

# Upscaling of business model experiments in off-grid PV solar energy in India

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## Abstract

Rapidly developing countries like India face numerous challenges related to social and environmental sustainability which are associated with their fast economic growth and rising energy demand, climate change, and widening disparities between rich and poor. Recently, a range of creative innovations have been emerging that attempt to address these complex sustainability-related problems, in part facilitated by increasing globalization of technology and knowledge. These initiatives can be conceptualized as early ‘sustainability experiments’ in a budding sustainability transition process. This paper reports on some promising experiments in the area of off-grid PV solar energy, specifically honing in on the innovative business models that are evolving, and the key role played by social entrepreneurs as the shapers of these models and drivers of success. The experiments are found to be quite successful at a local / regional level, but that they may not (yet) be in a position to bring about change at the required massive scale. The paper provides key insights into the challenges of, and barriers to upscaling, using information from interviews conducted with social entrepreneurs, supplemented by secondary sources.

**Keywords:** India, globalization, sustainability experiments, solar PV, upscaling, business models

## 1. Introduction

Billions of people live without access to modern energy services. About 1.5 billion people still don't have access to electricity, and around 2.5 billion people rely on traditional biomass as their primary source of energy. It is widely accepted that the lack of access to affordable, reliable energy services is a fundamental hindrance to human, social, and economic development and is thus a major impediment to achieving the Millennium Development Goals. (Srivastava et al, 2006; Urban et al, 2009).

India's recent acceleration in economic growth is expected to continue to drive a fast increase in its energy needs during the coming decade. In the past, the electricity sector in India was mainly confined to centralized electricity provision based on fossil fuels and especially coal. However this fossil-based system of centralized energy planning and supply has run into several problems, including difficulties with balancing demand and supply; high transmission and distribution losses; frequent supply disruptions; practical difficulties and lack of financial viability of extending the grid to remote and inaccessible areas; poor financial health of the state electricity boards; and poor environmental performance especially in terms of climate change-inducing effects. Moreover, a huge portion of the Indian population still depends on state-distributed and subsidized kerosene, animal and human energy, candles, and traditional biomass such as wood, harvest residues and cow dung. Accidents due to spillage of kerosene from wick lamps, and health hazards from indoor air pollution and accidental drinking of kerosene have been reported. Furthermore, kerosene usage in rural households in India is estimated to emit some 6.5 million tonnes of carbon dioxide annually. Moreover, part of the kerosene supplies intended for distribution through the subsidized public distribution system in India is illegally diverted to the black market for mixing with diesel stocks. All these problems have resulted in an articulated need to diversify from central grid-based electrification and fossil fuels such as kerosene (Bhattacharya, 2006; Bhattacharya, 2010; Deshmukh et al, 2010; Nouni et al, 2009; Rehman et al, 2010; White et al , 2009).

In principle there exist a number of alternative, clean and renewable options for supplying reliable energy that are characterized by decentralized supply, such as solar-based technologies, bio-oil and biogas. Off-grid renewable energy technologies can be particularly suitable for remote rural areas given the prohibitive costs of expanding the central grid into these areas, especially since their costs are gradually declining and their efficiency and reliability are improving over time. Off-grid renewable energy is relevant for lighting, refrigeration, telecommunications, applications in agro-processing, water pumping and other productive uses, with lighting being the most common application.

Solar home systems (SHS) is one of the technologies that are gaining increasing attention from entrepreneurs and social enterprises in India for electrification of subsistence households in off-grid areas. SHS also make sense as a reliable backup system for grid-connected households. Typical SHS use PV technology to provide energy for lighting and operating a television or radio for limited time periods. The modularity of SHS systems has been noted as their main advantage over the grid, enabling immediate full utilization of available capacity as well as possibilities for subsequent expansion (Wamukonya, 2007). Although unsubsidized SHS using PV technology is still too expensive to reach millions of people, other solar technologies are already cost-competitive, for instance lanterns that use light emitting diodes (LEDs) powered by batteries

which in turn can be charged by small solar panels. In general, solar energy is expected to hold many benefits for the poor, including improved security, higher literacy, and increased opportunities for income generating activities in the home. Hence, solar lanterns have already proven to be attractive for many rural households, both in India and elsewhere in the developing world.

A major question remains, however, how current initiatives with solar energy in India might upscale to reach millions and millions of poor people. There are several constraints on their widespread adoption, such as problematic access, reliability and maintenance, high product subsidies that limit the total number of potential beneficiaries, and lack of attention to user needs, learning, monitoring and evaluation in projects and programmes (Rehman et al, 2010). Not all of these issues have received adequate attention so far, even though upscaling issues of renewable energy technologies have already been addressed in several studies, such as Balachandra et al (2010); Brown et al (2009); Ghosh et al (2006) and Reddy et al (2004). However, these studies have tended to concentrate on techno-economic viability issues only. Prominent evolutionary innovation theories such as ‘Systems of Innovation’ approaches suggest that embedding in the wider social, institutional and cultural context is also a prerequisite to successful innovation (Geels, 2002). Social acceptance of any technology, for example, is critical because technologies must be deeply embedded in user contexts. Conversely, technological innovations shape the behaviour of actors and the institutional setting. Thus, the development and implementation of new technologies can be understood as a highly complex and multi-faceted co-evolutionary process: technological change and social change interact and mutually influence each other.

The aim of this paper is to analyse the efforts of five Indian organisations to upscale their businesses and to identify the key challenges and barriers that impede this co-evolutionary process. In section 2, we discuss elements in the existing literature on system innovations, sustainability experiments, grassroots innovation, and social entrepreneurship, which we identify as useful building blocks for an analytical framework on upscaling of sustainable innovations in an emerging-economy setting. Section 3 is devoted to data collection methods. Section 4 contains the empirical analysis. Section 5 draws conclusions.

