GrOW
Research Series

Opportunities and Constraints for Women's Employment and Entrepreneurship in Renewable Energy

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GrOW Working Paper Series
GWP-2017-10 – Research Contribution Paper

ISID
INSTITUTE FOR THE STUDY
OF INTERNATIONAL DEVELOPMENT

Produced with support from McGill University and the International Development Research Centre (IDRC). Working papers are in draft form and distributed for purposes of comment and discussion only. The observations and views expressed in this working paper are the sole responsibility of the author(s).

Abstract

This paper identifies opportunities and constraints that low-income women face in accessing livelihoods in the renewable energy sector in India through research conducted in collaboration with The Energy Resources Institute (TERI) and the Self-Employed Women's Association (SEWA). Whereas previous research has focused on women mostly as end users of solar and biomass technologies, this research attempts to also understand women's potential as entrepreneurs, facilitators, designers and innovators. Findings reveal that although their access to technology and employment in the energy sector is limited by inadequate purchasing power and low social status, there is tremendous potential to create livelihoods for women at all levels of the energy supply chain. Broader findings indicate that women can gain optimal traction from employment in the renewable energy sector only if there are wider socially progressive policies in place, including state intervention to create robust social welfare infrastructure and quality public services accessible to all.

Keywords

Gender, women, green economy, development, renewable energy, India, South Asia

Introduction

Countries around the world are experimenting with ways to make their economies greener by developing less polluting technologies, creating new green jobs, or by retrofitting existing sectors such as forestry, agriculture, tourism, manufacturing, waste management, construction, public transportation and energy production (Rajagopal 2007; International Labour Organization 2011). A gendered analysis of green growth and development strategies reveals at least two very problematic blind spots. First, women are known to have weaker access to new technologies almost everywhere in the world (Rosser 2005; Hafkin and Huyer 2006) so there are likely to be unequal access issues inherent in the transition to low-carbon economies. Second, it is well-established not only that 70 percent of the world's poorest 1.3 billion people are women and children (UN Women 2014) but also that women are already very poorly represented globally in sectors like construction, renewable energy, manufacturing and public transportation that are critical to the green economy. Women account for 9 percent of the global workforce in construction, 12 percent in engineering, 15 percent in financial and business services, and 24 percent in manufacturing. Women have also long been marginalized in the energy sector where they constitute less than 6 per cent of technical staff and below 1 per cent of top managers (UN Women 2012). If issues of gender equity are not addressed proactively and systematically, the green economy may do what the green revolution did in the 1970s - boost economic productivity by putting capital and technology in the hands of wealthier, predominantly male, farmers while marginalizing and making women in the agricultural sector even more invisible and vulnerable to poverty than they already were. Authors like Ross (1998) have described how market-based solutions like the green revolution end up entrenching rather than subverting social inequalities. In the absence of appropriately targeted training, education, apprenticeships, employment placement, financial tools and supportive social policies, the green economy may exacerbate existing gender inequities and hinder poverty alleviation goals. Gender-blind approaches to economic development and environmental protection - regardless of whether they are driven by governments, civil society, private corporations or international aid - have tended to marginalize women in their roles as workers, consumers and citizens. For the green economy to be socially inclusive, gender equity issues must be addressed. The terms "green" and "low-carbon" economy are used interchangeably in this paper. There is a lot of debate and contradiction about the definition of these terms. For the purposes of this paper, a green economy is defined as one that produces lower greenhouse gas emissions; uses resources more efficiently; and generates income and jobs while paying attention to social equity and inclusiveness.

To enable the transition to a gender-sensitive global green economy, we must (a) understand the opportunities and constraints women face in accessing green technologies and livelihoods and (b) document and analyze concrete examples from around the world of making green technologies, education, training and financing affordable and accessible for low-income women. Assembling such a body of knowledge will enable us to formulate appropriate programs

and to advocate for policies to ensure that green technologies and livelihoods do not remain unaffordable and inaccessible for low-income groups in general, and women in particular.

