thermal energy, or enable more efficient utilisation of manual labour. Instances where the extension of the electric grid to formerly underserved populations has been made possible by – for example – better ways of billing and metering, are also studied. Only organizations whose operations are sustainable are studied. This does not limit the research to for-profit organizations, as many organizations have established mechanisms to fund themselves sustainably from charitable or government sources. Programmes that are funded for a pre-determined period of time are excluded.[6]

A significant energy service that is excluded is cooking. Modi (2004) suggests that even if the upfront cost of a modern stove is met by subsidy, fuel is likely to cost $0.40 per day, making it unaffordable for those who live on less than $2 per day. As such, we do not expect to encounter models for the provision of modern cooking fuels that do not require an ongoing subsidy.[7]

Data collection

Information about the business models is drawn largely from secondary sources. This approach avoids the memory or self-report bias that Chandy and Tellis (2000) suggest could result from methods of primary data collection; e.g., surveys of current managers.

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[6] An example is the China Township Electrification Program, which ran from 2001-2010. By 2003, this program had brought photovoltaic, wind and micro-hydropower to about 1 million households in China's off-grid western region, at a cost to national and regional governments of $240 million (Plant 2004).

[7] The Shaanxi Mothers' Environmental Protection Volunteer Association's biogas plant initiative (The Ashden Awards 2009b) is an example of a model to provide clean energy for cooking. The organization sets up biogas plants that use human and pig waste to produce cooking gas and fertilizer. Two-thirds of the cost of the plant is met by government subsidies and donations, and customers pay the rest. It is not unusual for demand to exceed levels that can be met by available subsidies; in which case some demand goes unmet. Annual maintenance is undertaken by the Shaanxi Mothers.

The search for relevant organizations and the details of their business models had several starting points. The websites of the Ashoka Foundation[8], the Shell Foundation[9] and the Ashden Awards[10] were searched for enterprises that they supported, and that were provided energy services to the rural poor. The Shell Foundation supports E+Co, a fund that makes clean energy investments. All the companies that E+Co invests in were considered, and those that were relevant to the research studied in greater detail. A search was done on Factiva; and all the articles ever published about each of the organizations were identified. Duplicate articles (e.g., reprints of a United Press International story) were ignored. In some cases, articles mentioned organizations that had not been previously identified. If they fit the parameters of the research, these organizations were studied also. Over 500 unique Factiva articles were analysed, in addition to a large number of reports and websites. For each enterprise, answers to the questions posed in Figure 1 were sought.

Data presentation and analysis

The data thus collected were stored in a table of the form discussed by Miles and Huberman (1994), for further analysis. Table 1 lists all the organizations studied. An illustration of the nature and organization of the collected information is presented in Table 2, which displays it for one of the 47 organizations about which such information was collected.

[8] The Ashoka Foundation (Ashoka Foundation 2011) is a charity that supports social entrepreneurs by providing them a living stipend for an average of three years, thus freeing them to focus on nurturing their ventures.

[9] The Shell Foundation (The Shell Foundation 2011) is a charity set up by the Royal Dutch Shell to "develop, scale-up and promote enterprise-based solutions to the challenges arising from the impact of energy and globalisation on poverty and the environment."

[10] The Ashden Awards (The Ashden Awards 2011) recognize "inspiring sustainable energy solutions… and help ensure that they are spread more widely."

Organization & Country		Product or service
Husk Power Systems	IN	Power from biogas produced from rice husk
Schneider Electric India	IN	*Indiya* 45-LED panel; rentable batteries
Eskom	ZA	Pre-paid electricity meters
Jain Solar	IN	Range of photovoltaic (PV) and solar thermal products
NU Energy Corp.	IN	Custom photovoltaic installations
Green Light Planet	IN	Sun King LED-based solar lantern
Slum co-operatives	IN	Eliminating middlemen and power theft in peri-urban slums
IBEKA	ID	Community-owned micro-hydro power plants
Thermofluidics	IN	Water pumps powered by solar thermal energy
Orb Energy	IN	Photovoltaic systems for homes and small businesses
d.Light Design	IN	LED-based solar lanterns
Duron	IN	'Plug & play' solar devices (lanterns, chargers etc)
Intelizon	IN	LED-based solar lanterns
SELCO	IN	Solar PV systems and lights
Cosmos Ignite	IN	'Mighty Light' LED-based solar lantern
The Energy and Resources Institute	IN	Rental of solar lanterns with compact fluorescent lamps (CFL)
Philips	IN	Sustainable lighting products: hand-cranked flashlights to solar home systems
Light Up The World	*	LED-based off-grid lighting solutions
Solantern	KE	Sun King LED-based solar lantern
Mitticool	IN	Earthen cooler
Mohammed Abba	NG	Earthen cooler
IKEA Sunnan	IN	Solar LED study lamp, distributed through Unicef
Godrej chotuKool	IN	Low-energy cooler that can be operated by battery and charged using solar energy.
Samsung Solar Guru	IN	Phone with built-in solar charger
Promethean Power	IN	Solar PV-powered cooling system for milk
Saran Renewable Energy	IN	Power from biogas produced from *dhaincha* a local weed
Solar Ear	BR	Low-cost hearing aid with solar PV charger
EGG Energy	TZ	Rental system for batteries charged by solarPV or the grid
Kaito Energie AG	SN	Solar PV charging stations and village mini-grids
Nuru Lights	RW	LED lights, with a bicycle-cranked charger
Technosol	NI	Solar PV systems
Zara Solar	TZ	Solar PV systems
Emprenda	AR	Solar PV systems and microfinance
SolSource	NP	Solar heating, electricity and cooking
Kayor Rural Energy	SN	Photovoltaic systems for homes and communities
DESI Power	IN	Power from biogas produced from the ipomoea weed
ECAMI	NI	Photovoltaic home systems
Barefoot College	IN	Photovoltaic home systems, passive solar homes
AuroRe	IN	Photovoltaic systems for homes and communities
Noble Energy Solar Technologies	IN	CFL-based solar PV lanterns
Prokaushali Sangsad	BD	Women's co-operative that manufactures and installs photovoltaic home systems
Grameen Shakti	BD	Photovoltaic home systems and microfinance
International Development Enterprises - India	IN	Treadle pumps
Deng Ltd.	GH	Photovoltaic home systems
Sunlabob	LA	Photovoltaic home systems
Practical Action	PE	Micro-hydro power
Alternative Indigenous Development Foundation Inc	PH	Hydraulic ram pumps for village water supply

Table 1: List of all the firms studied. The two-letter codes in column two are ISO country codes of the enterprise's primary area of activity. (*)Light Up The World is global.

