

## Improved stoves in India: A study of sustainable business models

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### ABSTRACT

Burning of biomass for cooking is associated with health problems and climate change impacts. Many previous efforts to disseminate improved stoves – primarily by governments and NGOs – have not been successful. Based on interviews with 12 organizations selling improved biomass stoves, we assess the results to date and future prospects of commercial stove operations in India. Specifically, we consider how the ability of these businesses to achieve scale and become self-sustaining has been influenced by six elements of their respective business models: design, customers targeted, financing, marketing, channel strategy, and organizational characteristics. The two companies with the most stoves in the field shared in common generous enterprise financing, a sophisticated approach to developing a sales channel, and many person-years of management experience in marketing and operations. And yet the financial sustainability of improved stove sales to households remains far from assured. The only company in our sample with demonstrated profitability is a family-owned business selling to commercial rather than household customers. The stove sales leader is itself now turning to the commercial segment to maintain flagging cash flow, casting doubt on the likelihood of large positive impacts on health from sales to households in the near term.

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### 1. Introduction

Burning of biomass in traditional stoves is associated with a host of ills among the estimated 2.5 billion people around the world that do not have access to modern fuels (IEA, 2009). Indoor air pollution (IAP) from traditional biomass burning contributes to serious health problems, particularly cancer and respiratory infections that cause an estimated 1.6 million premature deaths annually (Naeher et al., 2007; Smith, 2006; WHO, 2006). The time required for biomass collection can preclude formal employment outside the household for women, and the cost of purchasing biomass can weigh heavily on household budgets where formal biomass markets exist (Ramani and Heijndermans, 2003). Moreover, a growing body of literature suggests that incomplete combustion products and black carbon from traditional biomass burning have a significant contribution to climate change (Johnson et al., 2009; Smith et al., 2000).

Technologies are reasonably well-established for “improved cookstoves” that burn biomass more cleanly and efficiently, and could thus help mitigate the above problems (Hulscher, 1998; Masera et al., 2007). However, after more than 25 years of effort, largely by governments and NGOs, less than a third of the total biomass-using population – an estimated 166 million households

encompassing about 828 million people – has adopted an improved stove (UNDP/WHO, 2009).<sup>1</sup> The Chinese National Improved Stove Program (NISP) has been the lone cookstove dissemination effort to achieve broad success at scale, distributing approximately 130 million stoves, most of which remained in use over a long period of time (Smith et al., 1993; Barnes et al., 1994; Sinton et al., 2004). The Indian National Program on Improved Chulhas (NPIC), on the other hand, is often seen as emblematic of the kinds of things that can go wrong with government-run cookstove initiatives.<sup>2</sup> NPIC was criticized for poor stove design, high program cost, and low uptake rates; by heavily subsidizing stoves, it also undermined pre-existing local markets for stoves (Barnes et al., 1993).

NGOs have not had much luck either. Despite more than 25 years of effort, NGO efforts remain small-scale (Barnes et al., 1994). Numerous problems, including fragmentation of effort and

<sup>1</sup> The WHO and UNDP estimate that there remain 116 million improved stoves in the field in China, 13 million in East Asia, 20 million in South Asia, 7 million in Sub-Saharan Africa, and over 8 million in Latin America and the Caribbean (UNDP/WHO, 2009). It is unclear what fraction of households possessing improved stoves actually uses them on a regular basis.

<sup>2</sup> It ultimately distributed 32 million stoves in the period 1983–2000, and a 1995–1996 survey showed that perhaps 60% of stoves distributed to that point were still in use (Sinha, 2002). This number has likely declined significantly since then, given the lack of government support and the ultimate withdrawal of the program.

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insufficient attention to scalability and sustainability, have prevented such operations from expanding to serve a larger customer base (Edwards and Hulme, 1992; Uvin et al., 2000). Overall, NGOs have not made a significant impact in increasing access to improved stoves; the vast majority of stoves now in use were distributed by government programs—particularly the Chinese and Indian programs (Barnes et al., 1994).

The poor track records of government and strictly charitable efforts at large-scale and sustained diffusion of improved cookstoves have contributed to an increased focus on complementary commercial and market-driven solutions. In fact, the most successful stove program to date, China's NISP, combined a central push with locally coordinated efforts to create functioning markets for stoves. Similarly, the Kenya Ceramic Jiko (KCJ) charcoal stove is an example of an improved cookstove that has seen wide distribution on a commercial basis, with approximately 2 million stoves in use as of 2002 (Ministry of Energy, 2002). The KCJ was originally developed with substantial NGO funding in the early 1980s but over time has made the leap to commercial sustainability (Hyman, 1986, 1987; Bailis et al., 2009; Kammen, 2001).

The emphasis on commercially sustainable solutions also reflects a broader shift in the conventional wisdom on how to improve the welfare of the poor, with donors focusing on catalyzing markets rather than providing indefinite support (Bailis et al., 2009). In this context, a hybrid model of a “social enterprise”, which attempts to blend a commercial approach in operations with relaxed requirements on returns in order to fulfill a social need, is increasingly being used (Borzaga and Defourny, 2001). Though the exact definition of a “social enterprise” is often left vague, commercial or semi-commercial operations offer the potential in theory of being both more scalable and more sustainable than fully subsidized efforts because they develop viable supply chains and customer-responsive business models rather than relying on centralized distribution mechanisms and ongoing funding support.

Recently, organizations aiming to sell cookstoves commercially have emerged around the world, with operations in Latin America, Africa, South Asia, and the Asia Pacific region. However, there are few demonstrations thus far of self-sustaining commercial distribution of improved stoves, and there is a need to assess what would make commercial cookstove programs successful. As part of a larger study directed toward this need, this paper focuses on commercial cookstove companies in India, given that India has been a focal area for commercial cookstove operations. Reasons include its large population centers, relatively supportive and stable policy environment, comparatively well-developed infrastructure, and rapid economic growth. In particular, India offers a large potential market for improved stoves—approximately 75–100 million households (Venkataraman et al., 2010).<sup>3</sup> An assessment of commercial approaches in India is especially timely as the Indian government considers various approaches for its newest biomass cookstove initiative (Venkataraman et al., 2010).

Several fledgling efforts now exist to serve the Indian market on a commercial basis. The two companies that have achieved the largest market penetration had sold approximately 450,000 and 120,000 stoves, at the time of the June 2010 interviews on which

<sup>3</sup> Of India's population of nearly 1.2 billion, more than half live in rural areas, where biomass use is most common. 71% of the Indian population does not have access to modern fuels, although in rural areas the percentage of the population without access to modern fuels rises to 90%. Worldwide, 27% of those reliant on solid fuel live in India, but only 9% of the Indian population reliant on solid fuels has access to an improved stove, leaving a large remaining market (UNDP/WHO, 2009).

this paper is primarily based.<sup>4</sup> The goal of this paper is to perform an initial assessment of the progress of these and other commercial stove distribution efforts in India in order to extract broader insights into the conditions under which commercial business models for cookstove distribution might be able to overcome the obstacles to cookstove diffusion.

We note that few of the efforts in India are at a sufficiently advanced stage to conclusively evaluate their performance. However, many of them have been in operation for long enough that their experiences thus far offer preliminary indications of the key factors that affect the ability both to achieve scale in improved stove sales and to be self-sustaining.<sup>5</sup>

## 2. Background and hypotheses

Prahalad (2004) popularized the theory that commercial enterprises can profitably serve those at the “bottom of the pyramid”. However, improved stoves have several characteristics that may make them uniquely challenging products to sell to the poor (Slaski and Thurber, 2009). First, with typical prices in the range of \$20–\$85,<sup>6</sup> they are expensive, especially for populations that are truly at the bottom of the pyramid—those earning less than \$2 per day, or about 2.6 billion people globally (World Development Report, 2007/2008). To illustrate this point, Table 1 compares the consumer affordability hurdle for four different interventions that can improve the health or welfare of low-income populations in the developing world. Second, the switch to new fuels and cooking technologies may be complicated by cultural and societal norms related to cooking (Eberhard, 1993). Many stove programs have failed because their designers failed to deeply understand user preferences and cooking patterns (Barnes et al., 1993; Crewe, 1997). In fact, one advantage the KCJ stove might have had was that it only represented an incremental modification to traditional stoves in Kenya (Hyman, 1987). Third, and most importantly, many users have simply failed to sufficiently value the advantages of the improved stoves on offer to spend scarce money on these stoves or to discard traditional cooking methods. Health or time benefits that seem compelling to outside observers may not be observed or prioritized by the potential users themselves (Barnes et al., 1994; Jin et al., 2005; Baris and Ezzati, 2007; Howells et al., 2010).<sup>7</sup>

The existing literature on diffusion of cookstoves and other products targeting the poor offers insights into how the above obstacles might be overcome in commercially oriented stove distribution models. Many of these insights are not unique to commercially oriented stove distribution models and apply to government distribution programs as well.