A review of the existing academic and practitioner literature reveals very little empirical research devoted to understanding how to optimize low-income women's ability to participate in the green economy. One of the only broad-based pieces of literature on gender and the green economy is a framing document that was put together by the Rio+20 Women's Steering Committee. It describes all the social, economic and environmental benefits that could accrue from women's greater involvement in different sectors of the green economy from agriculture, fisheries and forestry to water, sanitation, waste management and renewable energy but there are no descriptions of existing initiatives aimed at increasing women's participation in the green economy (ENERGIA 2011). Another background paper, commissioned by UN Women in advance of the Rio+20 conference in June 2012, engages with the definitional dilemmas, philosophical underpinnings and contradictions of the green economy while documenting women's participation in its various sectors in different parts of the world (Tandon 2012). Perhaps because the paper was intended as an effort to catalogue women's participation, it does not provide us with any evaluations of existing green initiatives. Similarly, a draft report - produced by the International Labor Foundation for Sustainable Development (see Stevens 2009) describes existing programs but does not provide empirical evidence about how well or badly such initiatives may be working to meet their stated goals.

This paper will contribute modestly towards addressing this knowledge gap through empirical research conducted in India with two organizations - The Energy and Resources Institute (TERI) and the Self-Employed Women's Association (SEWA) - that not only design and disseminate green technologies but also provide training and financing to enable low-income women to earn incomes in key sectors of the green economy. It will identify specific challenges and opportunities women face in accessing green technologies and livelihoods in the clean energy sector. TERI is India's leading government-funded think-tank on sustainable energy. Its mandate includes advocating for universal energy access, promoting renewables and energy-efficient technologies, influencing policy and disseminating knowledge on sustainable energy. SEWA is a trade union founded in the city of Ahmedabad in 1972 to organize low-income women for better working conditions and social security provisions. The initiatives analyzed in this study are (1) TERI's Lighting a Billion Lives (LaBL) program, which introduced solar lighting in rural communities across India and (2) SEWA's Hariyali Green Energy project, which distributes energy-efficient stoves and solar lanterns to its members in various urban and rural locations in India.

Research for this study included assembling and analyzing (1) existing academic and practitioner literature on gender and the green economy and (2) quantitative and qualitative data on women's participation in the LaBL and Hariyali projects as well as other renewable energy initiatives in India. TERI and SEWA provided current baseline data about LaBL and Hariyali as well as annual reports and other documentation about their activities and accomplishments. TERI also

provided data from a study conducted in 2012 in Rajasthan to evaluate the effectiveness of the LaBL program in reducing poverty, creating economic opportunities and promoting gender equality in rural communities. The TERI study relied on surveys to collect quantitative data (about household-level savings generated from switching to solar energy, for example), focus groups with men and women in 5 villages in Rajasthan to document end user benefits and constraints, and a series of 5 in-depth interviews (3 men and 2 women) to understand the opportunities and constraints faced by entrepreneurs who operated solar charging stations.

This data was complemented with a series of 10 interviews with energy sector practitioners in NGOs and the private sector; and program management and policy staff from SEWA, TERI and SELCO Solar, a social enterprise based in Bangalore that works with SEWA to design clean energy technologies for low-income households and small businesses in rural and urban India. The interviews provided information about (1) the challenges and opportunities of making technologies and financial services accessible to low-income households and (2) their experiences of advocating for pro-poor and pro-women energy policy at a broader state and national levels.

Although TERI and SEWA provided up-to-date sex-disaggregated data about technology users, entrepreneurs and access to financial services, the lack of regional and national sex-disaggregated data on energy sector employment limits the ability to draw broader generalizations from this research. The Ministry of New and Renewable Energy and the Confederation of Indian Industry, for example, maintains extensive statistics on employment in the renewable energy sector in India but the data is not sex-disaggregated. Despite the inability to generalize more broadly from the findings of this study, complementing existing quantitative data from the LaBL and Hariyali projects with ethnographic data collected through interviews and focus groups did reveal a range of previously undocumented challenges and opportunities faced by women in the renewable energy sector. Since this research is exploratory in nature, its findings shed light upon problems that may well warrant more detailed investigation. The issues identified by this research may provide the grounding and detail against which other research, perhaps using very different methodologies, can be tested and verified.