Organization	Product	Collaborations at		
		Macro	Meso	Micro
Grameen Shakti	Solar home systems (SHS)	Grameen Shakti earns carbon credits for every SHS installed	Procurement agreement with GrameenPhone for renewable energy	
		Innovations in		
Product	Awareness	Accessibility	Affordability	Sustainability
Free checks of the system when microfinance payments are collected. Annual maintenance contracts made available. Improved components to enhance life of the system	Door-to-door visits, meetings with village leaders, brochures, school science fairs, workshops for policymakers, scholarships for buyers' children	Grameen Technology Centres train technicians, making it possible to bring production, marketing, and maintenance closer to customers.	Microfinance loans with flat fees of 4-6%, down payments of 10-15% and terms of 24-36 months available.	
Founders and Antecendents	**Funding**	**Sales**	**Price**	**Market**
Founding director: Dipal Chandra Barua, MA Economics, University of Chittagong	Part of the Grameen Group of Organizations 2000: $4 million from US AID 2005: $1.2 million from US AID 2009: $1.5 million from the Zayed Future Energy Prize	577,679 systems as of 2011	Tk.12,000 to 50,000 for rural customers, depending on system size; less a Government subsidy of Tk.2,000 per unit. Tk.60,000 to Tk.114,000 for urban areas. (US$1 = Tk.74)	Bangladesh

Table 2: Marketing innovations, collaborations and other contextual information for Grameen Shakti

OBSERVATIONS

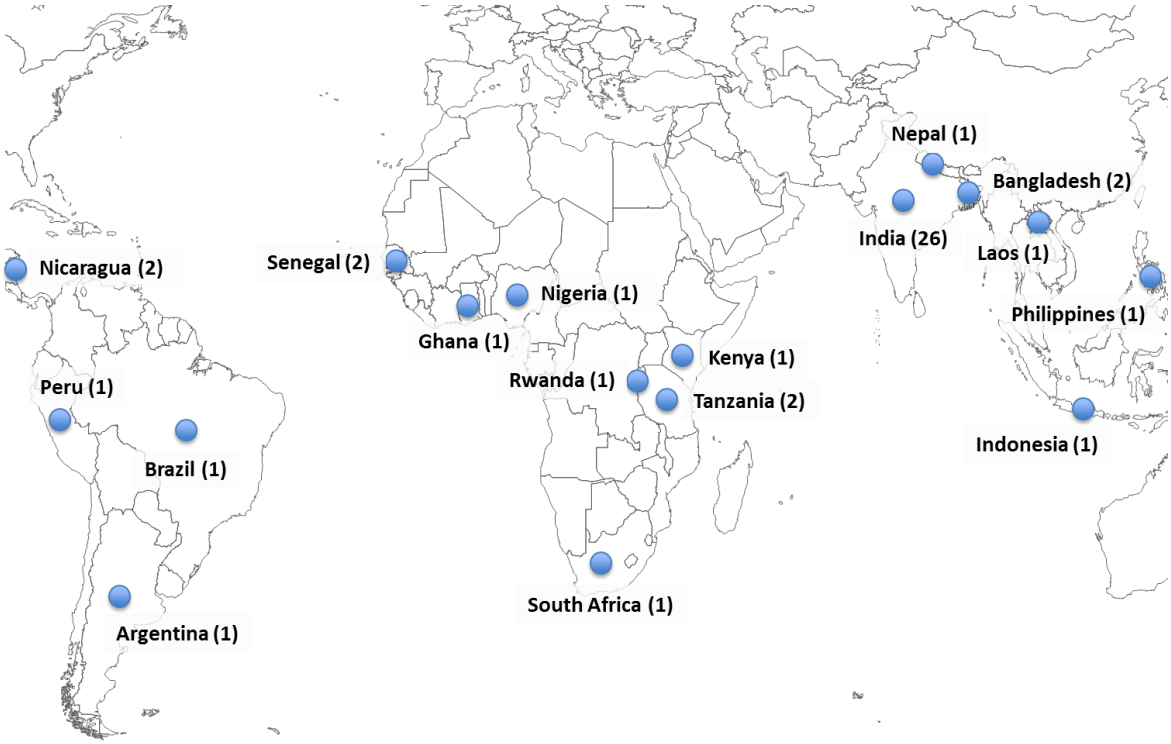

Figure 2: Number of organizations studied by country.

The majority of the organizations studied operate primarily in the Indian subcontinent (Figure 2); and a large majority of these (26 of 29) operate mainly in India. The Light up the World (LUTW) project has a significant presence in Nepal, India, Sri Lanka, the Philippines, the Dominican Republic and Bolivia, among other places.

Standalone electric lights (19 of 47 organizations), solar home systems (15/47), irrigation systems (7/47) and micro-grids[11] (6/47) are the most common products. Lighting is the most common application for solar home systems, as well as micro-grids. As such, a vast majority (40) of the organizations are primarily in the business of providing lighting. Irrigation systems include innovative products that require either only manual labour (e.g., treadle pumps) or no energy at all (e.g., ram pumps), as well as those that are designed to operate with the small amount of energy available from a

[11] Micro-grid refers to a small power generation facility that is unconnected to the national or regional electricity grid, but supplies electricity to up to a few hundred nearby households.

source such as a solar thermal heater (e.g., a pump that employs a thermofluidic oscillator). All the organizations operate in tropical countries, some of whose populations live in mountainous regions and nevertheless require space heating. Two examples of efforts to provide space heating using only sustainable sources were found. South Africa's Eskom and the electric co-operatives set up by Ashok Bharti in Delhi do not fall into any of these categories. Both are included because they have deployed innovative solutions to ensure that power consumption is properly metered and billed, and therefore sustainable.

Studying the business models of the organizations revealed that virtually all (41 of 47) had innovated to make their products affordable to consumers at the BoP. Nearly as many (35) had modified their products to suit the particular needs of such customers. About half (24) had adopted strategies to make their products or services accessible to dispersed customers, and to ensure that operations could be sustained (23). A minority (16) of firms had specific strategies in place to increase awareness of their products. A number of the adaptations address more than one dimension. Consider collaborations with microfinance institutions (MFI). Enabling customers to obtain microfinance loans makes it easier for them to buy the product. Partnering with well-entrenched MFIs to promote – as well as finance - the product increases awareness of it.

Most (46) organizations have formed some form of collaboration; a quarter (11) formed collaborations at all three levels.

A number of organizations illustrate the type of multi-level institutional work that Tracey et al. (2011) suggest social entrepreneurs must do. At the macro level, tapping into the "global discourse" about climate change, eleven firms either receive - or are preparing to apply for - credits through the CDM. At the meso level, it is not unusual to

see micro-finance organizations (e.g., Grameen Bank) that have leveraged the ability to reach remote, rural populations to add energy services to their portfolio of activities (e.g., by the formation of Grameen Shakti). At the micro level, entrepreneurs have recognized the unmet need for lighting, and developed a counter-intuitive solution: modern technology (e.g., LED-based solar lanterns) to meet the needs of the poor more cheaply than primitive technology (e.g., kerosene lanterns).

Detailed descriptions of the operations of two firms - Husk Power Systems and Greenlight Planet – are presented next. The firms were chosen for two reasons. First, each represents a relatively common method of the provision of energy services to poor, rural, widely dispersed populations. Second, while both firms sell the same basic service (lighting and mobile phone charging), they have very different business models. The Husk and Greenlight cases are followed by a discussion of the answers, gleaned by studying all 47 cases, to the questions posed in Figure 1.