## **2. Theoretical building blocks**

### **2.1 System innovation, experiments and entrepreneurs**

‘Systems of Innovation’ and ‘Transitions to Sustainability’ approaches have received considerable attention in the last decade (Geels, 2002; Smith et al, 2010). The Strategic Niche Management (SNM) framework is part of that evolutionary innovation literature (Kemp et al, 1998; Raven, 2005). In SNM, innovations with promising sustainability characteristics are conceptualised as emerging and developing in ‘niches’, i.e. partially protected spaces where actors experiment and incubate promising concepts or prototypes (Romijn et al, 2010). According to Berkhout et al (2010) ‘sustainability experiments’ can be defined as planned initiatives that embody a highly novel socio-technical configuration which is likely to lead to substantial sustainability gains. Experiments represent small initiatives in which the earliest stages of socio-technical learning and co-evolution take place. Experiments typically bring together new networks of actors with knowledge, capabilities and resources, who cooperate in a process of learning. Experiments can encompass a wide range of projects, pilot plants and demonstration facilities initiated by firms,

public research organizations and universities, community and grassroots organizations, and so on. Sustainability experiments are seen as playing a key role in the development of innovations that have the capacity to modify or even replace dominant 'socio-technical regimes'. Regimes constitute the extant social, institutional and technological fabric of economic activity. Experiments may involve novel technological, actor, and market configurations, and are therefore likely to face considerable initial uncertainties, problems, misalignments and high costs compared with conventional, incumbent regimes to which they offer more sustainable alternatives.

Previous research on niche development of sustainable energy systems (primarily set in high-income countries) has concentrated on technological experiments and their role in regime change. Few studies have focused on entrepreneurial firms and their importance as prime movers (Teppo, 2006). Entrepreneurs do have an important role in transition processes since they are agents of creative destruction, with potential to commercialize sustainable innovations and consequently bring the necessary institutional change that favors such innovations (Keskin et al, 2009; Markard et al, 2008; Meijer et al, 2008). While previous SNM literature has acknowledged the role of entrepreneurs (e.g. Kemp et al, 1998), to our knowledge entrepreneurial business models as experiments in sustainability transitions have not been the focus of attention.

Within the entrepreneurship field as a whole, 'social entrepreneurship' deserves special attention here. Social entrepreneurship encompasses the activities and processes undertaken to discover, define and exploit opportunities in order to enhance social wealth by creating new ventures or managing existing organizations in an innovative manner. Social wealth may be defined broadly to include economic, societal, health and environmental aspects of human welfare. Essentially, then, one can conceive of social entrepreneurs as key players in sustainability transitions (Witkamp et al, 2010). According to Witkamp et al (2010) social entrepreneurship is pitted against two extant regimes, i.e., the business regime where profit maximization and increasing shareholder value is the major goal; and the civil-society regime where societal objectives take a major role and profit maximization takes a back seat. Social entrepreneurship therefore continuously faces tensions between private profit making and fulfilling societal objectives.

Most social entrepreneurs have an ability to create new connections among people and organizations for new paths, or business models, in which these tensions are managed and societal value is created. In so doing, social entrepreneurs also create and develop the institutions and infrastructures needed for development (Dees, 2009; Mair et al, 2009; Santos, 2008; Zahra et al, 2008, 2009). According to Mair et al (2009), Robbin (1984), and Sud et al (2008), entrepreneurs can leverage resources to create new institutions and norms or transform existing ones. Maguire et al (2004) speak about entrepreneurs' leading efforts to identify political opportunities, frame issues, and induce collective efforts to infuse new beliefs and norms into social structures. In other words, social entrepreneurs can foster development in many different ways, by getting new legislation or regulations passed; getting old legislation or regulations enforced; shifting social norms, behaviors and attitudes among fellow citizens, corporations, government personnel; changing the way markets operate; and finding ways to prevent the problems they have been solving or reducing the needs they have been serving.

A somewhat related area concerns the role of grassroots organizations in innovation. Bergman et al (2010), Monaghan (2009), Seyfang et al (2007, 2010) argue that grassroots innovations that are

developed in networks of activists and non-governmental organizations have potential to generate novel bottom-up solutions for sustainable development by responding to local situations, interests and values of communities. In contrast to mainstream business, grassroots initiatives operate in civil-society arenas and involve committed activists experimenting with social innovations as well as greener technologies who have experience and knowledge about what works in their localities and what matters to local people.

In sum, it is recognized in various strands of business strategy and innovation literature that entrepreneurial individuals and collectivities working with innovative business models have the potential to contribute to systems-changing solutions, by deploying hybrid strategies that balance economic viability with broad social impact. We thus bring these literatures to bear on our analysis of upscaling of renewable energy experiments for low-income people in an emerging economies context.

## **2.2 Upscaling in social entrepreneurship and development studies**

Several social entrepreneurship studies have discussed the phenomenon of upscaling (Bloom et al, 2008; Brown et al ,2004 ; Santos et al, 2009; Dees et al, 2002, 2004, 2009; Klein, 2008; and Smith et al 2009). Smith et al (2009) define upscaling as increasing the impact produced by a social-purpose organization to better match the magnitude of the social need or problem it seeks to address. They distinguish upscaling and deep scaling. Upscaling up refers to the growth in social value by expanding a current program to other geographic locations. This involves effort and costs in terms of building infrastructure, organizing and developing an ecosystem, obtaining licenses, and educating customers in a new region. Deep scaling refers to focusing energies and resources on achieving greater impact in the same location where the enterprise was started by engaging in activities like, improving the quality of services, achieving greater penetration of the target population, finding new ways to serve people, extending services to new people and developing innovative financial management approaches.

Karmachandani et al (2009) and Klein (2008) have a somewhat different view. They refer to upscaling as the capacity of the enterprise to expand quickly, effectively and efficiently. Upscaling can also mean expanding the capacity of the existing business, in the sense of developing resources, building a knowledge base, employing people, developing management systems and even developing a culture. According to them, upscaling thus includes serving more people with the same product within the same region as well as extending into new markets i.e. different geographies. In a given situation the meaning of upscaling to a large extent depends on the motivation of the entrepreneur. Some enterprises may focus on developing a specific region in terms of new products and services before scaling geographically, while others may choose to scale into new geographies before venturing into new products and services.