First, the literature suggests that stove technology and design choices are very important, including the strategy for how and where to manufacture the stove. In particular, the quality of the stoves is very important as evidenced by the poor adoption of NPIC stoves, which were of low quality (Barnes et al., 1993).

<sup>4</sup> The company with 120,000 stoves in the field as of June 2010 had reached the 200,000 customer mark a year later.

<sup>5</sup> We use “self-sustaining” in an expansive way in this paper—not precluding, for example, the incorporation of government subsidies into a business model if these subsidies are judged to be sustainable over a reasonably long period (at least 3–5 years).

<sup>6</sup> For consistency purposes, we have converted all price and cost numbers to US dollar equivalents, using appropriate conversion factors. For example, we have used a 47-to-1 conversion ratio (the exchange rate on June 9, 2010) between the Indian Rupee and the US\$.

<sup>7</sup> For example, stoves can be contrasted with malaria nets, where 99% of those surveyed cited at least one advantage for a child under five to sleep under a net, whereas only 3% named a disadvantage (NetMark, 2003).

**Table 1**  
Affordability comparison of technologies for low-income populations.

	Example price	Comments
Improved biomass stoves for household use	\$20–\$85/stove	The price of the stove varies widely depending on materials, sophistication of technology, and manufacturing method and location. Stoves with higher combustion efficiencies and greater emissions and fuel reductions will cost more than less efficient stoves.
Point-of-use-water treatment	\$9/3-year-supply	WaterGuard, a solution of 1% sodium hypochlorite, sells for approximately 25 cents for a month's supply (250 ml)
Long-lasting insecticidal net	\$10/net	\$10 (includes the net, distribution, teaching usage and monitoring usage)
Small-scale solar home lighting solutions	\$12–\$200/lantern	Approximately \$12 for the base model d.light solar lantern

Note that this table does not normalize costs by the magnitude of health or welfare benefits; rather its purpose is simply to give an indicative sense of the relative affordability hurdle to consumers of different technologies. While the costs of a stove can be quite high, the attendant social benefits through reduced collection times and improved health outcomes can equally be very substantial. A quantitative analysis of the relative health benefits (i.e. in terms of quality-adjusted life years or per unit of avoided health care costs) is beyond the scope of this paper. However, benefit–cost analyses conducted by the WHO show that overall benefits generally outweigh the costs of improved cookstoves by a significant margin (Hutton et al.).

Quality means not only that stoves function well under a variety of real-world scenarios but also that they meet users' preferences, which generally requires that customer feedback be incorporated in an iterative design process (Barnes et al., 1994; Bryden et al., 2010). One source of potential advantage for commercial efforts is that the imperative to make money might lead to a greater focus on matching product attributes to customer needs and desires. To the extent that customers do not value the health-improving character of cleaner stoves (Slaski and Thurber, 2009), stove designers must find other ways to offer utility to consumers. One way is to create stoves that are either "status goods" or provide "recreational utility" (Howells et al., 2010). What complicates stove design considerations further is that the main beneficiary of an improved stove is typically the woman in the house, who may care about the health benefits and ease of use, while the financial decision maker is often the man of the household (Ramani and Heijndermans, 2003), whose priorities may be different. Tradeoffs between design goals such as cost, efficiency, low emissions, ease of use, and durability translate into basic design choices such as stove material, fuel type, and draft mechanics (Bryden et al., 2010). They also have a bearing on decisions about how and where to manufacture the stoves. Mass production of stoves coupled with foreign manufacturing (for example, in China) may allow greater quality and cost control (Barnes et al., 1993).

Second, existing literature leads us to expect that the population targeted by a commercial cookstove operation will have an important effect on the success and sustainability of the enterprise. An important criterion for the stove designers is whether they are targeting rural or urban buyers. In rural areas, biomass use is higher, incomes are lower, and biomass is likely to be collected rather than purchased (Barnes et al., 2005). Customers may be segmented on the basis of income as well. As income increases, people shift away from biomass to fuels like LPG that provide energy in a more convenient and efficient manner (Victor and Victor, 2002). Other demographic factors like occupation or education may be predictive of stove uptake and usage patterns as well (Howells et al., 2010). Higher education levels are associated with higher valuation of health attributes and lower discount rates, which should encourage the transition to modern fuels. LPG users, for example, tend to be more affluent and more literate (Reddy et al., 2003). Cookstove companies targeting more affluent and educated populations may need to compete with LPG-fueled alternatives but may also find their customers more willing and able to pay for the attributes of an improved stove. Conversely, it may be difficult to profitably serve the neediest populations with purely commercial business models (Bailis et al., 2009), implying the need for subsidies (Kremer and Miguel, 2004). Companies may enhance financial sustainability by focusing on commercial rather

than solely household buyers. Where both segments are targeted, such commercial or "anchor" customers (who are committed to a pre-determined amount of demand) typically cross-subsidize household customers with less purchasing power and may be necessary to make a business viable (Zerri, 2010). In summary, given the complexities of the customer segments, companies must think hard about which segments to target and how, and different strategies may be required to sell products targeted at different segments.

Third, financing strategy is a critical part of the business model (Zerri, 2011). Unlike fully subsidized programs, a commercial venture selling to low-income populations must find a way to make its products financially accessible to its customers. "Consumer" finance – to help customers that might otherwise struggle to front the cash to purchase a cookstove – may be provided in many forms, including through commercial banks, the stove company itself, retail outlets, etc. A particularly attractive avenue to emerge in recent times is microfinance,<sup>8</sup> as suggested by Taishi (2006) and Rao et al. (2009). Financing could also play a role by supporting local entrepreneurs who wish to become cookstove distributors. Such "enterprise" financing can help reduce the cost structure of the stove enterprise and enable it to generate positive returns at a lower price point for stoves. There is a continuum of enterprise financing options: from the purely commercial, such as venture financing (Gompers and Lerner, 2004); to the purely non-commercial, such as grants; with intermediate options like social venture capital that are intended to both provide attractive returns to investors and to provide market-based solutions to social and environmental issues (Silby, 1997; Harrington, 2003; Borzaga and Defourny, 2001; Nyssens, 2006). One relatively new type of finance that could be applied in theory at the consumer, distributor, or enterprise levels is "carbon finance," which works through carbon offset programs that provide credits to developed world buyers for greenhouse gas reductions from improved cookstoves deployed in developing countries (Edwards et al., 2004; GTZ, 2010). Carbon finance for cookstoves is becoming increasingly popular, and various carbon offsets mechanisms have been used for this purpose, including voluntary offsets (DNV, 2007) and the Kyoto Protocol's Clean Development Mechanism (CDM, 2008).

Fourth, marketing strategies may crucially influence the performance of a commercial stove-selling venture. Studies of both commercial and non-commercial distribution of health-improving products have emphasized the importance of "social marketing"

<sup>8</sup> Though the concept of microfinance is not new (Siebel, 2005), it has become popular in recent times through the involvement of commercial banks, such as the Grameen Bank in Bangladesh (Yunus, 2003).

(Gordon et al., 2006; Schellenberg et al., 2001; Grier and Bryant, 2004). Social marketing can be used to create awareness of the product and its benefits; as an example, Schellenberg et al. (2001) reported a five-fold increase in the use of insecticide-treated nets in Tanzania when locally specific branding and packaging was used. It may be that improved cookstoves have been slow to catch on because consumers are unaware of their health benefits, although it may also be that these benefits are simply not prioritized (Jin et al., 2005; Baris and Ezzati, 2007; Howells et al., 2010). An understanding of what benefits are actually of most value to the targeted population should drive stove design, but then skillful marketing is needed to create awareness of these benefits among potential consumers (Karnani, 2007), such as the “Swasthya Chetna” campaign used by Hindustan Lever Limited for selling soaps in rural India (ICMR, 2006). In fact, social and cultural pressures on behavior can be more powerful than the promise of health benefits per se—for example, shaming and being made to feel dirty may be more effective methods of increasing hand-washing rates than simply educating on disease prevention (Scott et al., 2007). Furthermore, to reach rural customers, companies may need to wed social marketing strategies to rural marketing ones, such as client and location specific promotion, joint or cooperative promotion, bundling of inputs, and partnership for sustainability (Velayudhan, 2007). Where possible, marketing techniques should be specifically adapted to the target population. For example, the behavior of “opinion leaders” such as village chiefs has been found to affect adoption rates in rural areas (Feder and Savastano, 2006), suggesting that stove sellers may be wise to enlist these leaders in their promotional efforts. Overall, savvy marketing can be effective if it helps to publicize and reinforce a strong value proposition for consumers, but it will do little for a product that fundamentally cannot compete in the marketplace on cost and perceived benefits.