The Case of Greenlight Planet, Inc.[12]

Who are the founders and what are their antecedents?

In March 2005, Patrick Walsh, an engineering student at the University of Illinois volunteered to work on an Engineers Without Borders project to help farmers in the Badakmandara village in Orissa, India. He installed a biodiesel generator to help mechanize laborious tasks such as rice husking. Returning to the village in January 2006, Walsh was astonished to find that a local electrician had hooked the generator to stretches of wire and lit the homes of the farmers.

[12] The information presented in this case is based on two interviews (Thakkar 2010; Thakkar 2011) with Anish Thakkar, co-founder of Greenlight Planet, as well as secondary sources.(Guha 2010; Narayan 2009; Massoloka 2010)

Walsh realised that the villagers wanted good quality lighting much more than they wanted labour-saving devices. He resolved to design a solar lamp that was cheap enough for the villagers to afford. With advice from Nick Holonyak, the inventor of the LED, who was a member of the faculty at Urbana Champaign, Walsh soon had a working prototype ready. He flew to Shenzhen, China to work with manufacturers on adapting the design for mass manufacture.

Once he had designed a suitable lantern, Walsh teamed up with two classmates – Anish Thakkar and Mayank Sekhsaria – to form Greenlight Planet, Inc., "to deliver honest, long-lasting, affordable products to emerging-market families."

How did Greenlight obtain its initial capital?

Thakkar had worked as a consultant at ZS Associates, one of whose founders was the Indian-born Prabha Sinha. Sinha had grown up in Bihar, and had often studied by the dim, flickering, sooty light of a kerosene lantern. He gave the firm $550,000 in seed capital.[13] Since then, Greenlight has sold over 100,000 of its Sun King lanterns in the states of Bihar and Orissa in India.

How did Greenlight modify its products to meet the needs of BoP customers?

The lantern can provide 16 hours of light that is roughly as bright as a kerosene lamp, and four hours of light that is four times as bright. The lantern can operate in a mode that focuses light on tasks (e.g., reading) or provide ambient illumination. Village dwellings have earthen or brick roofs, which would not reflect light. Light that is directed upwards is 'wasted'. Therefore, the Sun King lantern uses reflectors to direct light so that it stays below the plane of the lamp. Each light comes with a stand that

[13] In 2010, Greenlight received a further $250,000 from the Deutsche Bank Americas Foundation when it won a competition organized by the Solar for All Initiative.

allows it to be stood up and used for such tasks as chopping firewood, or milking cows early in the morning. The stand also allows the light to be worn around the users' necks, so they have both hands free when using it. The lantern was rated the best (of 30 competing products) in the task lighting category, and second in the 'best value' category, of the Lighting Africa Conference organized by the International Finance Corporation (IFC).

The Sun King is soon to be joined – and potentially replaced – by the Sun King Pro, which has been improved based on customer feedback. The battery life has been extended from three to six years, by switching to a cutting-edge technology. Paradoxically, makers of more advanced products - such as mobile phones and music players – are reluctant to switch to this costlier technology, as they expect their products to become obsolete and be replaced in two to three years. Greenlight recognizes that long battery life is critical for poor customers, who would therefore be willing to pay for it. The most frequent complaint the firm receives is that the battery is only partially charged, even after the panel has been left out in the sun for an entire day. In the Sun King Pro, the designers have introduced a display that tells customers the rate at which the battery is being charged, allowing them to position the solar panel in a way that ensures the quickest and fullest possible charge.

How has Greenlight made its products affordable?

Each Sun King lantern costs Rs.750 ($17, $1≈Rs.45). At $2 per month, this is roughly what a family would spend on kerosene over eight or nine months. Though the Sun King Pro is priced at Rs.1600 ($36), Greenlight believes that many of its users will find that it pays for itself in less than a year. This is because the lantern, which is four times as bright as the Sun King, also makes it possible to charge mobile phones.

Greenlight estimates that users who do not have access to any other source of electricity pay Rs.80 ($1.80) per month for a phone charging service. The new product will, therefore, displace $3.80 in existing consumption, and pay for itself in nine to ten months.

Greenlight is working with a bank to monetize the reductions in carbon dioxide emissions that its products achieve, by displacing the consumption of kerosene. Once the company can start claiming credits under the CDM, it will be able to lower the price of the product and make it affordable to an even larger number of customers.

How does Greenlight make its products accessible to remote populations?

Greenlight has been remarkably successful at distributing the lanterns. Sanjoy Sanyal, director at the green consultancy New Ventures India says it has been able to penetrate villages that are nearly impossible for others to break into. The firm has a two-tier distribution network. Salaried team leaders oversee the work of local entrepreneurs (called *saathis*: Hindi for comrades), who join by buying two units of the product to sell on to end customers. *Saathis* work part time, 1-2 hours a day, after completing their day jobs,[14] and earn a commission of between Rs.60-160 per light sold. This allows the best 20% of them to augment household incomes of Rs.3000-6000 per month by Rs.1500. As this is a significant boost, the top-performing *saathis* are loyal and committed to the company. The best performers have the opportunity to become team leaders, of which there are currently 40. Team leaders can progress to become district and regional sales managers, of which there are six and three, respectively.

[14] Most *saathis* are men. They demonstrate the product door-to-door. Because of the nature of the product, and because they work part time, they do this after sundown. Given the mores of Indian society, and concerns for personal safety, women have been reluctant to undertake the role.

Physically, the distribution is managed by selling one week worth of product for cash (no credit is offered) to the owner of a stock point, typically a local shop, in the market town closest to the cluster of villages that the firm is trying to reach. The stockist carries no risk: Greenlight team leaders and *saathis* undertake all the promotion and sales to ensure that the products are sold quickly. The products have been made light and robust enough for them to be conveniently posted to stockists or end customers.

How does Greenlight make its customers aware of its products?

Saathis are given flipbooks that explain the benefits of the lanterns to potential customers. They are also given product bags and badges with the company logo. *Saathis* have – on their own initiative – promoted the product by organizing Sun King *morchas* (demonstrations). In a *morcha*, several *saathis* team up with existing customers to build up product awareness and cycle – carrying banners and posters, and conducting demonstrations - through villages that the product has not been sold in yet.

The model has allowed Greenlight's operation in the Indian state of Bihar to break even in a year. About 30 team leaders serve the state. The operation has been replicated in the state of Orissa, where the network became as productive as the one in Bihar in six months. The firm is selling over 4,000 lanterns per month: two-thirds in Bihar and the rest in Orissa. Greenlight believes it is currently addressing only 10% of the target market, and has aggressive expansion plans.

The Case of Husk Power Systems

With an annual per capita income of Rs.13,663 ($306) – compared to the national average of Rs.37,490 ($838) – Bihar is one of India's poorest states (Press Trust of India 2010). Understandably, those who live in Bihar have very little to waste. Yet, Bihar

produces 1.8 billion kilograms of rice husk annually, and until recently had no use for it (Bornstein 2011a).