According to Dees et al (2002) and Dees et al (2004), choosing the right path towards broader social impact is a complex matter since it involves judgment, experimentation, and continuous learning. They develop an approach towards upscaling based on following five R's, i.e., Readiness, Resources, Receptivity, Risk, and Return. Bloom et al (2009) suggest the SCALERS model, i.e., Staffing, Communicating, Alliance-building, Lobbying Earnings-generation, Replicating, and Stimulating market forces. Santos et al (2009) suggest that successful upscaling

can be achieved by disseminating information through the use of best-practice blueprints or intermediaries such as multilateral organizations and consulting firms.

Since our study is set in an emerging economy with deep-rooted social inequality and poverty in addition to environmental problems, it is pertinent to also examine literature about development projects, programmes and NGOs for possibly useful insights about upscaling. Gillespie (2000), Myers (1984), Uvin et al (1994, 2000) and Uvin (1995), Vermeulen et al (2009) have developed taxonomies of different types of upscaling and paths to achieve it. Uvin (1995) defines ‘quantitative scaling’ as reaching increasing numbers of people; ‘functional scaling’ as adding unrelated new activities to existing programmes; ‘political scaling’ as an organization’s members participating in or influencing political activities; and ‘organizational scaling’ as increasing the degree of self-financing through subcontracting. Myers (1984) discusses ‘institutional scaling’, i.e., involvement in processes and mechanisms for promoting wide stakeholder participation; ‘geographical scaling’, i.e., expanding project coverage to other communities/municipalities; ‘technological scaling’ i.e. broadening a project’s technological scope, or implementing appropriate technologies to increase productivity; and ‘economic scaling’, i.e., bringing down unit costs. Other issues that have been discussed include timing and duration of upscaling. Writers about development have obviously found it difficult to come to grips with the phenomenon. According to Uvin et al (1994), “All in all, the literature on upscaling is reminiscent of the Loch Ness monster. It has been sighted enough to make even the skeptical give it a measure of respectability; [but] ... its description is as varied as the people who have written about it”.

### **2.3 Collective upscaling**

One big complication is that an individual social entrepreneur usually does not have all the competences, resources, and legitimacy that are necessary to create a full infrastructure for a new business. Santos et al (2009) point out that while social entrepreneurs are often successful in establishing effective business models to address problems in their local areas of operation, they face enormous challenges in scaling their operations and achieving greater social returns for constituents such as funding agencies. They need a supportive ecosystem and infrastructure such as targeted financial services, cultural encouragement and accommodating legal and regulatory mechanisms. These conditions have to be created in concert by a large number of actors, since complex environmental problems are rooted in behaviors, norms, institutions, social structures, and policies. Individual entrepreneurs usually cannot bring about radical institutional change on their own without broad societal support. Rarely do individual powerful actors possess sufficient resources to impose institutional change (Garud et al, 2002; Leca et al, 2008; Hmimda et al, 2009; and Weijn et al, 2007).

Therefore, governments, multi-lateral aid agencies, philanthropic organizations, social investors, financial service organizations, universities, consultants, corporations, bankers, and the media, all play an important role in creating conditions that help social entrepreneurs to scale their impact in a timely, significant and cost-effective way.<sup>1</sup> Entrepreneurs may also need to ‘run in packs’, which means coordinating their actions to simultaneously pursue their own interests and their collective interests, simultaneously cooperating and competing with others as they develop and commercialize their new ventures.

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<sup>1</sup>[http://whatmatters.mckinseydigital.com/social\\_entrepreneurs/creating-large-scale-change-not-can-but-how-](http://whatmatters.mckinseydigital.com/social_entrepreneurs/creating-large-scale-change-not-can-but-how-)

As the numbers of entrepreneurs grow, a complex network of cooperative and competitive relationships begins to generate critical mass and produce effective collective action. This infrastructure includes institutional arrangements to legitimate, regulate, and standardize a new technology; public resource endowments of basic scientific knowledge, financing mechanisms, and a pool of competent labor; the creation and development of markets, consumer education and demand, proprietary R&D, and the development of manufacturing, production, and distribution functions by private entrepreneurial firms to commercialize an innovation for profit. This infrastructure may be developed by superstructure organizations often specializing in coordinating flows of information or coordinating the activities of substructure organizations (Van de Ven, 1993, 2005; Van de Ven et al, 2007).

Concerted action from different social enterprises and mobilization of support from multiple other actors in the innovation system for diffusion and legitimization of new institutional arrangements are thus key requirements for successful upscaling of sustainability experiments. Even so, it is good to remember that not every successful social innovation is amenable to upscaling, even when a broad societal support base exists. Local successes sometimes depend on rare specific conditions, scarce skills or innovative business models which may not be easily transferrable to other contexts (Dees, 2009).

## **2.4 Typology of upscaling**

On the basis of the literatures reviewed above we define the following dimensions of upscaling for investigating the cases in this paper:

1. Quantitative: Upscaling in terms of number of beneficiaries (Uvin, 1995; Rogers et al, 2006).
2. Organizational: Upscaling in terms of expanding the capacity of existing business, i.e., developing resources, building a knowledge base, employing more people, or developing management systems (Klein, 2008; Westall, 2007).
3. Geographical: Upscaling in terms of regional expansion, i.e., serving more people in new regions and extending into new markets (CASE, 2008; Klein, 2008; Karmachandani et al, 2009).
4. Deep: Upscaling in the sense of achieving greater impact in an existing location, e.g., through reaching increasingly poorer segments of the population (Rogers et al, 2006; Smith et al, 2009).
5. Functional: Upscaling in terms of developing new products and services (CGIAR NGO, 2000; Klein, 2008).
6. Replication: Upscaling in terms of replication of a particular business model, by supporting and incubating new entrepreneurs (CASE, 2008; Westall, 2007).
7. Institutional: Upscaling in terms of transforming existing institutions and creating new ones (Macquire et al, 2004; Mair et al, 2009; Robbin, 1984; Sud et al, 2008).

In Table 1 we define several empirical indicators for each of these dimensions of upscaling. These will be used to assess the upscaling potential of the ventures studied in this paper, on the basis of their track record and progress achieved so far.