Fifth, it may be that where companies succeed or fail is in the development of a robust supply channel to sell stoves, along with an after-market support channel (possibly one and the same) to handle maintenance and quality-related problems, such as were experienced by the NPIC in India (Sinha, 2002). Indeed, the scaling issues of NGOs are well documented (Edwards and Hulme, 1992; Uvin et al., 2000), and the notion of an appropriately incentivized supply chain is part of what distinguishes a commercial operation from a charitable one, and provides its associated advantages of scalability and financial sustainability. Selling to the very poor in rural areas, however, can present significant obstacles to the development of viable distribution and support networks, including the fundamental challenge of keeping costs down while distributing to far-flung areas with poor infrastructure (WLPG, 2005). Various strategies have been attempted to overcome these challenges: Indian Tobacco Corporation (ITC) and Hindustan Lever Limited (HLL) have been successful in expanding their procurement and marketing channels in rural India by combining the use of information technology (IT) and involvement of local communities in the “e-Choupal” and “iShakti initiatives”, respectively (Annamalai and Rao, 2003; Simanis and Hart, 2009). The extensive distribution networks created by microfinance institutions have also been used successfully to distribute products, such as Hindustan Unilever’s water filters and Emami’s personal care products (Monitor, 2009). Partnering with NGOs – for example, the Self Employed Women’s Association (SEWA), through its rural distribution network (RUDI)<sup>9</sup> – may also allow firms to maximize their reach. However, they need to balance reach with control;

<sup>9</sup> Information on SEWA’s distribution network, RUDI, is available at <http://www.sewa.org/Rudi%20Products%20And%20Rudi%20Multi%20Trading%20Co%20Ltd.asp>.

increased reach through third parties may result in reduced control over the feedback loop required for after-sales support.

Sixth, there may be something about the inherent nature of the organizations selling cookstoves commercially that pre-disposes them to succeed or fail. We are not strictly limiting our evaluation of commercial cookstove distribution approaches to for-profit entities; any organizations that sell stoves to customers and attempt to recover costs are considered to be commercial for the purposes of this study. Different types of organizations might be expected to have different relative strengths, however. Organizations with experience operating on a for-profit basis might, for example, be more adept at developing and scaling distribution channels. Experienced non-profit entities might be more patient in the face of the inevitable setbacks and challenging working environment associated with bringing products to the very poor.

### 3. Methodology

Our goal is to characterize the business models of the most significant commercial cookstove efforts in India – anonymized in this paper as companies A through L – along the above dimensions and then evaluate how these factors have influenced the relative success achieved by these ventures thus far. We gauge success in terms of both scale achieved and financial sustainability. These two variables have to be considered together rather than solely in isolation from one another. After all, the NPIC (India’s previous government program) was successful in initially distributing tens of millions of stoves and so achieved a scale well beyond the nascent commercial operations discussed in this paper. At the same time, as discussed above, it is generally considered to have been a failure for a number of reasons. For a commercial enterprise to be financially sustainable over the long term it will have to solve many of the problems encountered by the NPIC in the areas of stove quality, ongoing support, and program efficiency. If, however, these solutions put prices out of reach for many consumers, then the scale of the stove dissemination will be limited to a relatively narrow market. Such commercial efforts can thus also “fail” in the sense of being unable to provide improved stoves to the much larger population that could benefit from them.

Given the still early stage of many of the businesses we consider, the two dependent variables of scale and financial sustainability must be characterized in a rather provisional and subjective way. To measure scale, we consider the number of stoves sold relative to the age of the organization (Rogers, 2003). To measure financial sustainability, we rely on qualitative judgments of whether the business is financially self-sustaining or, if it is not, whether trends suggest that it might become so within several years. If the business benefits from some kind of ongoing support and requires this support to remain sustainable, we consider whether this support is likely to be available for as long as it is needed.

The independent variables in Table 2 as well as the dependent variables of scale and financial sustainability were characterized through structured interviews with representatives of each organization in our sample. The great majority of interviews were conducted by phone, though we also met in person with representatives of several of these organizations.

As much as possible, we attempted to include in our sample the most significant commercially oriented cookstove distribution efforts currently operating in India. From an initial list of 14 companies of possible interest,<sup>10</sup> we ultimately interviewed

<sup>10</sup> We express our particular gratitude to Katie Hill and the Acumen Fund for sharing some of Acumen’s market research on cookstove enterprises in India, which helped us significantly in defining our sample.

**Table 2**

Independent variables: Business model factors hypothesized to influence scalability and financial sustainability.

Technology and design choices	<ul style="list-style-type: none"> <li>• Design priorities: e.g., cost, fuel efficiency, emission reduction, attractiveness, ease of use</li> <li>• Basic technology type: e.g., natural vs. forced draft, gasification vs. simple combustion, material used</li> <li>• Fuel type: e.g. raw biomass, processed biomass, charcoal</li> <li>• Manufacturing strategy: e.g. mass-produced vs. artisanal, domestic vs. international</li> </ul>
Target customers	<ul style="list-style-type: none"> <li>• Commercial vs. household segment</li> <li>• Household demographic characteristics: e.g. income, education, occupation, household size, gender</li> <li>• Geographic or regional focus</li> <li>• Dwelling location and type: e.g., rural, urban, peri-urban</li> <li>• Competing fuels and cooking methods: e.g., LPG, kerosene</li> </ul>
Financial model	<ul style="list-style-type: none"> <li>• Stove pricing strategy</li> <li>• Enterprise finance/funding</li> <li>• Distributor finance</li> <li>• Consumer finance</li> <li>• Carbon finance</li> <li>• Government support</li> </ul>
Marketing strategy	<ul style="list-style-type: none"> <li>• Stove selling points to consumer</li> <li>• Advertising channels: e.g., TV/radio ads, word-of-mouth, billboards, demonstrations</li> </ul>
Channel strategy	<ul style="list-style-type: none"> <li>• Means of building and incentivizing distribution network</li> <li>• Maintenance and after-market support strategy</li> <li>• Means of sourcing biomass, if stove uses processed fuel</li> </ul>
Organizational characteristics	<ul style="list-style-type: none"> <li>• Type of organization: e.g. branch of foreign/multinational company, indigenous company, NGO, government agency</li> <li>• Number of employees and operational experience of management team in related fields</li> <li>• Expected returns: e.g., commercial vs. "social"</li> <li>• Other products sold, if any; experience with products analogous to stoves</li> </ul>

representatives of 12. Of these, 10 formed the core data set for this study; one company (Company L) is not part of the core data set<sup>11</sup> because it is a supplier that manufactures stoves for other organizations that sell them (Company D and Company C), and another (Company K) was excluded because its operations thus far have been confined to Africa. (Subsequent research plans to extend the scope of this evaluation outside of India.) Table 3 provides summary data for our core sample of companies. As highlighted in Fig. 1, the organizations interviewed exhibit significant variation in the stage of their cookstove business development; this is taken into account in the analysis.

Based on the interviews with these selected companies, we seek to draw qualitative inferences about which business model factors have had the most important influence on scale and financial sustainability of cookstove operations for these companies so far. In some cases the interview questions sought specific data about operations and results; in other cases they aimed to elicit more impressionistic information about what these different organizations see as their main challenges and what logic underpins their strategic and operational decisions. Because the sample size of companies is relatively small, the number of possible explanatory factors (Table 2) rather large, and the ultimate fate of most of the businesses still undetermined, we are limited in our ability to make sweeping generalizations from our data. Furthermore, we are not able to independently verify the majority of the information provided to us by respondents. This may introduce systematic biases in our interpretation. One such bias could be from companies overstating their own viability – in particular, in terms of expected earnings in the future. Another bias could be from companies overstating the positive

environmental attributes of their stoves. Despite these limitations, the ensemble of interviews does allow us to make provisional conclusions about which business model factors are more or less important.

#### 4. Results and discussion

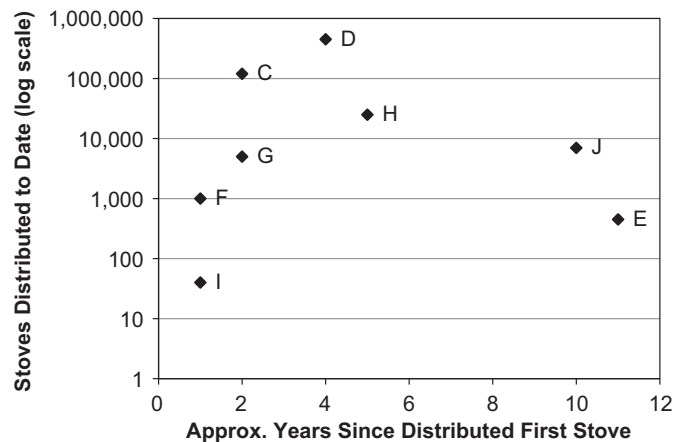
The right-hand side of Table 4 summarizes the performance of the organizations in our sample on our dependent variables of scale and financial sustainability; the left-hand side highlights selected independent variables that may have a bearing on these results. We make some broad observations now, and then in the sub-sections that follow we delve into the observed influences of different independent variables in more detail.