Who are the founders and what are their antecedents?

That was until Manoj Sinha – then a student at the Darden Business School at the University of Virginia – decided to burn the husk in an anaerobic digester to produce a gaseous fuel that could be used to generate clean electricity. Sinha teamed up with classmate Charles Ransler; and the duo were joined by Gyanesh Pandey, who gave up a lucrative career in the technology sector in Los Angeles to participate in the venture (Bornstein 2011a).

How did Husk obtain its initial capital?

Sinha and Ransler won $50,000 at the Social Innovation Competition at the University of Texas (Cannon 2008). This was one of a number of prizes that funded the venture until the Shell Foundation gave it a grant of $165,000 in 2008 (Cannon 2009). In 2009, the team won a $250,000 investment from Draper Fisher Jurvetson and Cisco (Marketwire 2009a). Also in 2009, it received $375,000 in convertible debt from the Acumen Fund (Acumen Fund 2009), an equity investment of $300,000 from LGT Venture Philanthropy (LGT Venture Philanthropy 2010), as well as an investment from the Oasis Capital (Husk Power Systems 2011). This was followed in 2010 by an investment of $1.25 million by the IFC (Davenport 2011). The company also receives Indian government subsidies for renewable energy (The Economist 2010).

How did Husk modify its product to meet the needs of BoP customers?

Sinha calculated that if the gasifier could be fed just over 50kg an hour of husk, it would generate 33kW of power. This would be enough to supply 300-500 houses (Bornstein 2011a) – which would have to be within a 1.5km radius of the generator to

maintain voltage (Bornstein 2011b) – with enough electricity for lighting and mobile phone charging.

How does Husk make its products affordable?

Sinha, an electrical engineer, stripped the gasifier and engine down to their bare essentials. For instance, he replaced an automated, water-driven mechanism for the removal of husk char with a hand crank. This made the machinery cheaper, and used significantly less water. Wires from the plant to the houses were stretched across cheap, easy-to-replace bamboo poles, reducing the cost of distribution and maintenance (Bornstein 2011a).

Each 33kW plant is costs Rs 1.5 million ($33,535) to install (Ghosh 2010). Annual running costs are $22,500[15](Walker 2008) (rice husk is bought at Re. 1 per kilo) and can be met by selling each household 30W of electricity for up to seven hours a day, from dusk to midnight, at the price of Rs.80 ($1.80) per month. This is roughly half of what they would spend on kerosene for lighting. Households can buy additional power in 15W increments at Rs.40 ($0.90) (Rai & Mishra 2010). During the day – when households do not need electricity for lighting – power is used for irrigation (Indian Government News 2010).

How does Husk make its products accessible to remote populations?

As of January 2011, Husk was operating 65 units and serving 30,000 households. It was adding two or three units every week (Bornstein 2011a). India's Ministry of New and Renewable Energy has started supporting Husk's expansion; and plans to take up

[15] When the business first started, millers hoarded the rice husk in order to drive up prices. Husk responded by setting up a free milling service that farmers could bring their grain to. Faced with the prospect of going out of business, mill owners chose to negotiate six- to eight-year contracts with Husk at fair prices (Boyle 2010).

the model on a 'Mission Mode'. It claimed in late 2010 that – in addition to households - 5,000-10,000 industries would benefit in 2-3 years, and calculated that power from Husk's plants would avoid the consumption of 200-250 million litres of diesel annually (Indian Government News 2010).

Husk is happy for its model to be replicated (Rai & Mishra 2010). It has set up the non-profit Husk Power University (HPU), which is run independently of Husk Power Systems. HPU will train power plant owner-operators, as well as skilled technicians, in order to ensure not only the sustainability, but also the rapid diffusion, of its technology and business model (Chaudhary 2011).

How does Husk make customers aware of its products?

Sinha, Pandey and Ransler speak to village elders to ensure that they have buy-in before setting up a project. Three or four individuals, usually locals, operate the plant (Ghosh 2010). Such personnel often come from the poorest families; have only basic education and low prospects of finding other employment (Bornstein 2011a).

How does Husk ensure that its activities are economically sustainable?

Each plant turns cash flow positive in a few months (The Economist 2010), and profitable within three years (Cannon 2008), assuming a load factor of 40% (Ghosh 2010). As the economics improve at higher load factors, big customers are offered discounts (Business Today 2010). Husk charges Rs.100 ($2.24) as a connection fee and employs staff to collect the monthly charge in advance (Pande 2010). Collectors also distribute products such as soap, biscuits and oil to customers. Char from the rice husk is sometimes used to make incense sticks, providing income to 500 women. The company collaborates with a maker of efficient light bulbs, and supplies these to customers (Bornstein 2011a).

Auditors ensure that customers do not use more power than they have paid for. Meters are expensive; so Husk installs a cheap circuit breaker ahead of a branch line serving several customers. The device is set to trip and interrupt supply if the load exceeds the total that all customers are contracted to receive, or if the lines are tampered with to 'steal' electricity from them. As such, customers have an incentive to make sure their neighbours do not use more than they have paid for (Cannon 2008). While and distribution losses in India's electricity grid are about 30% - a large fraction of which is due to theft – Husk has managed to keep losses at 5% (Bornstein 2011a).

Husk's profit margins from selling power are 30%, with an additional 20% coming from ancillary activities. As it scales up, Husk recognizes that it will become harder for it to prevent theft. As such, the company has developed a low-cost prepayment smart-card reader to install in each customer's house. While such a device normally costs over $50, Husk's version will cost $7 or less (Bornstein 2011a).

Innovation and multi-level collaboration across all organizations

Who are the founders and what are their antecedents?

Of the 47 organizations studied, 35 were independent (i.e., not part of a larger organization), and some biographical information about the founders was available for 33 of these. Of the 33, 22 founders were either foreign to the country in which the organization primarily operated, or had spent some time abroad. Of the 22, the work of 12 had its origins in their activities as students.

The phenomenon is particularly striking in India. Table 3 indicates that of the 18 independent firms that are active in India, ten were founded by entrepreneurs who had studied abroad, mostly in the United States. With one exception the work that lay at the root of the business had been done when the founders were students. One potential

explanation for this is selection bias: ventures founded by students and alumni of prestigious universities are more likely to receive publicity and be identified for study.