**Table 1:** Indicators for assessing upscaling potential of sustainability experiments along different dimensions

Dimensions of upscaling of sustainability experiments	Empirical indicators
1. Quantitative	Number of beneficiaries/people
2. Organizational	Organizational growth, improvement in technical and managerial capacity, development of infrastructure and resources, development of knowledge base and management systems, diversifying funding sources and becoming financially self sustainable, upgrading in the external value chain, dissemination of knowledge and ideas, research and development activities
3. Geographical	Expansion to new geographical locations (local communities, villages, municipalities, cities, states and countries)
4. Deep	Reaching extremely poor and vulnerable sections of the population, and/or greater impact in the same location where enterprise was started
5. Functional	Increase in number and type of activities, new products and services
6. Replication	Creating, incubating, or supporting new entrepreneurs; creating new affiliates; branching; franchising
7. Institutional	Modification in public policy at national and international level, transformation of existing institutions (regulative, normative and cognitive)

Source: own elaboration based on the literature review

In order to assess the upscaling performance of the Indian SHS sustainability experiments on each of these seven dimensions, we distinguish potential for ‘high’ (+++), ‘medium’ (++) and ‘low’ (+) upscaling performance in Table 2, based on an assessment of their achievements to date, and retrospective analysis. The three categories have been defined in accordance with insights from Ashoka and Hystra (2009); Bloom et al (2008); George (2009); Zahra (2009).

**Table 2:** Description of different categories for assessing upscaling performance of sustainability experiments

Dimensions of upscaling	High upscaling performance (+++)	Medium upscaling performance (++)	Low upscaling performance (+)
1. Quantitative	Reaching hundreds of millions of beneficiaries	Reaching millions of beneficiaries	Reaching hundred thousand beneficiaries
2. Organizational	Employing thousands of people, having multiple offices, manufacturing and assembly facilities and work places, large	Employing more than one hundred people, a few offices, manufacturing and assembly facilities and work places, four to	Employing less than one hundred people, confined to one central office and manufacturing and assembly facilities,

	number of funding sources and investors, presence in multiple stages of external value chain, presence of specialized R&D centres and innovation departments for innovative activities, knowledge dissemination activities in media	five investors and funding sources, presence in one or two stages of the external value chain, R&D activities but no specialized departments for such activities, limited knowledge dissemination activities in media	dependent on one or two main investors and funding sources, presence limited to one stage of external value chain, very limited research and development and knowledge dissemination activities in media
4. Geographical	Presence in more than fifteen countries apart from the home country, and large number of states/regions (around 70 to 80 % coverage) in the home country, depending upon the geography of the home country	Presence in less than ten countries and around half of states/regions in the home country (around 40 to 50 % coverage), depending upon the geography of the home country	Presence limited to two or three countries, and a few states/regions (around 10 to 20 %) in the home country, depending upon the geography of the home country
4. Deep	Reaching people at the Bottom of Pyramid (earning less than 2 USD per day, PPP); significant presence (around 70 to 80 %) in villages, local communities and districts in the location from where the enterprise operates	Reaching people close to the Bottom of Pyramid (earning between USD 2 and 5 per day, PPP); presence (around 40 to 50 %) in villages, local communities and districts in the location from where the enterprise operates	Reaching people above the top of the Bottom of Pyramid (earning more than 5 USD per day, PPP); presence (around 10 to 20 %) in villages, local communities and districts in the location from where the enterprise operates
5. Functional	More than fifteen mainstream products and services and large number of activities and schemes	Around ten mainstream products and services, limited activities and schemes	Around four to five mainstream products and services, very limited activities and schemes
6. Replication	Creating, incubating and supporting thousands of new entrepreneurs, more than hundred branch organizations or affiliates	Creating, incubating and supporting hundreds of new entrepreneurs, around one hundred branch organizations or affiliates	Creating, incubating and supporting less than one hundred new entrepreneurs, less than one hundred branch organizations or affiliates

7. Institutional	Bringing powerful social change by destabilizing existing institutions and creating new institutions	Modifying certain institutions through persuasion, lobbying and collective activities	No significant efforts in modifying or destabilizing existing institutions
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Source: Adapted from Ashoka and Hystra (2009); Bloom et al (2008); George (2009); Zahra (2009).

### 3. Data collection

Due to the relatively new and unexplored nature of the phenomenon of upscaling, an exploratory research strategy based on case study methodology was adopted. The following five social enterprises were selected: SELCO India, Bangalore; AuroRE, Auroville, Pondicherry; THRIVE energy technologies, Hyderabad; NEST (Noble Energy Solar Technologies), Hyderabad; and D.light Design, New Delhi with headquarters in Hong Kong. These social enterprises differ from each other in many aspects, i.e., in terms of position in the PV value chain, business model, geographical location, non profit to commercial status, and financing mechanisms.

Data were collected over a period of three months, from December 2009 to February 2010, in different locations in southern India. Primary data were collected through interviews and secondary data were collected from the enterprises including sources such as websites of firms, business plans, press releases, internal and external reports, educational pamphlets, and promotional materials. Additional secondary documents consisted mostly of short case studies and case summaries written by other researchers, organizations and journalists about the same social enterprises. Other documents gathered included reports from research institutes, universities, consultancy firms, articles from scientific journals, websites, internet blogs, and newspaper articles.

A field visit was then made to four enterprises. D.light Design could not be contacted for direct interview and most information exchange took place through email. In-depth interviews took place with respondents from the four case studies. Generally we interacted with 1 to 2 informants from each enterprise. We interviewed some important employees with extended periods of involvement with the enterprise and founding entrepreneurs who had been involved in the start up phase of the enterprise. However it was not always possible to meet all key stakeholders in the enterprises due to their busy schedule.

Most interviews took between 30 minutes and 2 hours, depending on the amount of available time of the key informants. Generally the initial portion of the interviews focused on the history of the enterprise along with challenges they faced till today. The later part of the interview was focused on questions directed at thoughts on the upscaling process. By visiting the actual sites of the social enterprises additional insights could be gained about how they were really functioning. Direct observations also helped us to note discrepancies between what had been documented about the social enterprises, discussion during the interview, and how they were actually functioning.