An overview of the two (LaBL and Hariyali) renewable energy initiatives

Lighting a Billion Lives (LaBL) is a decentralized solar lighting initiative that is being implemented by TERI in 16 states in India in a total of 640 rural communities that are either un-served or under-served by grid electricity and rely on kerosene or wood for lighting and cooking. LaBL is operated on a fee-for-service model. Solar Lantern Charging Stations (SLCS) are set up in villages and lanterns are rented to households and enterprises for a daily fee. A typical SLCS consists of 50 lanterns, 5 solar panels and 5 junction boxes. The lanterns either have compact fluorescent lamps (CFLs) or light emitting diodes (LEDs) and provide 4-5 or 6-7 hours of light respectively.

The charging stations are operated and managed by local entrepreneurs trained by LaBL associates from TERI. At INR 200,000 (USD 3,250), the initial investment needed to start a charging station is high and unaffordable for most rural people. However, LaBL has succeeded - through collaborations with private sector Corporate Social Responsibility (CSR) initiatives and government and donor agency schemes - in minimizing the initial cost (and therefore the risk) to the entrepreneur of setting up a centralized charging station. The daily rental fee for a large and small solar lantern is INR 5 (8 cents US) and INR 2 (3.5 cents US) respectively. A part of the revenues earned from renting lanterns is used to meet the operation and maintenance cost of the charging station. The remainder constitutes the entrepreneur's profit. Although LaBL associates try to preferentially recruit women to operate the charging stations, the program does not have an explicit gender equality focus. Women currently make up fewer than 5 percent of the 640 rural entrepreneurs who operate SLCS across India. The 5 villages in Rajasthan included in the study conducted by TERI in 2012 were selected purposively because 2 of them had female LaBL entrepreneurs.

SEWA is a member-based organization of 1.75 million self-employed women workers across 12 states in India that provides microfinance, insurance products, livelihood and financial training, rural production and marketing, and housing services. Lack of access to affordable and clean sources of energy affects the lives and livelihoods of low-income women negatively. SEWA responded to this problem by developing suitable technologies and disseminating them to its members. SEWA Bank became the first organization in India to provide loans targeted specifically at enabling women to acquire clean energy technologies. Members can access these loans to purchase solar lights and cookstoves for use in their homes and businesses. Larger loans are available for those who want to start entrepreneurial ventures to sell, rent and repair the same technologies. To consolidate and scale up its existing work in the energy sector, SEWA started the Hariyali Green Energy Campaign in 2009 aimed at distributing energy-efficient cookstoves and solar lanterns to members across India. SEWA solicited designs of suitable technologies manufactured in India in 2010. A total of 13 stove models were field tested for 10 days on average by 137 members and judged for user-friendliness, fuel efficiency (with a variety of raw and processed fuel sources), low emissions, portability for indoor and outdoor use, durability, service warranties and effects upon household savings. A total of 16 solar lantern models were evaluated for similar values as well as ancillary benefits such as the availability of built-in mobile phone charging outlets. Design improvements were made by manufacturers based on user feedback. The campaign was officially launched in September 2011 and the selected technologies were offered to members, either for sale at maximum retail price, or through credit financing. A package, comprised of a cook stove and a lantern, costs about 100 USD (5,996 INR) and can be paid back in 16 installments of 7USD (420 INR) per month. Using financing provided by the ICICI Bank of India (and guaranteed by the International Finance Corporation), SEWA plans to reach 1 million households over the next 5 years. Hariyali is currently one of the largest green energy projects in the world (IFC South Asia 2011).