Company	Founders	Universities	First funds
Husk Power Systems	Gyanesh Pandey Manoj Sinha Chip Ransler	Rensselaer Polytechnic University of Massachusetts University of Virginia	$50,000 in the Social Innovation Competition at the University of Texas; $100,000 in other University prizes.
Green Light Planet	Patrick Walsh Mayank Sekhsaria Anish Thakkar	University of Illinois, Urbana Champaign	$550,000 from Prabha Sinha of ZS Associates
Thermofluidics	Tom Smith	University of Cambridge	Carbon Trust, Department of Trade and Industry, UK
Orb Energy	Damian Miller	University of Cambridge	Zouk Ventures Renewable Capital, Singh Family
d.Light Design	Sam Goldman Ted Nozun	Stanford University	Up to $50,000 Stanford Social Entrepreneurship Challenge
Duron	John Howard James Burgess	California Institute of Technology	$1 million from angel investors in US (IDEASLab, Quercus Trust, Solgenix)
Intelizon	Kushant Uppal	University of Southern California	Ventureast, Emergic Venture Capital
SELCO	Harish Hande	University of Massachusetts	Own funds and credit, with a $40,000 Rockefeller grant as guarantee.
Cosmos Ignite	Amith Chugh Matthew Scott	Stanford University	Vinod Khosla Ventures
Promethean Power	Sorin Grama Sam White	Massachusetts Institute of Technology	$10,000 as runners-up in MIT's 100K Competition

Table 3: Ten of the 18 independent firms operating in India had founders who had studied abroad.

It may also be that universities provide particularly fertile ground for the germination of social enterprises. Drucker (2006) observed that many American universities are themselves remarkably successful examples of social entrepreneurship. Competitions held at universities – and funded by the start-up ecosystems surrounding them - have become a significant source of seed capital for social ventures. Etzkowitz (2003) has argued that academic research is an entrepreneurial activity, and that a research university "shares homologous qualities with a start-up firm."

Product	Affordability	Accessibility	Awareness	Sustainability
Enable the use of multiple energy sources	Reduce upfront cost: through product modularity and CDM	Create network of local entrepreneur-franchisees	Engage, and demonstrate product to, communities and customers	Teach locals to manage technical & commercial aspects of enterprise
Ruggedize	Enable access to finance though MFI or other loans or by channelling subsidies (whether loans make products affordable or merely *accessible* can be debated)		Use celebrities, sport and entertainment	Ensure payments (by peer pressure or pre-payment)
Tailor product to specific tasks	Promote income generation	Piggyback on existing networks (MFIs, post office, NGOs)	Engage consultants	Facilitate replication of the model

Table 4: Common types of marketing innovation

How do organizations modify their products to meet the needs of BoP customers?

Most organizations (35/47) modified products to meet the needs of the customers more precisely. Products are frequently modified so they can be powered by multiple energy sources (Table 4). Cosmos Ignite's MightyLight can be charged by a solar panel or a lead acid battery (Kumar 2008). CDM standards (UNFCC 2010) require that products prevent insect ingress, a particular concern in developing countries (Bahra 2009). SELCO, an Indian marketer of solar lanterns and home systems, has designed lamps specially modified for flower pickers, silk farmers[16] and makers of cricket bats (Wall Street Journal 2009). Solarear of Brazil recognized that even when hearing aids were donated to the poor, they were quickly discarded because the batteries cost $1 per week, more than many families could afford. It therefore developed hearing aids that were significantly cheaper and came with a solar charger (Marketwire 2009b). Nuru Lights has designed a bicycle-cranked charger, which can charge five two-LED lights in 20 minutes (Nicodemus 2010). This is a 300:1 charge-to-output ratio, compared to 1:1

[16] Flowers must be picked between 2am and 4am for them to reach the markets punctually. Pickers often hold kerosene lamps in one hand and pick flowers with the other. SELCO designed headlamps; so pickers could use both hands. Silk worms are sensitive to bright light and must be fed in the dark. Farmers feed them by candlelight or kerosene lamps. However, a drop of spilled kerosene could destroy a basket full of worms (Bhattacharya 2008).

for photovoltaic charging. Promethean power uses a thermal battery to ensure that it can cool milk rapidly when it is delivered to its refrigeration facilities every morning. This keeps the bacterial count in milk low, preventing spoilage and allowing small dairy farmers to access exacting but distant customers (Promethean Power Systems 2011).

How do organizations make their products affordable?

Over half the organizations (24/47) have responded to the limited purchasing power of their customers by making their products modular. For instance, Zara Energy, which sells solar home systems in Tanzania, calculates that a charge controller - which prevents damaging deep discharge of the battery - adds 17% to the cost. It therefore sells systems without this component, but is careful to educate customers on preventing the over-discharging of the battery (The Ashden Awards 2007a).

A number of companies emphasize the use of locally available materials. Saran Renewable Energy burns *dhaincha*, a weed that grows on waterlogged land that is unfit for other forms of cultivation, in a biomass gasifier to produce power. The firm has created producers as well as consumers. Farmers, who are given *dhaincha* seeds for free, earn an incremental Rs.7,500-10,000 ($167-$223) per hectare per year from selling the crop to Saran (Prasad 2009). International Development Enterprises – India (IDEI), which makes treadle pumps, has replaced metallic filters that it places at the mouth of tube wells with bamboo ones. The new filters cost 75% less, and do not rust (The Ashden Awards 2009a).

How do organizations make their products accessible to remote populations?

A common approach is to use networks already established by microfinance institutions, NGOs and charities. Godrej, India, is collaborating with the Indian Postal

Service,[17] and the 8,600 mailmen it employs in the state of Maharashtra, to distribute its chotuKool[18] refrigerator (Nikkei Report 2010). In addition to displaying the product at the post office, postmen will educate customers about it, collect orders and payments, and deliver the orders. The service will cost Godrej Rs.275 ($6), seven per cent of the product's Rs.3,790 ($84) retail price (Dahitule 2011). Nuru Lights co-opts entrepreneurs who sell kerosene to run charging stations for its lights, as they are best placed to reach the populations that need Nuru's products. Such entrepreneurs can earn up to $13.50 daily from charging and renting out Nuru's one-LED lights. Their capital costs are covered by a loan, which they pay off in six months (Nicodemus 2010).

How do organizations make customers aware of their products?

A number of firms adopt standard methods of publicity; e.g., the distribution of leaflets and door-to-door selling. Some organizations are partnering with specialist marketing firms. d.Light Design, which produces LED-based solar lanterns, hired Vizeum (Adsert Web Solutions 2010) as a 'strategic communications consultant'. EGG Energy partners with Kickstart (EGG Energy 2011b) – a non-profit organization that specialises in marketing for start-ups and social enterprises – for marketing, distribution and sales. Customers are often illiterate; so, IDEI produces full-length Bollywood-style films to promote its products (The Ashden Awards 2009a). Mohammed Bah Abba, a schoolteacher from Nigeria, who makes and distributes a passive 'refrigerator' consisting of two earthen pots, one inside the other, uses a video featuring local actors to demonstrate the benefits of his product (Rolex Awards for Enterprise

[17] Of the 155,000 post offices in India, 139,000 (or 90%) are in rural areas (Government of India Department of Posts 2011).

[18] This is a small, low-cost appliance that can operate on battery power, and be charged from the electric mains or by means of a solar panel.