None of the organizations in our sample have yet achieved both scale and proven financial sustainability in cookstove distribution, though several have achieved appreciable scale (Company D and Company C), one small operation has proven its ability to generate modest profits (Company E), and another reports that it is nearly breaking even (Company H). One operation that has depended on donor funding is clearly struggling to survive (Company J). Several other ventures remain too early in their development to allow proper assessment of their prospects. Company A has not sold any stoves yet; Company I has made some sales, focusing on street vendors, but also remains at a nascent phase of business development. The large multinational consumer products firm, Company F, has been eyeing the improved cookstove space for four years, and has just started selling its stoves after extensive field testing and market research. The clear frontrunners in commercial cookstove distribution in India are Company D and Company C; accordingly, this study will devote somewhat more attention to these two cases.

<sup>11</sup> Nevertheless, our interviews with Company L did provide some useful insights into the business models of the companies to which it supplies.

**Table 3**  
Summary data for organizations in our sample.

Organization	Years in stoves business	Approx. # of direct employees in stoves	Est. total # of stoves sold in India (as of June 2010)	General information (Organizations are for-profit unless otherwise noted)
A	1	3	0	Received first VC funding in late 2010
B	40	300	0 (sold 150,000 in Africa)	Previously funded by Foundation Y, but never managed to develop commercial operations in India; now active in Africa
C	2	60	120,000	Partnered with a US university, parent NGO, and Foundation Y; ramping sales
D	4	21	450,000	Part of Multinational X 2006–2009; currently focused on fuel supply chain
E	11	2	450	Family-run business; initial customers were schools, now expanding to restaurants
F	1	Unknown	1000	Part of large consumer appliances multinational; moving cautiously and has just started operations
G	2	5	5000	Not-for-profit “social enterprise” selling stoves in India, Haiti, Africa
H	5	10	25,000	Private company that grew out of an NGO; seeking funding to grow further
I	1	5	40	Small for-profit company (same founder as Company J); starting to sell to street vendors
J	10	20–50	7000	Non-profit organization; declining sales and concerns about funding stability



**Fig. 1.** Stoves distributed to date (log scale) by the principal companies in our sample as a function of how long they have been selling stoves. Company A had not sold any stoves as of the time of this writing, and Company B is largely excluded from our analysis because its commercial focus is outside of India.

Companies C and D have both focused on the western state of Maharashtra as well as the southern states of Karnataka, Tamil Nadu, and Andhra Pradesh. The only states in which the companies do not overlap are Kerala, where only Company C operates, and Madhya Pradesh, where only Company D does. The companies cite cooking practices as the dominant reason for focusing on these states, with other reasons like biomass availability and concentrated populations also playing a role.

Company D started life in 2006 as a small division of a large multinational oil company X but was sold by Multinational X in 2009. Now it is privately owned by Indian entrepreneurs as well as the Indian managers who had run its operations under Multinational X (and now lead the company). The extensive market research and stove design and development work that underpins Company D's product and marketing strategy took place while the organization was still part of Multinational X.

Company C has also indirectly benefited from oil company resources, although through a charitable pathway rather than as a business unit. Foundation Y, supported by a large multinational oil company, not only supported preliminary market research and field testing (including through the activities of Company B

and others) but has also provided a majority share of the \$2 million start-up funding.<sup>12</sup> Further, Company C has benefited from the help of its parent company, an international NGO, which currently funds staff at a US University who provide stove R&D and top managerial functions.

Both Company D and Company C appear to have the potential of becoming self-sustaining businesses within several years, although this outcome is far from assured for either enterprise. Company C is rapidly ramping up stove sales and has momentum: The company sold 30,000 stoves in 2007–2008, 70,000 stoves in 2008–2009, and 20,000 stoves in the first quarter of 2009–2010.<sup>13</sup> Company D is still in a retrenchment phase following its separation from Multinational X. Without the deep capital reserves of Multinational X, Company D must now pursue profitability more aggressively, which has led among other things to a 60% increase since mid-2008 in the price it charges for the biomass pellets that fuel its stove. Company D has sold approximately 450,000 stoves in total, but usage as measured by fuel sales has dropped steeply since the beginning of 2009 in response to these price hikes. Since our original interviews in June 2010, Company D has focused more intensely on commercial customers, for which, unlike households, LPG is not subsidized and Company D's pelletized biomass fuel therefore remains economically competitive. This development has significantly improved the financial outlook for the operation.

In the remainder of this section, we consider how each of the six independent variables in turn has influenced the prospects for success of the stove businesses canvassed.

#### 4.1. Technology and design choices

The majority of the stove organizations surveyed ranked stove technology and design as among the most important success factors for the business. Company D and Company B representatives made the point that stove technology and design cannot be separated from the overall price-value proposition presented to

<sup>12</sup> Foundation Y initially worked with Company B to develop stoves and perform field tests. It then allowed open bidding for the commercialization phase, and Company C won the bid. Company B now operates mainly in Africa.

<sup>13</sup> These refer to fiscal years that span two calendar years. For example, the fiscal year 2007–2008 spans from April 1, 2007 to March 31, 2008.

**Table 4**  
Summary of some key business model attributes and results.

Organization	Selected independent variables					Dependent variables		
	Technology and design	Target customers	External enterprise funding	Channel involvement	Management experience (operations and marketing)	Scale	Sustainability (if current trends continue)	Rationale for assessment of financial sustainability
A	Incremental	Household	Private	Unknown	Limited	TBD	Unknown	Too early to assess
C	Incremental	Household (> \$7/day)	Donor	Significant	Significant	High	Likely	Self-reported possibility of positive cash flow in 2011 and profit in 2012
D <sup>h</sup>	Radical	Household (\$2–8/day)	Private	Significant	Significant	High	Unlikely	Household use has plummeted due to required fuel price increases
D <sup>hc</sup>	Radical	Household (\$2–8/day); commercial	Private	Significant	Significant	High	Likely	Commercial customers starting to help stabilize cash flow
E	Radical	Commercial	Limited	Limited	Limited	Low	Proven	Has demonstrated profits in sales to commercial segment
F	Unknown	Household (\$3–7/day)	Private	Unknown	Limited	TBD	Unknown	Too early to assess
G	Incremental	Household; commercial	Limited	Limited	Limited	Moderate	Possible	Self-reported expectations for profitability in 2010
H	Incremental	Household (> \$3/day)	Limited	Limited	Limited	Moderate	Possible	Selling moderate numbers of stoves but funding stream uncertain
I	Incremental	Commercial	Limited	Unknown	Limited	TBD	Unknown	Starting to sell to street vendors
J	Incremental	Household	Donor	Limited	Limited	Moderate	Unlikely	Declining sales; concerns on funding stability

## Notes:

- (1) Unshaded cells denote parameters for which we have no information or assessment is premature.
- (2) D<sup>hc</sup> takes into account Company D's burgeoning business serving commercial customers, while D<sup>h</sup> considers only the household customers that it originally targeted.
- (3) "Private" enterprise funding denotes any seed funding that was not charitable in nature, covering both operations started within for-profit companies (D and F) and independent operations receiving venture capital funding (A).
- (4) TBD ("to be determined") for scale means that the organization has sold few stoves because it is at a very early stage of operations.
- (5) The financial sustainability of Company E is classified as "proven" because it is the only company in the sample that reports being profitable.

the consumer. As indicated in Table 4, we characterized each organization's technology and design strategy as being either incremental or radical. The incremental strategy aims to provide a more advantageous cooking experience without requiring any fundamental change in user cooking habits. The radical technology and design approach seeks a more revolutionary improvement in cooking and associated activities but in the process asks a more dramatic change of customers, including possibly a change in fuel type and the means by which fuel is procured. All of the organizations in our sample except for Companies D and E followed a mostly incremental approach, at least for the stoves they had sold in volume so far. Company D employs the most innovative stove technology, in the form of a carefully optimized, gasification-type design. However, where Companies D and E both offer the most radical design proposition overall is in their reliance on processed biomass fuel.