#### 4. Analysis and discussion of case studies

In this section the case studies i.e. SELCO, AuroRE, THRIVE, NEST and D.light Design are presented. First we discuss key characteristics of the cases studied in terms of their business models and type of finance, followed by a performance analysis along the different dimensions of upscaling found in each case.

**SELCO** was founded by Dr. Harish Hande and Neville William in 1995. SELCO's vision and mission is to empower the lives of underserved populations throughout the world by selling, servicing and financing products that continuously improve their quality of life, and create linkages between income generation and sustainable energy services. Important products and services include solar lighting (CFL and LED), solar thermal (water heaters), solar inverters, cook stoves, custom system design, installation, training and after sales maintenance and support. Key aspects of SELCO's business model include customized energy solutions based on user needs, installation and after sales services. These are supported by local assembly operations which source different components from wholesalers and distributors located in Bangalore depending upon price of components. SELCO has a network of regional branch offices and energy service centers which have teams of technicians, managers, sales motivators and administrators actively engaged in selling, installing, and servicing energy related products and services. Another important aspect of SELCO's model is customized packages developed for consumer financing with linkages with various financial institutions including commercial banks, regional rural banks, rural farmer cooperatives, and micro finance institutions.

**AuroRE** was founded by Mr. Hemant Lamba in 1998. AuroRE's vision and mission is to establish a platform for reliable delivery of applications and services from renewable energy sources and technologies and becoming a hub uniting end users with an array of service providers, product developers, financiers and policy makers. AuroRE's key products and services include solar home systems, PV water pumping and solar lanterns, power packs, street lights for villages, installation and post sales services as well as knowledge & consultancy services. AuroRE acts as an Energy Service Provider (ESCO) i.e., as a system integrator and installer providing high quality renewable energy systems by combining technical, practical, financial, and management skills for renewable energy projects. It also acts as a maintenance and service company offering maintenance services to end users; training local people through demonstrations and written instructions about solar energy in local languages as well as in English. AuroRE has been successful in developing consumer financing mechanisms for energy services through government subsidies and schemes by MNRE, IREDA and other government agencies.

**THRIVE** was founded by Dr. Ranganayakulu Bodavala in 2001. THRIVE's vision and mission is to provide clean and reliable lighting solutions to billions of people around the world, improving the living conditions of people by carrying out projects in rural ICT, water conservation, energy conservation, ecology development, rural connectivity and livelihood training. THRIVE's products and services include LED portable home lights, solar LED home lighting systems for large homes, low cost study lights for children in villages, multi mobile charging systems for remote villages, solar panels of different watts, solar panel based power back up systems, institutional solar lighting for schools, hospitals, banks etc. THRIVE is also engaged in consultancy services in energy efficiency and development of different solid state lighting technologies. Some important aspects of THRIVE's business model are the importation of

microchips from U.S.A, batteries from China, LED lights from Japan, and local assembly operations in Hyderabad for development of solar lanterns. THRIVE has assembly line plants in Nairobi and Ranchi, Jais in Raiberily district of UP for localizing production. THRIVE has developed a network of energy kiosks for reaching rural people and also has formed partnerships with various NGO's, organizations like the United Nations, World Bank etc. In addition THRIVE has developed customized financing mechanisms for customers through partnerships with micro finance institutions, women's groups, rural banks and international financial institutions.

**NEST** was founded by Mr. D.T. Barki in 1998. NEST's vision and mission is to provide innovative lighting solutions to truly needy people all over the world by applying its scientific, technical and management expertise. In addition NEST also wants to emerge as a serious manufacturing company in the supply chain of solar grade products starting from high purity Silica/Quartz. NEST's key products and services include Aishwarya, Aishwaryasunkiran-360 and Aishwarya Wow solar lanterns, solar home lighting systems and solar street light systems, PV modules and quartz. NEST's core competence lies in design, development of new and innovative solar energy products. It has manufacturing and assembly facilities for polycrystalline PV modules in Bangalore and facilities for design of electronic controllers and other components in Hyderabad. NEST reaches customers through a network of dealers and sub dealers, independent businessmen who sometimes also sell other goods in various small towns in India. These dealers are also responsible for sales, training, after sales services and recycling of batteries. Other means of distribution include networking with NGO's, CSR programmes and using networks of global organizations such as GTZ. NEST has also developed customized financial packages for customers through its network of dealers on credit and daily rental schemes for its poorest customers.

**D.light Design** was founded in 2007 by Sam Goldman and Ned Tozun. D.light Design's vision and mission is to enable households without reliable electricity to attain the same quality of life as those with electricity and to replace kerosene with clean, safe and bright solar light. D.light Design's products and services include Nova Series, the Solata (a low cost portable LED lamp) and the Kiran (one of the most affordable quality solar lamps). D.light Design has four main offices with a sales and marketing and R&D division in New Delhi, a sales office in East Africa in Dar es Salaam, Tanzania; a product design and international sales and marketing division in Hong Kong, and manufacturing & production in Shenzhen, China. D.light Design has a good and experienced sales and marketing team with major distributors and local dealers who reach semi urban and rural households. In addition D.light Design uses multiple channels to distribute products including: retailers, wholesalers, NGOs, microfinance institutions, and corporate retail chains. It has also formed partnerships with microfinance institutions and various NGOs for consumer financing.

#### **4.1 Business models**

When we examine the essential characteristics of the social entrepreneurial business models in our cases, we note that all have focused on a value proposition through need-based quality products and services, i.e. customized solutions by taking account of usability in hostile environments, affordability, social heterogeneity and inequality (notably due to caste issues), local customs, and knowledge. The enterprises discussed have improved accessibility of products and

services through innovative distribution channels and marketing, which include such aspects as user demonstration programmes, word of mouth marketing, using middlemen from local communities, referral through financial institutions, hosting community meetings for spreading awareness and information about the use of solar energy technologies, and promises of doorstep service and money back guarantees. All this has been supported by good installation and after sales service through well trained local technicians, and consumer financing through packages developed as a result of their linkages with a range of financial institutions. The case studies have also benefited from developing a logo and brand name which has stood for their products and services as a sign for quality, reliability and trust for people at the Base of the Pyramid.