2005).[19] Zara Solar uses in-store demonstrations to help customers identify and avoid shoddy, cut-price systems that imitate well-known brands, but fail quickly. According to Mohamedrafik Parpia, Zara's founder, the counterfeits create a bad reputation for solar power, and impede its rapid dissemination (The Ashden Awards 2007a). The Energy and Resources Institute (TERI) organized large, televised fundraisers as part of its Light Up a Billion Lives programme. During such fundraisers, celebrities from the Indian film industry were encouraged to publicly 'adopt' villages, and sponsor the establishment of a recharging station equipped with a few dozen lanterns and run by a local entrepreneur (The Press Trust of India Limited 2008; United News of India 2009).

How do organizations make their activities economically sustainable?

A key challenge for organizations is ensuring that those who use electricity pay for it. Sunlabob sets up photovoltaic systems and rents solar lanterns in rural Laos. Instead of individuals, the firm leases the equipment to elected 'Village Energy Committees' (VEC) that rent it on to individual households. The VEC is in charge of setting prices, collecting rents and performing maintenance. Because the VEC is of the community, it can be flexible about managing irregular payments. Users are eager to ensure that the VEC can meet its obligations to Sunlabob: failure to do so would tarnish the community's image (The Ashden Awards 2007b). Ashok Bharti of New Delhi organizes slum dwellers into committees that volunteer to pay the local distribution company for

[19] Contrast Abba's relative success with MittiCool, an earthen cooler developed by Mansukhlal Prajapati of India. Apart from operating a website, Prajapati does not publicize his product in any way. Abba sells more than 30,000 of his coolers annually, whereas Prajapati has sold only 4,000 units in seven years. After an initial grant of Rs.680,000 ($15,100) from India's National Innovation Foundation, Prajapati has received no further help, whereas Abba has received awards from Rolex and Shell. In the present framework, we would argue that Prajapati has ignored the issue of affordability (Godrej's chotuKool electric cooler costs $84; only slightly more than the $56 Prajapati charges for the passive, earthen Mitticool). Abba initially gave away his pots, which cost $1.60 to make; and now sells them for $2. Furthermore – unlike Abba, who employed potters to expand production and got help from larger organizations – Prajapati has formed no collaborations at any level. In a recent telephone interview with an Indian journalist, Prajapati confessed, "I am not literate…I can't do it all myself."(Worldaware Business Awards 2001; Pande Lavakare 2011)

the electricity they consume. In the past, the slum dwellers bought electricity from middlemen, who stole it from the grid. The connections were unsafe and sometimes caused fires. The distribution company – a joint venture of the local state government and Tata, an Indian conglomerate - now ensures that connections are safe, and gives customers advice on how to avoid fires and shocks. Moreover, as the firm is able to recover its costs – which it had previously failed to do, due to rampant theft – it can now promise a more reliable service (Ashoka Foundation 2005). Some organizations are trying to replicate their models and approaches to addressing the needs of the BoP. In 2008, SELCO started to raise $7.5 million to build a centre that would create 'SELCO-type' organizations, where entrepreneurs could incubate their ideas, while receiving hands-on training at SELCO (Bhattacharya 2008). Providing training on the establishment of social enterprises can also be part of aid packages: in 2009, Liberia agreed to send a team to be trained in solar energy development at India's Barefoot College, an NGO that works on deploying sustainable solutions to social problems (Asian News International 2009; Barefoot College 2011).

Macro	Meso	Micro
Channel to customers, or collect, subsidies and funding from governments and international organizations	Partner with organizations to finance (through loans or subsidies) customer purchases	Engage microentrepreneurs to produce, promote, distribute or maintain products.
Earn credits under the CDM mechanism	Partner with organizations to promote or distribute products	Organize customers to generate income from, or operate product.
Lobby for, identify, and exploit beneficial government regulations or international programmes	Partner with firms or universities to gain access to key technologies	Buy biomass fuel, labour or produce from customers.

Table 5: Common types of collaborations at different levels

How do organizations collaborate with other organizations at the macro level?

The CDM allows emissions-reduction or -removal projects in developing countries to earn credits, which developed countries can buy to meet their emission reduction targets under the Kyoto Protocol (UNFCC 2011). Eleven of the organizations (Table 5)

studied have set up – or intend to set up – projects that will earn them carbon credits. d.Light Design (2006) describes the activities that a seller of solar lanterns must undertake in order to qualify for CDM credits. It must prove that it is offsetting fossil fuel consumption, and quantify displaced it. It must also prove 'additionality'; that the project would not be economically feasible without the credits. It must put in place a method to check – annually, by means of site visits and interviews – that either all, or a statistically meaningful sample, of the lamps sold continue to operate. This requires the organization to keep a detailed record of every sale.[22]IDEI's treadle pumps earn credits under the CDM as they displace diesel-powered pumps. IDEI claims additionality as carbon finance would free it from the constraints of limited donor funding and enable it to expand rapidly (JPMorgan Climate Care 2011; TÜV NORD CERT GmbH 2008).

National governments have progressively cut import duties for equipment used in the provision of decentralised energy services. Import duties on photovoltaic modules in India have fallen from 110% in 1992 to 0% in 2005 (Miller 2010). The Indian Union Budget of 2011 halved import duties on solar lanterns to 5% (Economic Times Bureau 2011). This is in the Government's interest, as well as that of the entrepreneur. d.Light Design (2006) estimates that kerosene subsidies cost the government Rs.34-51 ($0.76-$1.14) per household per month. Governments can be a source of uncertainty and institutional work needs to be done to manage it. IBEKA facilitates the construction of micro-hydro power plants in rural Indonesia. Communities finance projects with loans from aid agencies. These projects would cease to be viable if the state were to extend the grid to whenever they are operating, as it has been promising to do for several years. IBEKA successfully lobbied the Government to pass legislation that would compel the

[22] Toyola (which sells clean-burning stoves) has worked with E+Co (a green investment firm) to develop a mobile phone platform that makes it possible to record sales immediately, using text messages(Murray 2010).

state electricity company to buy power from the projects if grid extension were to occur (Ashoka Foundation 2006; Connell 2010).

How do organizations collaborate with other organizations at the meso level?

The most common purpose of meso collaborations is the provision of finance: 13 of 47 organizations provided buyers with access to microfinance loans. A further 11 arrange some form of financing for their customers. Ikea gives one Sunnan solar lamp away to schoolchildren for each one it sells. Since June 2009, it has donated over 500,000 lamps to Unicef, which is far better able to reach children in need (Liss 2010). While large organizations are a source of technical, financial and managerial expertise, the relationship with smaller enterprises is symbiotic. LUTW and EGG Energy have set up programmes that allow employees of larger companies to volunteers some of their time to projects, and gain exposure to social enterprise. They can also help companies test new products for emerging markets against the real needs of customers (Light Up The World 2009; EGG Energy 2011a). NGOs can make common cause with other NGOs. LUTW is working with the International Gorilla Conservation Project to help the communities surrounding the Virunga Bwindi Gorilla Reserve manufacture LED-based solar lanterns, which would prevent the community from chopping down and burning wood for lighting. It is expected that this will preserve the habitats of the last 700 endangered mountain gorillas that inhabit the national park (Chin 2006).