Company D's design grew out of extensive market research during the Multinational X days, including through in-depth studies in which small teams would live in villages for months at a time to study and understand behaviors around cooking and other activities. These studies resulted in initial lists of over 30 potential value propositions that Multinational X could offer, which were then ultimately pared down to the final stove idea. The stove concept arrived at by Multinational X/Company D was a response to feedback that users really wanted a "total solution" for cooking, including to address perennial user difficulties obtaining quality fuel reliably, rather than just an incrementally better stove. The resulting stove, which was designed at the Indian Institute of Science, thus uses a design in which special biomass fuel pellets are gasified in a reaction chamber and the resulting gas is then mixed with additional air and burned.

Thermal efficiencies,<sup>14</sup> at around 50–55%, are among the highest among the demonstrated stoves in our sample. As long as Company D can dependably supply fuel pellets of consistent quality to users (an important caveat, as we will discuss later), the fuel supply concerns of customers will also be resolved. However, the operation of the stove is also significantly different from anything to which potential customers are accustomed. The fuel pellets are loaded into the chamber and kerosene is sprinkled on top of the pellets and lit. The kerosene flame initiates gasification of the top layer of pellets; the gasification then becomes self-sustaining, with the remainder of the pellets being progressively gasified and the resulting gas burned over the course of an hour. A battery-powered electric fan is required to force separate streams of air up through the pellets and to the burner. However, the stove has less flexibility – both in terms of flame and temperature control – than the LPG stove. Further, the stove has more parts that can fail than a traditional three stone "chulha".

Company C chose a much simpler technology. In the Company C stove, biomass of any type is fed into an opening in the side of the combustion chamber and burned to heat a pot sitting above. The essence of the combustion process is little different from that occurring in a traditional stove, but Company C has devoted significant effort to optimizing materials and geometries for this simple base configuration, incorporating feedback from emissions and other testing at the US University with which it partners.

<sup>14</sup> Thermal efficiency is defined as the proportion of fuel energy that is delivered to the cooking utensil. It is the product of "combustion" efficiency – the proportion of fuel energy converted to heat – and "heat transfer" efficiency – the proportion of heat being transferred to the pot (Venkataraman et al., 2010).

Company C estimates thermal efficiency for its top-of-the-line stove to be around 36%. As will be discussed further, the company has also focused on ensuring that its stoves are attractive, modern-looking products.

The fundamentally different technology/design choices of Company D and Company C create significantly different challenges and opportunities for their respective business models. First, Company D might in theory face more challenges in convincing consumers to adopt a new cooking approach. However, the fact that Company D successfully sold 450,000 stoves over approximately three years suggests that consumer unfamiliarity with a new cooking approach does not by itself present an insuperable obstacle to success. However, Company D accepts the fact that, to sell into the market, the product must be cost-competitive with the existing solutions, such as LPG stoves.

Second, Company C's technology means that it manages only one supply chain, for stoves, whereas Company D must manage two, for stoves and for fuel. (Company E could conceivably also need to become more involved in the fuel supply chain if it scales up and finds that existing supply of biomass briquettes is insufficient; for the moment, it relies on a combination of existing briquette markets and the output of one particular village-level briquetting plant.) Being a fuel supplier could provide an additional source of ongoing income for Company D while providing value to the customer, assuming pellets compare favorably to alternative fuels on price, quality, and availability. It also enables the company to better understand stove use, as fuel pellets can be distributed and tracked through the same dealers that sell stoves. In the very best case, developing a wider infrastructure for pelletized fuel in India could enable a wide variety of end-use applications, and allow the company to sell fuel directly to other users. So far, though, creating a viable supply chain for fuel has been among the most significant challenges for Company D. The original idea was to sell the stove at a discount price of around \$10 and make a profit by selling fuel pellets at \$0.13/kg. However, fuel supply challenges caused Company D to reconsider, and it has since roughly doubled the price of its stove and also raised fuel prices twice since becoming independent of Multinational X. The company was hit particularly hard in the 2008–2009 time period when prices more than doubled for bagasse, which was being used as the principal raw material for the pellets. The company is spending significant effort at the moment trying to diversify its raw material supply, for example towards ground nut husk, in order to stabilize input prices. The problem is made more complex by the costs of transporting raw materials over any significant distances.

Third, Company C's simpler stove design might may it less vulnerable to quality problems that would affect profitability and reputation in the marketplace. Company D has reportedly had difficulties at particular junctures with component reliability, including issues related to battery performance as well as corrosion of the inner chamber.

Manufacturing strategy is closely tied to the design of the stove. The great majority of organizations interviewed opted for a mass-production rather than artisanal approach. This near-consensus presumably reflects the recognition that mass production facilitates the cost and quality control needed to allow stove efforts to run as true money-making (or at least cost-recovering) businesses. Of the large existing stove producers, most had some or all manufacturing located in India to take advantage of proximity to customers and in some cases government incentives for local manufacturing. China is also a key manufacturing location for some organizations. Company D buys components for its India-based assembly from China. Company C has one assembly plant in Pune and one in China, though it says it plans to consolidate all manufacturing in India in the future. Company J was the one

organization in our sample that seemed to deliberately favor an artisanal approach, with women stove builders producing the stoves near the customer location. This choice probably has some grounding in the non-profit character of Company J.

#### 4.2. Target customer

A striking observation from our study is that none of the companies interviewed were truly targeting the very “bottom of the pyramid”—individuals earning less than \$2/day (see Table 3). The Company J representative stated this conundrum explicitly, saying: “We wanted to reach the very poorest segment [with our stove], but they don't have the money to afford it.” This appears to confirm the unsurprising notion that commercial business models have difficulty serving the poorest of the poor, even when companies have substantial enterprise financing like Company C or Company D (when it was part of Multinational X). Critically, urban households and households with higher incomes are more likely to purchase rather than collect biomass, which makes improved stoves significantly more likely to gain traction (Barnes et al., 2005).

The choice of which customers to target is integrally connected to these technology and design choices. Company D and Company H expect that 40–45% of their stoves will be bought as a substitute for LPG when that fuel is too expensive or not available. Company C representatives, on the other hand, estimated that 80% of their stoves will be replacing traditional biomass cooking methods. (All three companies estimated that about 10% of the use of their stoves would be at the expense of kerosene.)

Company C has taken what is arguably the safest commercial approach. It has reduced risk by sticking with a proven technology while appealing to relatively high-income consumers with attractive design and skillful marketing (to be discussed later). It has also been quite focused in targeting a particular demographic with which it feels its stoves can be competitive: buyers of wood fuel in rural areas.<sup>15</sup>

Company D hopes to offer household fuel buyers an attractive value proposition of a different sort. It offers cooking costs that are competitive with LPG and wood: 1 kg of Company D's biomass pellets, at \$0.17 (8 Rs), is equivalent from an energy perspective to 0.4 kg of subsidized LPG (\$0.21) and 4 kg of wood (typically also around \$0.21). The value proposition was of course much stronger at the pellet price of \$0.11/kg (5 Rs/kg) offered by Company D through the third quarter of 2008 and even the \$0.13/kg (6 Rs/kg) price in place at the time Company D separated from Multinational X. Company D's household consumers are of two main kinds. The first category is LPG users, who are always looking for secondary cooking sources given the limited supply of subsidized LPG. They buy the cookstove for a similar cooking experience at comparable cost. The second category is wood buyers, who might aspire to LPG and buy the stove for more LPG-like performance with less smoke and soot.

The choice of customer segment has implications both for the total welfare benefit of cookstove distribution and for the size of the market. We illustrate some possible effects on market size in Table 5. Targeting current LPG buyers, the table suggests, would mean addressing a market that is smaller than the total population of rural households that purchase firewood. In general, moving up the income and energy usage scale (compare, for example, the first and last rows of the table) shrinks the target market but also means that it may be easier to serve profitably.

An even more commercially viable target market than higher-income households is commercial or institutional customers,

<sup>15</sup> According to Company C, it is hard to find wood-buyer pockets in urban areas.



**Table 5**  
Estimated market size in number of households for different market segments in India.

Market definition	Estimated market size (households)
“Bottom of the pyramid” rural households (spend less than \$75/month)	114 million <sup>a</sup>
“Bottom of the pyramid” rural households that purchase firewood	30 million <sup>a</sup>
Rural households that use LPG	3.5 million <sup>b</sup>
Rural households in top two energy consumption tiers (> 30 W per capita)	60 million <sup>b,c</sup>

<sup>a</sup> Data from CDF-WRI (2010).

<sup>b</sup> Calculated by taking Pachauri and Spreng (2004) data for five-member households in India (constituting 20% of all households) and assuming that households of all sizes follow the same pattern as these five-member households.