By 2012, five models of cookstoves and 4 models of solar lights were being distributed in the states of Gujarat, Jammu and Kashmir, Assam and Rajasthan. The cookstoves require 40 percent less fuel than existing stoves, reducing time spent gathering wood by as much as an hour per day per household (SEWA-Hariyali 2012). The reduction in wood used for cooking will also result in consistent annual reductions in carbon emissions. Monetizing these reductions through the sale of carbon credits would create additional income for SEWA members.[1] In addition to scaling up access to decentralized renewable energy in India, SEWA hopes Hariyali will create a replicable environmentally-sustainable business model in other parts of Asia and Africa.

Findings

Opportunities and constraints perceived by end users

Close to 2 billion people gained access to electricity worldwide between 1990 and 2008 (International Energy Agency 2010) but it is estimated that more than 1.3 billion people still lack access to electricity while another 1 billion have unreliable access. More than 90 percent of rural areas in India are electrified and the Government of India has recently embarked upon a major program of grid extension and strengthening to achieve 100 percent household electrification by 2019. Despite such progress, there continues to be a strong need for access to decentralized on- and off-grid energy technologies such as wind, solar and micro hydro-power. Many rural and urban communities continue to supplement their energy needs from other polluting or flammable sources such as kerosene, firewood, animal dung and agricultural residue because they either do not have reliable access to electricity or because they cannot afford the cost of electricity (Clancy, Skutsch and Batchelor 2003). Additionally, grid electrification does not always ensure equitable access for women and men (Cecelski 2004). The grid in many rural communities often extends only to spaces that are typically occupied by men, the courtyards of households and agricultural areas, for example (Dutta 2003). Since rural women in India typically spend more time in their homes, they may not benefit equitably from grid extension.

By increasing access to reliable and affordable sources of decentralized clean (or cleaner) energy, initiatives like Hariyali and LaBL benefit households that are un-served or underserved by the grid as well as those that need to diversify their energy sources to save money. The communities in which the two initiatives are being implemented are typically at least partially served by the grid but the solar lanterns and cookstoves were widely adopted because the supply

[1] The concept of carbon trading has been met with strong opposition from critics who are concerned that far from reducing greenhouse gas (GHG) emissions, it simply advances the commercialization of the atmosphere and the creation of new sources of accumulation and speculation for finance capital (Edgardo Lander 2011). In a similar vein, Pio Verzola, Jr. and Paul Quintos (2011) call them at best questionable since they don't truly reduce global GHG emissions, but only pass the responsibility to mitigate from one entity to another. I consider these criticisms valid and well-justified but cannot ignore the practicality of enabling a member-based organization of poor self-employed women to benefit financially from their efforts to reduce GHG emissions.

of electricity is characterized by frequent voltage fluctuations and black-outs and because there are no other renewable energy projects operating in these areas. The need for diversification of home energy products in India is borne out by national-level data. The annual market for solar lanterns and cook stoves was estimated at $500 million and $400 million respectively (BusinessLine 2012).

Researchers and policymakers have paid close attention to decentralized renewable energy technologies because of the positive impacts on poor communities in general, and women in particular. That such programs offer benefits beyond lighting and cooking has also been noted (Reiche, Covarrubias and Martinot 2000). The Hariyali and LaBL initiatives provide economic benefits and also improve health and living conditions of poor urban and rural households. The biggest economic benefit identified by households that rent or own solar lanterns is savings. A rented solar lantern costs only INR 2 per day while kerosene costs INR 15 per liter even through the subsidized ration card system that is designed to meet the needs of Below Poverty Line (BPL) households. If a kerosene lantern is used for 4 hours a day, a liter of kerosene would last only 2 days. Since each household can purchase only a limited amount of kerosene through the public distribution system, any additional purchases must be made at much higher prices. Some families continued to purchase kerosene at subsidized rates but because their household lighting needs were being met by solar lanterns, they could use the kerosene for other activities such as running pump sets for irrigation. Some people also continued to use battery-operated flashlights and candles for activities like patrolling agricultural fields and watering crops at night but the cost benefits of using solar lanterns were so significant that most families had started renting additional solar lanterns for these purposes. A powerful battery-operated flashlight costs about INR 400 and 2 batteries typically cost about INR 20 and provide only about 12 hours of light. A candle may cost only INR 2 but, much like a kerosene lamp, does not provide more than an hour or two of dim light. Since the solar entrepreneurs were responsible for maintaining the lanterns in good condition, renting households were also able to avoid the cost of repairing lanterns. They had to assume the costs of repair if they owned kerosene lanterns or flashlights.