How do organizations collaborate at the micro level?

The most common form of collaboration is for organizations to work with micro-entrepreneurs to market their products: Zara Solar relies on a network of independent technicians who promote, install and maintain the solar home systems it sells. In turn, Zara directs customers who need assistance to entrepreneurs in their vicinity (The

Ashden Awards 2007a). Many organizations help customers take over the operation of the infrastructure they involve: for example, the micro-hydro power plants that IBEKA installs are all community-run (Ashoka Foundation 2006). Kaito Energie signs contracts with Senegalese farmers to buy future harvests of cash crops at pre-determined prices. Farmers can use these contracts as collateral to get loans, which they may use – individually, or as a community - to purchase Kaito's photovoltaic energy solutions (Thurston 2010). Intensive discussion with users helped Godrej make decisions about the function (users did not need freezers) as well as form (candy-red was a favourite colour) of its chotuKool mini-cooler (Subramanian 2010).

How much do customers pay for products or services?

Company	Location	Price	Effective unit price ($/kWh)
Husk Power Systems	Bihar, India	$1.80 for 30W for 7 hours a day	0.27
TERI's Light Up a Billion Lives	India	$0.07 per night to rent a 3W solar lantern	2.76
Sun King solar lantern	Bihar and Orissa, India	$17 for an LED lantern with a 700mW solar panel	2.71
Saran Renewable Energy	Bihar, India	Rs.8 - 12 per kWh	0.18 - 0.27
Noble Energy	Andhra Pradesh, India	$35 for a 3W CFL-based solar lantern	1.33
Prokaushali Sangsad	Bangladesh	$280 for a 20W solar home system, paid over three years	0.75
Sunlabob monthly rental	Laos	$2.80 monthly to rent a 20W solar home system	0.76
Kutir Jyoti village electrification scheme	Bihar, India	$0.03 per kW, monthly capacity charge of $0.7. Assumed consumption 30W for 7 hours a day.	0.13
Unmetered tariff for supply to rural areas	Bihar, India	$2.00 monthly. Assumed consumption 30W for 7 hours a day.	0.31
Metered tariff in urban areas	Bihar, India	$0.09 per kWh; $3.30 monthly capacity charge. Assumed average urban household consumption in Bihar	0.08

Table 6: Effective unit cost of electricity (student's calculations)

Table 6 demonstrates that the unit cost of electricity associated with solar home systems and solar lanterns exceeds the cost of grid electricity; in extreme cases by a factor of 30 or more. Micro-grids run by biomass-fired plants compete with state-run

rural electrification systems in terms of cost. Modi (2005) notes that the actual cost of supply through state-run schemes might be higher than officially stated, due to the unofficial charges associated with getting a connection, and ensuring that supply is maintained. Moreover, state power distribution companies run chronic deficits (Bihar Electricity Regulatory Commission 2010), whereas the non-state enterprises shown above are commercially sustainable. Importantly, even the most expensive of these schemes – the solar lanterns that TERI rents out for Rs.3 per night – is cheaper than kerosene lighting. d.Light estimates that a household in Bihar, India, uses seven litres of kerosene monthly, mostly for lighting. Of this, up to three litres are bought at a subsidised price of Rs.11 per litre. The rest must be bought at an unsubsidised price of Rs.28 per litre. As such, a family would typically spend Rs.145 per month or Rs.4.70, daily, on lighting (d.Light Design 2006).

DISCUSSION

Missing fortune

Little support is found for the claim that there is a 'fortune' at the bottom of the pyramid. In order to qualify for credits under the CDM, firms must prove that projects would be commercially unviable without such support. In its project design document, d.Light Design (2006) quotes one of its investors

> *Without the contribution of carbon credits, d.Light won't be able to substantially penetrate the very large market opportunity for providing lighting to families earning less than $2 per day because the cost of making and delivering lighting to those markets is just too high otherwise. Without access to that market, we could not project a return that would meet our threshold.*

It is useful to note that investors in d.Light include social investment funds that are "comfortable with…returns of 6-8%", well below what venture capitalists expect (Karunakaran 2009). Though it is possible to meet the needs of the poor in innovative and commercially sustainable ways, the returns associated with such activities are low.

It is also clear that the challenges in accessing these populations are formidable. d.Light Design's CDM project sought carbon credits to distribute lanterns to 1 million households over the course of a year in Bihar and Uttar Pradesh in India. The parameters of the CDM would have allowed it to sell up to 10 million lights (d.Light Design 2006). Census (Government of India 2001) and survey (Government Of India 2007) data indicate that over 26 million households in both states use kerosene for lighting; so d.Light hoped to penetrate only a small fraction of the market. Greenlight, addressing a market of 15.5 million households that use kerosene lighting in Bihar and Orissa, and equipped with an impressive distribution system, has sold just over 100,000 lights in four years (2007-11) of operation. These data support the view of many scholars (e.g., Warnholz 2007) that estimates of the enormous size and potential of the BoP market need to be treated cautiously. Even innovative and determined entrepreneurs have been able to reach only a fraction of these putative consumers.

The poor pay more

Prahalad and Hammond (2002) demonstrate the existence of a 'poverty premium' – whereby certain goods and services cost the poor up to 50 times more than they do the rich – in the markets for credit, water, telecommunications, medication and food. Table 6 suggests that a poverty premium also exists in the market for energy, and that it is of a similar magnitude (the poor pay up to 40 times more). The literature (e.g., Mendoza 2011) distinguishes between two types of causes for such a premium: shop effects and size effects.

It is apparent from the discussion in the previous section that the high prices that the poor pay are not due to shop effects, or 'sharp' practices (Caplovitz 1965) and excessive profit taking by sellers. Chung and Myers (1999) concluded that food was costlier for the poor because they did not have access to large, efficient supermarkets and made their purchases from neighbourhood stores. While based on only six data points and a considerable simplification, Figure 3 lends credence to the size effect as an explanation for the 'poverty premium' in electricity. The high unit cost associated with the enterprises studied is arguably a reflection of the diseconomies of scale associated with delivering minuscule quantities of power to rural households.