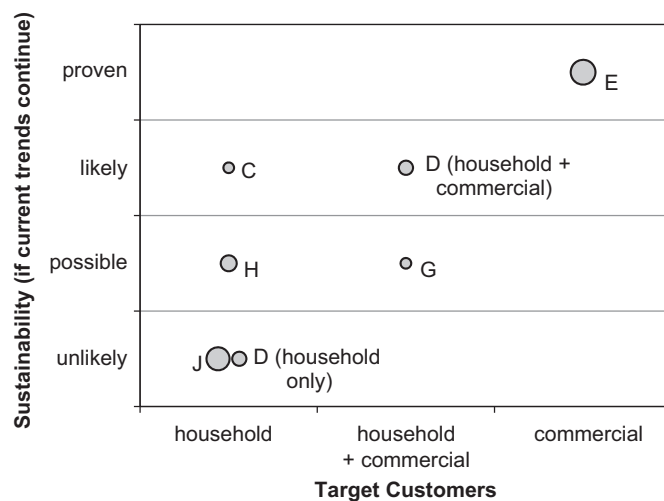
<sup>c</sup> Perhaps a more interesting candidate market to estimate would be the number of households in the top two energy consumption tiers who have incomes similar to those of LPG users but do not use LPG. Such a market is likely to be significantly smaller than 60 million households. However, such a calculation was beyond the scope of this paper.

although this means forgoing the potential health benefits of replacing unventilated, traditional biomass stoves in the home. The only business in our sample that reports being modestly profitable already (and for which we therefore classify financial sustainability as “proven” in Table 4), Company E, sells biomass briquette stoves to institutional customers, mainly restaurants. The attraction for these customers is simple economics. 50 kg of Company E’s briquette fuel, costing about \$6, is equivalent to 13 kg of unsubsidized LPG, for which such commercial buyers must pay \$10–20.<sup>16</sup> This results in a payback period of less than 6 months for the biomass cookstoves (in some cases less than a month).

Though it originally developed its business model around households as described above, Company D also noticed this powerful value proposition for restaurants and catering businesses that needed to buy unsubsidized LPG. Whereas household consumers using subsidized LPG might see a 20% reduction in fuel cost from switching to Company D’s biomass pellets (at the current 8 Rs/kg pellet price), commercial customers could easily realize a cost reduction of a factor of two or more. In follow-up interviews in April 2011, Company D reported that it had lost over half of its household fuel customers, largely in response to the increased pellet prices it has been forced to charge to cover costs since leaving Multinational X. While the company hopes that it can restore the competitiveness of its biomass pellets as a household cooking solution in the future, it has turned in the meantime to commercial customers to provide positive cash flow as it seeks to reduce costs in the fuel supply chain. As of the time of this writing, a substantial fraction of Company D’s fuel output is going to restaurants and caterers.

Though its operations have been limited so far, Company I has decided to target another food-related commercial segment: street vendors. The Company I representative argued that a street vendor burns approximately 10 times as much wood as an average family, so displacing existing stoves in this application with more efficient alternatives should be environmentally beneficial as well as profitable.

The overall message from our ensemble of interviews is that focusing on commercial customers appears to be a reliable route to enhancing financial sustainability in selling improved biomass stoves (see Fig. 2). At the same time, business success through this route does little in the near term to alleviate the health impacts of indoor air pollution, although there could be longer-term payoffs



**Fig. 2.** Sustainability of business model as function of customer segment targeted. The area of the circle representing each organization is proportional to the number of years that it has been in business (years since first stove sold, as shown in Fig. 1).

through the development of efficient stoves and markets for cleaner biomass fuels. Climate and environmental benefits could result if improved biomass stoves in commercial applications displace burning of firewood, with its attendant emissions of black carbon and other products with high global warming potential. Displacing commercial LPG use, on the other hand, will likely have only limited environmental benefits unless it somehow frees up LPG supply to displace firewood elsewhere.

#### 4.3. Financial model

One of the strongest differentiators of the relative success of these different organizations in getting a stove business off the ground was enterprise finance—whether they could secure upfront capital to finance the initial development of the stove business. All of the companies that distributed significant numbers of stoves (Company D, Company C, and Company B) needed significant enterprise financing to support the appreciable upfront time and money spent on customer research, stove design, and establishment of a supply channel.

The magnitude and stability of enterprise funding seemed more important to achieving scale than whether its source was private or charitable in nature. Company D in effect was incubated under its original parent organization, Multinational X, a large private oil company with correspondingly large cash

<sup>16</sup> According to the representative of Company E, LPG prices paid by commercial customers vary regionally, in part depending on whether a robust black market exists for LPG cylinders.

reserves. According to several current and former employees with whom we spoke, Multinational X initially showed no special urgency to earn returns from the stove business, in some sense treating the company as more of a charitable project than anything that would ever be material in comparison with its oil and gas portfolio. The fledgling cookstove effort at Company F is also taking place within a large multinational corporation, but one that as a consumer products corporation could more plausibly see stove sales as an organic extension of its business portfolio. Companies B and C, on the other hand, were supported by a non-profit organization, Foundation Y, that was backed by another major oil company. The foundation funded Company B (among others) to develop a stove, run field trials, and incorporate user feedback into the design. It then charged Company C with commercializing the improved stove business.

An obvious danger of relying on enterprise funding from a single large backer is that the business can be put in jeopardy if this funding disappears. Company B experienced this when it failed to receive continued support from Foundation Y for stove activities in India. Company J appears to be under serious threat due to the dissipation of much of its funding. The operation that became Company D was jolted by the decision of its parent organization, Multinational X, to exit the cookstove business (in the first half of 2009) as part of a broader strategy of refocusing on core oil and gas activities. In retrospect, it was probably inevitable that Multinational X would shed what was clearly a non-core and non-material business at some point. And yet Company D certainly benefited from being able to lay all the groundwork for its business and come to scale while having access to Multinational X's substantial resources.

Other companies, by contrast, remain stuck at the starting gate or unable to scale up further in the absence of substantial funding support.<sup>17</sup> Company H feels constrained in its ability to expand by limited funding. Small Company E received a small government grant that helped with initial stove design and development. It has generated modest profits from operations, but not sufficient ones, according to the Company E representative, to establish its own independent workshop for stove development and manufacture. In the absence of collateral, it reports having been unable to get a loan from banks, which has hindered its efforts to scale up.

Only after companies make it past the initial hurdle of procuring start-up funding is the viability of the ongoing financial model put to the test. The price point chosen for the stoves (see Table 6) is central to the company's business model and is of course closely related to the cost of manufacturing and the choice of target consumers as described above. Several companies initially priced the stove lower but then were forced to raise prices to make the business model more sustainable. (For example, Company D's basic model was initially marketed at approximately \$10 under Multinational X, but prices were later increased to approximately \$30.)

While the basic affordability of stoves is obviously important, none of the companies dedicated to household stoves saw lack of consumer finance as a major obstacle, and none of them have incorporated consumer financing into their business models in a significant way. Several representatives of stove companies expressed the view that, for the slightly more affluent consumers their household stoves are targeting, price should not really be an obstacle if the customer is convinced of the value proposition. However, companies are starting to look into consumer financing as a viable option to increase stove sales. Both Company D and Company C are involved in a pilot program with Foundation

**Table 6**  
Stove pricing for organizations in sample.

Organization	Approximate current price range of stoves
Company A	\$30–40
Company C	\$20–30
Company D	\$20–35
Company E	\$450 and up (institutional)
Company F	\$30–85
Company G	\$15–30 (household); \$300 (institutional)
Company H	\$6–30
Company I	\$300 (institutional)
Company J	\$5

Y to explore possible benefits of expanded consumer financing. Company B mentioned that they have successfully partnered with microfinance institutions to help distributors buy stoves. Sellers of higher-priced stoves for institutional use saw more of a niche for financing models that would provide direct assistance to consumers in reducing high upfront costs. Company E plans to start providing rental stoves, and Company I is working towards a customer finance model. Several companies selling household stoves mentioned that financing could play a more important role for their distributors, who need upfront capital to establish a stove inventory.

Another possible source of support would be government funds. Support from the Indian government to these stove sellers varied; in no case, though, did government support provide significant enterprise financing. Companies C, F, G, and I reported benefiting from government tax incentives; Companies B and G have received lump sum government grants; Company J has received some per stove grants; and Companies G and I have received R&D support from the government. Companies A, D, and H reported having received no significant government assistance of any type. A number of companies (including at least one that has received support) suggested that Indian government subsidy programs – past and present – have caused significant problems for their businesses. Though Company J did in fact receive some per stove grants from the government, the Company J representative said that the legacy of the previous government stove program, the NPIC, had proved detrimental to the organization's stove business by distorting or destroying markets. Even though NPIC was discontinued in 2003, the Company J respondent said that it has created an enduring expectation among potential stove customers that they should receive stoves essentially for free. Because of this, Company J has had to focus on markets that government subsidy schemes had not reached. In the case of stoves like those of Company D, Company H, and Company F that are potentially in competition with LPG, ongoing government subsidies for that fuel make the biomass alternatives less competitive. (At the same time, the subsidies can contribute to limited availability of LPG, which can actually help create a niche for LPG-like biomass cookers.)