We do not find any specific common patterns of financing across the cases. All except AuroRE have used a varied range of financial mechanisms, i.e., venture capital, social investors, and commercial sources. The main sources of revenue have come from sales of products and services, revenue from maintenance and servicing contracts and additional revenues from other lines of business developed by the enterprises, such as the NEST quartz business. An interesting point is that most cases have acquired financing from global and international sources such as international financial institutions, global venture capital firms, social investors, and even through the UNFCCC Climate Development Mechanism.

SELCO's initial funders included the Rockefeller Foundation and the Solar Energy Light Fund, a US-based NGO that promotes solar lighting. SELCO received INR 5.5 million funding from Winrock India in 1996-1997 which was provided under the USAID renewable energy commercialization project, and letters of credit totaling INR 2.9 million from the World Bank GEF. SELCO also received USD 850,000 in equity from SELCO USA between 1997 and 2000. SELCO's largest loan was from IFC-backed PVMTI which approved USD 1 million in 2003 for working capital for inventory and expansion, and as guarantee to back expansion of PV consumer financing through the Indian Banking system. In 2009 SELCO attracted social investors such as the Good Energies Foundation, Lemelson Foundation and E+CO. SELCO has also earned revenues by selling carbon credits. Since 2002 SELCO has sold 4,500 tonnes of carbon dioxide equivalent credits to UK-based Carbon Neutral. It has saved roughly 28,000 tonnes of carbon dioxide equivalent per year by helping poor families scrap the use of smoke-emitting kerosene for lighting.

AuroRE has not acquired any external investments due to the regulations of the Auroville community which it is a part of. However the PV business of AuroRE has been running on a commercial basis. A portion of the profits made through PV installations and services goes back to the Auroville trust. AuroRE thus runs on a non-profit non-loss basis. AuroRE has however relied on government financing agencies such as IREDA for financing packages for customers.

THRIVE initially survived on grants from the World Bank and other international agencies. It also won the World Bank Development Market Place award in 2006 through which it was able to sustain its activities. Moreover, THRIVE has a commercial enterprise running alongside it, THRIVE energy technologies Pvt Ltd, which also funds many of its development activities. Lately THRIVE has started looking into gaining carbon credits and developing CER (Certified emission reductions) from its LED lighting projects. It has also received approval from Global Environment Facility (GEF).

NEST secured finance on a straight commercial basis, through private investors and banks. A loan from Winrock International helped it in the rapid expansion of the business in 2004. NEST has also been financed by innovative means in the form of other businesses such as silica mining and revenues from supplying high purity quartz to polysilicon and silicon companies such as Msetek, Japan, and Becancour Silicon Inc.

D.light Design acquired USD 1.5 million as initial funding and a further USD 4.5 million from six investors. D.light Design received funding from famous private and social venture capital investors such as Nexus Venture Partners, Acumen Fund, Draper Fisher Jurvetson, Garage Technology Ventures, Gray Matters Capital, and The Mahindra Group. D.light Design also formed a partnership with the Shell Foundation for risk capital micro-financing partnerships and market education campaigns for its products. D.light Design has also received approval from the UNFCCC for a carbon offset project in Uttar Pradesh and Bihar in India. The project innovatively tracks the reduction in carbon emissions that result from D.light Design’s solar lamps replacing kerosene lanterns across different geographies. The revenue from the resulting carbon credits will support D.light Design’s efforts to meet needs of more people. Recently D.light Design raised USD 5.5 million from the United States Securities and Exchange Commission and USD 5.5 million from the Omidyar network. In addition D.light Design is planning an IPO in Hong Kong. If this would be successful, it can attract more investment and funding.

**4.2. Dimensions of upscaling**

Our assessment of the upscaling potential of the five enterprises is summarized in table 3, based on an analysis of their past performance and ongoing progress. As discussed before, we distinguish high upscaling performance (+++), medium upscaling performance (++) and low upscaling performance (+).

**Table 3: Upscaling performance in different dimensions for different case studies**

Case	SELCO	AuroRE	THRIVE	NEST	D.light Design
<b>Dimensions of upscaling</b>					
Quantitative	++	++	++	++	+++
Organizational	+++	++	+++	+++	+++
Geographical	+	++	+++	+++	+++
Deep	++	++	++	++	++
Functional	+++	++	+++	+++	+++
Replication	+++	+++	+++	++	++
Institutional	++	+	+	+	+

With respect to quantitative upscaling SELCO has provided sustainable energy products and services to more than 100,000 households and is in the process of reaching 200,000 households soon. SELCO has also supported 110,000 rural homes, 2,000 institutions and 10,000 small business cottage industries. AuroRE has been successful in delivering affordable, reliable renewable energy products and services to more than 80,000 Indians. AuroRE’s projects include installing 1,025 solar water pump sets to farmers in 11 Indian states such as Punjab, providing

solar lanterns to street hawkers in Chennai and coordinating a rural electrification project in Ladakh using 8,700 solar home kits and 6,000 lanterns. THRIVE's long term mission is to disseminate 100 million lights all over the world .Till now it has benefited approximately 160,000 people, and most of those are poor and tribal people. NEST had sold around 78,800 solar lanterns till 2008, a gradual increase from 12,100 back in 2002. The number of lanterns sold currently is around 90,000, of which 80 % are sold in India and rest 20 % exported. NEST is targeting 1 million solar lanterns in 5-6 years under its unique programmes such as Solar Seeding to contribute towards NEST's mission: a kerosene-free world. D.light Design had sold 1 million solar lanterns in over 30 countries by the end of February 2010. D.light is targeting 50 million people by 2015 and 100 million people by 2020.