The availability of solar lanterns had created other economic benefits. Many farmers attributed less damage to crops to their ability to sleep in the fields at night with the solar lantern set to ‘dim’ to ward off thieves and wild animals. Unlike kerosene lamps or candles, which they had relied on in the past, solar lanterns can also be used in rainy and windy weather conditions. Vegetable farmers benefited from being able to reduce their expenses on water by sowing their fields and watering crops at night with the help of a solar lantern. They also reported earning an additional INR 2 from each kilogram of vegetables sold by harvesting, grading, sorting and packaging vegetables at night and delivering the produce to the market earlier in the morning. In the past, these activities had to be completed during the day or at dawn. There are many other examples of benefits accruing to people when a reliable energy source makes it possible to complete livelihood and other activities during non-daylight hours. Livestock farmers, street vendors, petty shop owners, midwives, service providers and home-based workers have reported

economic benefits from the extension or flexibilization of working hours. Others have been able to take up new economic activities or optimize old ones due to the availability of a reliable lighting source. Tailoring, tutoring children, preparing food for catering and doing home-based piece work are a few examples that were mentioned frequently.

Authors like Vera Mkenda-Mugittu (2003) have emphasized that the impact of introducing new technologies is generally negative on women's work burdens and serves simply to reinforce their subordinate status and position relative to men. Speaking more specifically about energy technology, Álvaro Fernández-Baldor, Alejandra Boni, Pau Lillo and Andrés Hueso (2014) have reported findings in Peru that electrification can cause extra work for women and reinforce their reproductive role. They report, for instance, that it is common for men to extend their leisure time in the evening, by watching television or playing an instrument, for example, while women simply extend their working time by continuing livelihood or family maintenance activities. The research conducted by TERI does not indicate whether this may also be true in rural Rajasthan. What the findings do indicate consistently is that both men and women expressed satisfaction at being able to improve their own and their families' welfare by completing livelihood, family maintenance and leisure activities after dark.

The major reported benefits to users from the Hariyali cookstoves are greater household savings due to increased fuel efficiency; reduced drudgery for women and children who typically collect firewood; improved health and living conditions due to reduced emissions; reduced incidence of home fires; and more time for leisure and livelihood activities due to reduced cooking time. We can look at each of these findings in more detail.

The three-stone stove is the traditional means of cooking used in poor rural and urban homes across India. Women may cook up to three meals a day on these stoves and women and children often spend up to five hours a day in smoky kitchens in poorly ventilated homes. Inhaling smoke and soot [black carbon] causes respiratory diseases and also contributes to global warming. The World Health Organization (WHO) considers smoke from cookstoves to be one of the five biggest threats to health in developing countries. In India alone, 1.5 million people die every year from inhaling polluted indoor air. Children (44 percent of total deaths) and women (60 percent of adult deaths) are disproportionately represented in these numbers (ENERGIA 2006a). Cooking with solid fuels is responsible for about 3 percent of the world's disease burden (ibid.). Globally, 3 billion people are estimated not to have access to improved cooking technologies (IEA 2010).