Carbon credits for emissions reductions achieved with improved stoves are an additional potential revenue stream that could help make the finances of a stove enterprise more viable. The only two companies in our sample that reported revenue from carbon credits thus far are Company E, which estimated that about 20% of its income comes from sales of carbon credits, and Company G, which gets some minimal revenue (< 10% of total revenue) from carbon credits. Company C is working with J.P. Morgan, which already supports Company E's carbon crediting process, to assess the possibility that it too could sell credits on the voluntary market. However, relying too heavily on carbon finance could carry significant risk. In addition to high transaction costs (a factor mentioned by one respondent), carbon credits could create significant

<sup>17</sup> Subsequent to our interviews, Company A received venture capital funding, which will make it a unique and instructive case to follow going forward.

volatility in revenue flows due to both regulatory risk and carbon price fluctuations (Bumpus and Liverman, 2008). Given the need for enterprise financing discussed above, it may be that a more promising approach to carbon finance for stove businesses would be to have a third party buy the rights to an anticipated future credit stream and then provide an upfront payment which the stove seller could use to build and expand the business.

#### 4.4. Marketing strategy

Building consumer awareness about one's product was certainly recognized by the companies in our sample as being important to their businesses. All of the companies with significant current operations reported that at least 10% of their operating expenses went to advertising and brand awareness. Of the companies in our sample, Company C has probably applied the most creativity and effort to building brand awareness, with efforts including a "Bollywood"-based advertising campaign. Company C is also the only company in our sample (of which we are aware) that has used marketing tie-ins with other products, partnering with a telecom provider to provide the cookstove for \$27.66 when bundled with a mobile phone. This campaign aligns well with Company C's strategy of positioning its stove as an aspirational product. Company D has also deployed various marketing efforts including television advertisements in order to position the stove as an aspirational product that it is "as good as LPG."

At the same time, every single responding company in our sample identified product demonstrations as the most important driver of their stove's adoption in the marketplace. This suggests that, while media marketing may be important to attract early adopters, the fate of a given stove will ultimately stand or fall based on the combination of its own merits and the success of the company in developing a viable supply channel that can bring a large number of people into personal contact with the product (see Section 4.5). Corroborating this observation is the fact that Company J was second to Company C in the percentage of its operating expenses that went to building awareness, but this did not by itself create a sustainable business in the absence of solid base funding and a well-developed distribution channel.

#### 4.5. Channel strategy

Indeed, the companies that have achieved volume in our sample have focused significant attention on building out a scalable supply channel and remained actively involved in managing this channel. Company D and Company C (and Company B before) have followed remarkably similar strategies in this area. Both companies partnered heavily with women's self-help groups to quickly develop a core of village-level entrepreneurs who could sell the stove. In both cases, the dealer networks were diversified by adding proprietors of retail outlets. Both companies rely on two-level networks in which the company sells to a distributor, who in turn sells to the retail outlet or village-level entrepreneur. In both cases, margins typically run around 5–10% for the distributor and 10–15% for the retailer. Notably, Company D and Company C both tracked and managed their two-level networks much more actively down to the retailer level, including by collecting and responding appropriately to regular data on sales. This more aggressive and focused approach to distribution might partly explain how these companies have ramped up their stove distribution so quickly.

Most of the other organizations in our sample were not as sophisticated in the development of supply chains or as heavily involved in their management, although it may be difficult at times to determine whether a less developed supply chain is a cause or an effect of limited operational scale. Companies G, H,

and J appear to manage only the first level of a supply network, in which the central organizations sell to distributors and provide some centralized assistance in publicizing the product but do not involve themselves significantly in what happens to the stoves after that. Company E sells directly to customers, although this model might be challenged as the organization expands its distribution.

An intriguing finding was that none of the companies interviewed ranked after-sales support as one of the more important determinants of their success. One interpretation of this is that these companies are unwisely ignoring an area that has proven to be a pitfall for stove programs in the past, notably including the Indian national cookstove program (Barnes et al., 1993). A more charitable view is that these organizations may indeed appreciate the importance of good customer service on the back-end but are currently struggling with more immediate threats to the survival of their stove businesses. One benefit of the effective supply channels that Company D and Company C have developed is that these channels can be leveraged for customer support. In Company D's case in particular, the company necessarily continues to have ongoing contact with customers through its fuel sales.

#### 4.6. Organizational characteristics

We next consider whether the characteristics of the organization selling stoves might help to pre-condition the various other choices discussed above as well as the outcomes achieved in these areas. One striking finding of our interviews was that the two companies that have sold the most stoves in India – Company D and Company C – have markedly more management experience in marketing and operations as measured in person-years than any of the other companies in our sample (see Figs. 3 and 4). In the specific area of stove technology, on the other hand, the management of these three companies does not on average have substantially greater or lesser experience than in the other cases (see Fig. 5). This finding may suggest that their greater depth of experience in certain key business skills has helped these companies build out more effective operations at scale—for example, by enabling them to develop and manage a robust supply chain. Companies like Company H and Company J with more of an NGO heritage may struggle to commercially disseminate even a strong product.

Company D's origins within a large multinational company suggest that generous corporate backing can be one route to creating a large-scale energy business serving the poor. The support of Multinational X was critical in covering salaries,

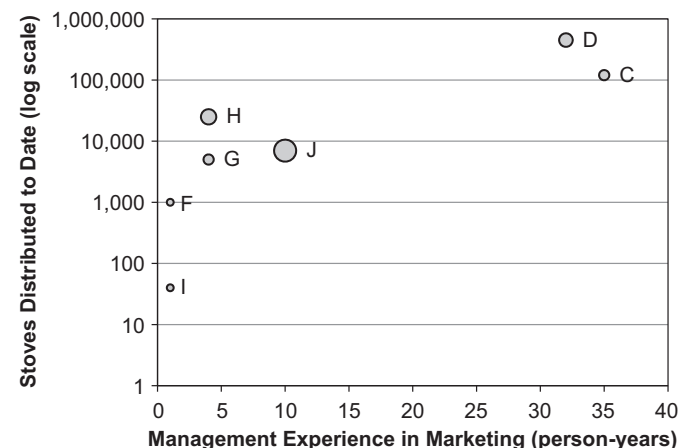


Fig. 3. Stoves distributed to date as a function of combined management experience in marketing. (Area of circle is proportional to number of years since first stove sold.)

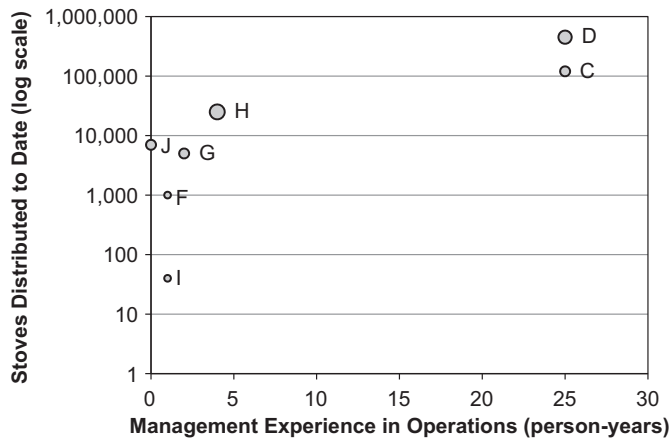


Fig. 4. Stoves distributed to date as a function of combined management experience in operations. (Area of circle is proportional to number of years since first stove sold.)

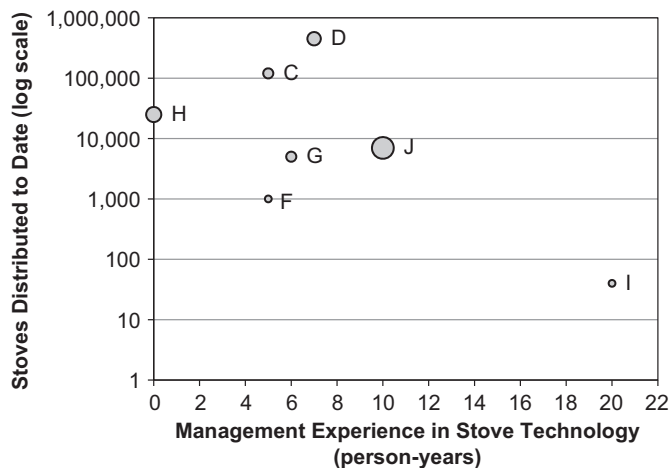


Fig. 5. Stoves distributed to date as a function of combined management experience in stove technology. (Area of circle is proportional to number of years since first stove sold.)

market research, stove design and development, and early supply channel development. The experience of Company D also suggests that this is an unpredictable path to success, as changes in leadership can cause large profit-maximizing companies to rapidly change strategy in areas that are not material to their businesses. Funding from such entities does not always represent the “patient capital” that seems to be required in the initial stages of business development. At the same time, Company D’s trajectory – strong and patient initial backing from Multinational X and then the experience of being divested to succeed or fail as a truly sustainable commercial enterprise – may yet position it to mature into a truly sustainable commercial enterprise. The cookstove effort under Company F may provide an interesting new data point of a large multinational for which the cookstove business is more directly related to its core activities.