As far as organizational upscaling is concerned, SELCO has had a successful growth over the last 14 years, with a turnover of around USD 1.75 million in FY 2009 and estimated USD 3 million in FY 2010. The company made a loss of INR 7.5 million in 2008-9 but returned to profit in the financial year 2009-10, earning INR 3.8 million on a revenue of INR 150 million. SELCO has around 150 employees (four regional sales managers; eight senior managers; 21 branch managers; 32 sales executives; 40 customer support executives and 18 office administrators in addition to members of the projects, finance and innovation departments, including senior management). SELCO's expansion plans include the achievement of an annual turnover of USD 6 million. AuroRE has quite different plans for organizational upscaling. It is focusing on becoming a knowledge service provider for energy services with core expertise in service provision, consultancy in renewable energy technologies, programme and project management and energy efficient architecture through workshops, demonstrations and site visits. Through its experience in renewable energy technologies AuroRE is also offering its services to European companies in looking to certify and carry filed inspections on renewable energy projects and carbon emission reduction projects and programmes for their Indian clients. THRIVE has generated revenues of around USD 2 million till now. THRIVE is developing a renewable energy center outside Hyderabad for training and demonstration projects in renewable energy. It has plans to start new programmes for rural water treatment, rural electrification, rural banks and rural village outlets. THRIVE also has plans to enter into the solar power generation business in line with the National Solar Mission of the Government of India. In addition THRIVE is helping many corporate organizations to implement Corporate Social Responsibility (CSR) programmes in relation to LED lighting. NEST is planning to expand its production, warehousing and marketing and sales capabilities through an investment of around INR 60 million. It expects revenues of around INR 543 million by 2014-15. Mr. Barki is also planning the manufacturing of solar panels in China to reduce costs. D.light Design on the other hand is focused on becoming a truly global company. D.light Design has grown to over 70 employees in three years and has offices in US, India, Tanzania, China and Hong Kong. In 2010 D. light Design centralized its product design and international sales in Hong Kong with plans to move additional corporate functions. In terms of revenue D.light Design's total earned revenue some time ago was approximately USD 4 million.

With regard to geographical upscaling there are unique patterns that are dependent on the chosen business model. SELCO is focusing on expanding geographically in five Indian states neighboring to Karnataka i.e. Maharashtra, Tamil Nadu, Kerala and Andhra Pradesh. By the end of financial year 2010-2011 it is expected that SELCO would be present in 16 districts of

Karnataka, 3 districts of Kerala, 4 districts of Gujarat and 3 districts of states like Maharashtra and Andhra Pradesh. However, SELCO has found it difficult to expand across state boundaries due to lack of spillover learning across different states and lack of financial institutions whom it can partner with. At the same time SELCO does not want to use the franchise system to sell its products and services, as the reputation of its brand depends on services and it is more difficult to guarantee the same quality of service from franchises. Hence SELCO has decided to only move into a new region if there are good contacts there both for dissemination of information and for providing good services. AuroRE has been successful in delivering affordable, reliable renewable energy products and services across 12 Indian states such as Andaman and Nicobar islands, Tamil Nadu, Pondicherry, Karnataka, Kerala, Orissa, Jammu and Kashmir and Gujarat. THRIVE, NEST and D.light Design are the most internationally oriented of the five cases. THRIVE has established an international geographical reach due to the support from various groups and organizations around the world. At present THRIVE is strongly established in Indian states like Orissa, Andhra Pradesh, Jharkhand, Bihar, Maharashtra, Manipur and countries such as Afghanistan, Cambodia, Bangladesh, Ethiopia and Kenya. NEST also has a wide geographical presence in India, with a network of 70 dealers in different states in India. Globally NEST has expanded its operations to countries such as UK, Sudan, Sri Lanka, Japan, Australia, Malaysia, Kenya, Nigeria, Malawi, Tanzania, Fiji, Bolivia, El Salvador and Puerto Rico. Now NEST has plans to reach other countries such as Nigeria, Somalia, Central America, Pakistan, Australia and China. D.light Design has also developed a strong distribution in around 10 countries and reach with more than 500 selling points in India and Africa. It has also built additional distribution outlets in places such as South East Asia, Latin America, Pacific Islands and West Africa. D.light Design is planning to expand further in India, Bangladesh and East Africa with the goal of selling millions of lighting products.

With respect to deep upscaling, it is found that the ventures discussed generally have not been able to reach increasingly poor segments of the population i.e. going deeper down the economic strata in their existing locations, although it has to be said that they have developed rental schemes and special financial mechanisms to reach people at the Base of Pyramid. The key problem is that commercial approaches, though appropriate in many cases, are unable to reach the extreme poor, i.e., those who cannot be offered loans from rural banks and microfinance institutions due to lack of any kind of assets. For reaching the very poorest segments of the population there is thus a need for mobilizing more financial support through government grants, carbon finance through the UNFCCC mechanism, and support from international financial institutions. This constitutes a major challenge for the future.

The ventures are generally performing well in terms of functional upscaling. SELCO has created new solar energy related businesses such as PV-powered battery-charging businesses which supply single-lamp systems for both street vendors and poor homes, PV power for sewing machines to increase the productivity of sewing businesses, PV powered soldering irons for TV repair and small PV-powered silk looms. SELCO is also in the process of developing a cheap, improved cook stove for its clients. It is also diversifying into energy services other than solar ones, such as thermal, efficient cooking, biogas provision, and drying, to its existing clients. Thus SELCO is looking to become a complete energy provider, from just a solar lighting provider. In addition SELCO is partnering with two organizations for multiple service based e-kiosks in rural areas of India, which will be run on solar power, and providing solar based power solutions for

water purification. AuroRE is developing new products such as LED/CFL based home lighting lanterns as well as solar powered reverse osmosis systems to purify drinking water. AuroRE is also working on new products such as an improved solar rice cooker, a solar lantern, and solar home lighting kits. In addition AuroRE is developing mission TEJAS, which is a platform of exchange and development for solar energy technologies by bringing together lighting designers, product manufacturers, NGOs, administrative bodies, financial institutions and corporate/industrial R&D players. THRIVE has introduced additional forms of lights that are useful to the villages, like street lights, task lights, etc., at very economical rates. THRIVE is looking for a major share in niche markets such as street lighting, boarding and institutional lighting. Similarly, NEST is planning to increase its product portfolio by developing new solar street lights, solar powered fans, mini solar desk lamps, etc. D.light Design is also developing several new products, such as premium solar lantern with four brightness settings; affordable solar lanterns with 360 degree lighting and quality solar task lamps which have a flexible gooseneck and can give up to 15 hours of light in a day.