	Size of generating asset (W)	Unit cost ($/kWh)
Sun-King solar lantern PV panel	0.7	2.71
NEST solar lantern PV panel	3	1.33
Solar home system PV panel	20	0.75
Husk power plant	33000	0.27
Saran power plant	100000	0.18
Grid (assume a 100MW plant)	100000000	0.08

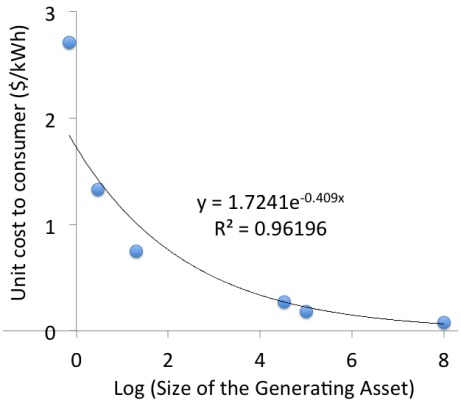

Figure 3: Unit costs fall rapidly as size increases

The role of social capital and multinational corporations (MNCs)

Ansari et al. (Forthcoming) argue that "true BoP empowerment" must involve preserving 'bonding' social capital – the "intensive stock of cohesion within a community" – as well as creating 'bridging' social capital, composed of the "more diffuse and extensive intergroup relationships" needed for empowerment. They posit that MNCs can help build 'bridging' capital. A self-assessment (West & Woodcraft 2010) of the work of The Shell Foundation – which supports many of the organizations studied here directly (e.g., Husk) and indirectly (e.g., Zara Solar through E+Co) - offers an insight into how an MNC might go about doing this. The Foundation reports that its "shared

branding" with Shell has enabled the social enterprises it supports to succeed by "leveraging support from others and opening doors."

Prahalad and Hart (2002) assert that, "MNCs with their unique global knowledge base, have an advantage that is not easily accessible to local entrepreneurs." Of the enterprises studied here, only four are linked to MNCs. Most organizations – including MNCs such as Schneider Electric or Ikea - have partnered with, and adopted the strategies of, NGOs and microfinance institutions (e.g., the formation of local groups to build and maintain infrastructure; or collect dues). The Shell Foundation reports that while it gives the ventures it supports *pro bono* access to the "skills, tools, market knowledge and networks" within Shell, fewer than 17% of the ventures it has funded in the last decade have drawn on such support (West & Woodcraft 2010). This might indicate that local entrepreneurs have knowledge - and therefore an advantage - that is not easily accessible to MNCs.

Further research

Energy and income generation

It has been suggested that having access to bright, clean light after sundown makes it possible to for people to work longer at home, or keep businesses open longer (Bornstein 2011a; The Ashden Awards 2007b; UNDP Small Grants Programme 2011; Simm 2004). Obeng and Evers (2010) showed that small grocers in rural Ghana earned an additional $5-12 daily after switching from kerosene to photovoltaic lighting, though this study was based on a small sample (n=23), and did not extend to other types of enterprises. Adkins et al. (2010) describe the difficulties associated with establishing and quantifying the effects on income of photovoltaic lighting. For example, the incomes of the poor are erratic and difficult to measure; and household practices may change

only slowly. Furthermore, a survey found that only 2% of households thought lighting was important for income generation; encouragingly, 18% thought it was important for children's study and reading.

Arguably, the total additional income generated by shifting away from kerosene cannot exceed the savings associated with the shift. For instance, if one greengrocer could stay open longer than others, she would earn more but at the expense of other greengrocers. If all of them stayed open longer, none of them would sell more; unless their customers had more to spend: perhaps by reducing or eliminating their own consumption of kerosene. A remote, off-grid village is – almost by definition – self-contained: traders can only sell to other villagers. Even if they could sell outside the village, they would – as Bateman and Chang (2009) point out – suffer from diseconomies of scale and be uncompetitive. To ensure scale, some suppliers (e.g. DESI Power) work with local organizations to initiate activities that can use power productively. Each DESI plant is of 100kW capacity, and plants are built in clusters with a combined capacity of up to 1MW. Significantly, this model generates power cheaply enough for it to be competitive with the commercial tariffs for grid electricity (Table 6; DESI Power 2011; DESI Power 2007). Similarly, Promethean power's cooling service that keeps milk fresh for longer and enables dairy farmers to access a wider market.

There is little doubt that off-grid energy solutions improve people's quality of life. Apart from reducing the risk of fire, and of respiratory illness from inhaling kerosene fumes and soot, access to good lighting is reported to have reduced the incidence of snakebites and burglaries (Bornstein 2011a). That children can study longer without inhaling noxious fumes will surely bolster literacy and education levels. As more entertainment, information, educational and financial services are delivered over

mobile phones, the ability to charge them conveniently in off-grid areas will become increasingly valuable.

The effects of off-grid electrification are likely to be complex and unfold over a prolonged period of time. A study of the type conducted by Collins et al. (2009), which combined quantitative methods and ethnography to study the financial lives of the poor, could yield useful insights. Indeed, one key insight from the *Portfolios of the Poor* study was that access to finance could make significant, non-income contributions to the wellbeing of the poor. The same may be true of off-grid energy solutions.

CONCLUSION

Academic contribution

Siggelkow (2007) observes that case studies are useful for "motivation, inspiration and illustration." The cases discussed above vividly illustrate the type of marketing innovation, multi-level institutional work and "multiple partnerships" that scholars have argued that firms seeking to serve the BoP must do.

Siggelkow (2007) also suggests that cases can sharpen, extend or refute existing theory. The data suggest that, for energy, the 'fortune' at the bottom of the pyramid is absent. They also point to the existence of a 'poverty premium' in the energy market that might be of similar magnitude as the one in credit, telecommunications, water, medication and food. Moreover, the data suggest that this premium exists because of 'size' rather than 'shop' effects.

The role of MNCs at the BoP is contentious. One view (Prahalad & Hammond 2002) holds that whether the world faces a bright or bleak future will be determined "primarily on one factor: the willingness of multinationals to enter and invest in the

world's poorest markets." Another (Karnani 2006) accuses multinationals of inflicting a "misfortune at the bottom of the pyramid." The data reveal a limited, indirect role for MNCs in the provision of energy services to the poor, and suggest that a more nuanced typology – as proposed, for example, by Munir et al. (2010) – is required to better understand how MNCs and other actors can engage with the BoP.

The study could potentially motivate research on whether the developing-world poor might 'leapfrog' from primitive fuels to modern renewables. The progress of nations up the widely spaced rungs of the 'energy ladder' – from biomass to modern renewable energy - is well understood (Burke 2010). Given concerns about the environmental impact of growing populations and increasing prosperity, policymakers and businesses must understand what happens at and in between the lowest rungs of the ladder, and develop alternatives to the traditional progression from biomass to fossil fuels.

Contribution to practice

The data suggest that the state's existing efforts to provide energy to the poor are ineffective and inefficient. The alternatives described above are an improvement, but still expensive. As such, this research bolsters the argument that governments should not absolve themselves of the responsibility to provide basic energy services to the poor. Policymakers can adopt models in which the state funds, but the private sector delivers, universal access to lifeline services (Goldemberg et al. 2004; The Independent Evaulation Group 2008; Modi 2004).

Businesses must give thought not only to how their solutions compare to the next-worst alternative, but to what the development needs of their customers are. This is not

a philanthropic pursuit. As Raymond Gilmartin, then-CEO of Merck Pharmaceuticals (Gilmartin 2003, in Rangan et al. 2006) observed

> *Corporations must view these issues from the perspective of a long-term investor. The ability to maintain and extend markets from the developed world to emerging markets . . . will be impossible unless we create the foundation of political and economic stability that can only come by addressing the economic and social needs of the world's poorest nations.*

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