Company C was never part of a larger for-profit enterprise in the same way, but substantial funding from Foundation Y (itself supported by a major oil company) has covered start-up and development expenses for the operation just as Multinational X helped seed Company D. Despite its non-profit status, Foundation Y appears to be at least as demanding in expecting results from Company C as Multinational X was from Company D. Ideally, the funding provided by Foundation Y may be more stable because it

is not subject to the changing objectives of a large for-profit corporation.

One attribute that was common throughout our sample, even among the most business-minded organizations, was modest expectations about expected returns from the stove business. While all of the organizations in operation hoped to break even and create self-sustaining businesses, none expected returns that would thrill venture capitalists. Company D says it is aiming for EBITDA (earnings before interest, taxes, depreciation, and amortization) margins of 7–8% over the longer term. Company C targets *net* margins of perhaps 1% and at most up to 3–4%. These targets reflect an encouraging realism about serving low-income populations. These companies believe that financial sustainability is possible, but not that massive profits are likely to materialize in such a low-margin segment.

## 5. Conclusion

Commercial cookstove efforts in India remain too immature and too few to allow a definitive assessment of whether such businesses are sustainable at scale over the longer term. However, the above comparison of the enterprises that do exist suggests some provisional conclusions.

First, with the right combination of enterprise funding and management expertise, commercial cookstove operations in India have demonstrated their ability to scale up to stove distributions of at least several hundred thousand. Most encouraging is the fact that Company D and Company C have both managed to create a legitimate value proposition for consumers through well-designed, commercial products distributed through well-conceived supply networks. Neither company would have been able to distribute the stove quantities they have on commercial terms without offering something customers wanted to buy—in Company C’s case an attractive, well-engineered version of a traditional technology, and in Company D’s case an LPG-like fuel that was cheaper and more readily available than either LPG or purchased firewood. Many previous government and NGO programs simply failed to offer consumers anything that made a switch away from traditional cooking methods compelling. There can be a temptation to blame consumers for failing to recognize the health or other benefits of a new technology. Company D and Company C instead have respected the priorities of their potential customers and provided them with something they value on their own terms. Whether these companies ultimately succeed will depend on execution and whether their value proposition can actually be provided at a profit over the long term. Company C’s business model is probably less risky, while Company D’s is more revolutionary in trying to create an entirely new fuel supply chain.

Second, commercial stove operations have encountered some harsh tradeoffs between financial sustainability and the ability to deliver substantial health benefits to a large population. Serving commercial customers offers better profit potential than serving households, in part because it avoids competition with government-subsidized fuel. However, focusing on the commercial segment also means forgoing many of the desired health benefits of replacing traditional biomass stoves in the home. Most of the companies in our sample remain focused at least in part on the household segment, but none of them reported being able to reach the poorest of the poor while remaining a commercially viable operation. Instead, the target household customers generally had higher incomes, which often meant that the improved biomass stoves were displacing LPG use rather than traditional biomass burning, further reducing the health benefits of commercial stove activities. Through its focus on marketing an incrementally better stove to rural buyers of biomass, Company C

probably shows most promise for displacing significant traditional biomass burning while remaining financially sustainable. On the other hand, if organizations like Companies D and E can help develop robust and cost-effective supply channels for processed biomass fuel through a near-term reliance on commercial customers, these fuels could ultimately diffuse back into household markets and thus finally achieve the desired goal of reducing indoor air pollution. (Development of a processed biomass supply ecosystem based on agricultural waste could also provide increased revenue to farmers and climate benefits through limiting the burning of agricultural waste in the fields.)

Third, though government assistance in the past has often done more harm than good in stove and fuel markets, it could play a useful role if policies are targeted and well thought-out. One potentially beneficial role could be to provide assistance in the upfront aspects of cultivating stove businesses, rather than in the provision of ongoing subsidies as was so damaging in the national stove program. The federal and state governments could also fund basic and applied research on stove technologies. Lump sum grants to companies in the early stages of stove business development might be useful as well, according to some respondents. The government might serve as an aggregator to help stoves receive carbon credit, as the Indian Bureau of Energy Efficiency (BEE) did in helping compact fluorescent light bulbs receive carbon credits under the Kyoto Protocol's Clean Development Mechanism (MNRE 2009). The government could also play a useful role in publicizing the dangers of indoor air pollution and promoting stoves and cooking methods that would reduce it. Perhaps most importantly, as mentioned by several companies in our sample, the government could help create standards and perhaps even efficiency labels for cookstoves. The Energy Star program run by the BEE is one step in this direction. The current lack of objective standards in the market is a major obstacle for companies in differentiating their products based on quality and performance.<sup>18</sup>

As far as ongoing support is concerned, the most important advice to government from the companies interviewed was to eliminate or mitigate market distortions resulting from financial supports for alternatives to improved biomass stoves. As one example, Company D competes with heavily subsidized LPG on the supply of fuels and with biomass-to-power (subsidized through feed-in tariffs) on the procurement of raw material for fuel. To provide a level playing field, the government might look at either eliminating LPG subsidies or providing equivalent subsidies to biomass fuel for stoves,<sup>19</sup> although caution would be necessary with the latter option to avoid creating still more unintended consequences. In other ways, too, the companies interviewed felt that the sustainable cookstove market does not get enough policy help, including because these stoves are not recognized as renewable energy devices. For example, Company C mentioned that it would benefit from more favorable tax treatment like excise tax exemptions on imports of stoves and stove components from China.

<sup>18</sup> One of Foundation Y's early initiatives in the cookstove space was in fact aimed at defining stove standards, but the effort ran into some controversy due to the fact that the non-profit defining the standards also had its own stove in the market.

<sup>19</sup> According to the representative of Company D, government support of \$25.5 million would be required to reach another 1.2 million households (through a biomass subsidy of approximately \$0.063/kg). He argued that this support would (a) allow another 1.2 million stoves to be disseminated; (b) result in an annual biomass based fuel output of 300,000 more tons; (c) have the advantage that more than 1/3rd of this support (\$9.57 million) would flow back as income generation and jobs in rural India for people to aggregate, collect and store biomass; (d) would save over 100,000 tons of carbon compared to LPG stoves; and, most significantly, (e) would save around \$31.9–42.6 million annually in avoided LPG subsidies.

Fourth, this study suggests some potential models for that hard-to-define entity that mixes business and charity, the “social enterprise.” The key success factor for the companies in our sample was patient upfront capital with low expectations for return coupled with urgency and acumen in developing and managing the supply chain. This is probably a good template for social enterprises more generally. The inevitable tension is that too-easy capital can diminish the urgency around making money in ongoing operations. For example, it is doubtful whether Company D's business would ever have become as lean and aggressive under Multinational X as it is now; at the same time, it would never have developed to the point it has without the generous support of Multinational X at the outset. One way to help maintain an aggressively bottom-line-oriented approach in supply chain development is by importing significant management and operational talent from the private sector—people who are so much in the habit of optimizing returns that they do not let up just because they find themselves in a “social” sector. If a few of these ambitious entrepreneurs are able to break through with scalable, sustainable, and replicable business models to serve the Indian stoves market, it may encourage the wider use of commercial models for serving the poor, even if not those truly at the “bottom of the pyramid”.

We focused in this study on the Indian market for improved stoves, but the potential market for these products is global in scope. In subsequent work we seek to expand the current research to cookstove endeavors under way elsewhere around the world.

#### Reference list of interviews

Company	Designation	Date of interview
Company A	Founder and Chief Executive Officer	Apr. 28
Company B	President and Chief Executive Officer	May 11
Company C	Managing Director	May 12
Company D	Managing Director	May 10
Company E	Chairman and Managing Director	May 4
Company F	Senior Manager—Consumer Marketing (Rural), Strategy & Business Development	July 16
Company G	Director	June 18
Company H	Founder Director	May 13
Company I	Chief Executive Officer	May 11
Company J	Chief Executive Officer	Apr. 30
Company K	Executive Director	May 17
Company L	Owner	May 8

#### Appendix A. Supplementary Information

Supplementary materials associated with this article can be found in the online version at doi:10.1016/j.enpol.2011.07.031.

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