As far as replication is concerned, SELCO is trying to start an incubation system for new entrepreneurs and business associates and aims to have 100 additional business associates by 2010. These business associates are rural youths, who would have a chance to create sustainable livelihoods for themselves by providing energy services through SELCO's products and services to poor people through their own business, keeping the SELCO management as board advisors. SELCO has also set up a USD 3 million fund to help new entrepreneurs planning to start new enterprises for energy services in different geographical locations. SELCO has already helped to create more than 25 entrepreneurs who are serving 750 clients by providing solar lighting to street vendors, home based workers and small businesses. AuroRE is also focused on creating solar entrepreneurs. Such ventures can become financially sustainable in different ways, such as hiring out solar lanterns to market traders or supplying and installing solar water pumps to farms. AuroRE is aiming to set up a whole chain of local energy entrepreneurs by effectively providing them with managerial, technical and financial back up. It is also training several people and developing a network of sustainable enterprises among economically deprived communities. This includes training of at least 250 people in installation and maintenance of PV solar systems. THRIVE is encouraging village entrepreneurship by promoting solar light entrepreneurs and LED based home lighting with the intention to create micro, small and medium energy service enterprises for manufacturing, selling and servicing LED lamps. THRIVE has also proposed alternative energy kiosks in villages in which users can walk and get light charges for a token fee and enjoy continued service and maintenance of light. The kiosks are run by local youth with minimum education like matriculation and basic training in electronics and mobile phone usage. NEST is developing small businesses which manufacture charge controllers and plastic works exclusively for NEST. In addition it is developing and supporting entrepreneurs in villages for distribution of its products. D.light Design has built a distribution base of 1500 rural entrepreneurs. Each rural entrepreneur handles around 2000 households who also source products from dealers.

From the literature review in section 2 it was found that institutional upscaling is generally beyond the scope of individual enterprises, and requires concerted action from a critical mass of entrepreneurs. All enterprises except SELCO score low in this respect. SELCO in the past has requested government institutions such as the Reserve Bank of India to reduce the procedural

bureaucracy of foreign investment from social investors abroad to firms such as SELCO. All the enterprises discussed found it difficult to involve in institutional upscaling. Some of the key institutional barriers mentioned include high subsidies for fossil fuels and high taxes for solar energy products, lack of consumer finance from financial institutions and other regulative barriers. Most enterprises have advised government officials about, and have even lobbied against high subsidies for fossil fuels but their efforts have not resulted in any major institutional changes. Enterprises have also found it time-consuming to engage in trying to bring in institutional changes since this may make them lose focus from their primary work – the day to day functioning of the enterprise and meeting the needs of their customers.

## **5. Conclusions**

On the whole, the discussion of the upscaling achievements and potential of the five solar PV ventures discussed in this paper demonstrates that currently there are indeed several promising experimental activities going on in India that appear to have considerable potential for large-scale upscaling. In fact, a few are already making headway in this direction.

One striking similarity between the initiatives is that they are conceived and nurtured by visionary people with creative ideas and drive, who have conceived innovative business models that manage to balance societal aims with the exigencies of financial sustainability. At the same time, the way in which the different ventures achieve this balance is found to vary a great deal. The most important issue seems to be that strategy and structure should reflect – and continue to reflect – the particular idiosyncratic vision and mission of the leadership. There is thus no single dominant, ‘best’, or even preferred way by which social entrepreneurial ventures can achieve upscaling. A broad multidimensional classification of upscaling as used in this paper, which is capable of capturing heterogeneity in performance, strategies, structures and plans, is therefore found to be a suitable research tool for getting a better grip on the ‘Loch Ness monster’. It has to be said, though, that a research approach like this one should thus be considered primarily useful for conducting a broad-sweep assessment aimed at mapping the level and diversity of innovative sustainability-centred activities in particular emerging fields. It is likely to be less useful for a detailed micro-level comparison of different individual cases, because of the inevitable subjectivity involved in translating research data/findings into particular scores in the classification scheme.

In addition to a need for further objectivising the assignment of scores in the classification, the analysis conducted in this paper raises several other pointers for policy and research. Our results indicate that the ventures are generally well on track towards upscaling, but that they lag behind in terms of two crucial – and closely intertwined – dimensions: (a) reaching the poorest of the poor; and (b) effecting broader institutional change. Reaching the people at the very Base of the Pyramid is indeed a massive challenge, and it does not help that many western corporations and even major international development organizations are currently advocating the use of commercial approaches even for this target group. Not surprisingly, there is very little evidence on the ground that such BoP approaches can actually produce win-win results at the required massive scale. A better strategy would seem to lie in the facilitation of non-profit social oriented ventures like the ones considered in this paper, including through making available more financial resources at appropriate conditions from national and international sources.

As far as the institutional dimension of upscaling is concerned, it would be particularly useful to complement the type of analysis conducted here with an assessment at a higher analytical level in order to explore the meaning and dynamics of ‘collective upscaling’ more comprehensively. A ‘meso-level’ investigation can reveal a more complete picture of pivotal institutional upscaling barriers faced by social entrepreneurs in the conduct of their sustainability experiments, and on the key factors that prevent different actors in an emerging ‘innovation system’ such as solar PV from acting in concert and achieving the critical mass needed for effecting change in the institutional sphere. Interviews and literature study focused on individual entrepreneurial ventures as conducted for the present paper miss out a substantial part of these issues, because their scope is restricted to the individual entrepreneur’s activities, strategies and point of view. In this respect, the adoption of multi-level analytical frameworks (such as used in Strategic Niche Management and some Sectoral Innovation Systems approaches) which set an analysis of innovation dynamics at the level of individual experiments and emerging niches within a broader overarching socio-technical context, would be a useful step in this direction.

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