Typical exposure to indoor air pollutants in homes with access to improved cooking technologies ranges between 25 and 50 micrograms per cubic meter per day (Balakrishnan 2009). For a household that does not have access to improved cooking technology, that figure goes up almost tenfold to between 400 and 500 micrograms per cubic meter per day (ibid.). None of the five models of Hariyali cookstoves currently achieve international emissions standards, such as those laid out by the WHO, but clean energy advocates warn against "making the perfect the enemy of the good" since they do significantly improve fuel efficiency and reduce indoor air pollution

(ibid.). The fact that many SEWA members chose to purchase a cheaper competing brand of improved cookstove (a social enterprise called Envirofit sells its stove for about USD 25) was perceived as cause for celebration by SEWA Bank staff because it demonstrated an awareness of the dangers of indoor air pollution, something previously accepted as a fact of life by poor rural and urban households (Jayshree Vyas, interview, Ahmedabad, India, December 24, 2012).

Increased household savings and reduction in time and effort spent collecting firewood was reported frequently by users of the improved cookstoves. SEWA members who did not own improved cookstoves reported spending up to 35 percent of their income on fuel (SEWA-Hariyali 2012). In rural settings, it is not uncommon for women to spend hours travelling to collect firewood, walking between one and five kilometers each way. The use of firewood also contributes to deforestation. On average, a rural family of 8 burns roughly 70 to 80 kilograms of wood each week and women must travel 1.5 to 2 kilometers on foot, often more than twice a week, in order to reach a source of firewood (ENERGIA 2006a). Once the wood has been collected, women must walk home carrying up to 40 kilograms of wood on their heads (ibid.). With greater deforestation, availability of firewood is becoming less reliable and women and girls must walk even greater distances. The improved cookstoves use significantly less wood but generate much more heat creating up to a 90 percent increase in fuel efficiency as well as commensurate savings in fuel cost and time spent gathering firewood.

The elimination of soot and smoke from homes was widely reported by users of cookstoves and solar lanterns. Reduced incidence of headaches, sinuses, eye infections and respiratory diseases was reported in almost every focus group and interview conducted to evaluate the impacts of the LaBL initiative. The use of efficient cookstoves and solar lanterns also dramatically reduced the incidence of home fires in both rural and urban communities. The use of flammable energy alternatives when power is cut off (or unavailable to begin with) as well as faulty wiring and paraffin poisoning have caused devastating fires, destroyed homes, killed, injured and displaced tens of thousands of poor urban and rural people around the world. The reduced risk of fire damage was reported as one of the most important benefits of access to decentralized clean energy in densely populated urban poor communities.

There are a range of other associated benefits reported by users of cookstoves and solar lanterns: extended study hours for children in a well-lit and smoke-free environment; increased nighttime mobility and safety for men, women and children; increased time for leisure and relaxation during the day; improved sexual and domestic lives; better connectivity owing to the cellphone charging capabilities of solar lanterns; and better social interaction due to the ability to host and participate in festivals, weddings and public functions in the evenings. Researchers working in other geographical settings have also reported similar benefits (see Fernández-Baldor *et al* 2014 for findings from rural Peru). That boys and girls benefit equally from access to solar energy for purposes of studying for school and doing homework in both the urban and rural settings is one of the most promising findings from the research in India. Instances of three or four families coming together to rent a solar lantern so that the children in the households could gather to

complete homework and study together uninterrupted for up to 4 hours every evening in each other's homes were reported in both urban and rural communities that participated in the solar lighting initiatives.

It is well-established that burning unprocessed biomass contributes to climate change and that reducing the production of soot [black carbon] will slow down global warming. Thus, many renewable energy advocates in India and abroad argue that there is an environmental imperative to promote the use of energy-efficient cookstoves and solar cookers. There are others who argue that getting billions of people to abruptly change the way they have always cooked because it is good for the environment is both impractical and unjust (Rajendra Pachauri, interview, New Delhi, India, April 16, 2013). If people could be motivated to change their behavior to protect the environment, more people in North American cities, for example, would demand better public transportation and take trains instead of continuing to drive gas-guzzling cars and SUVs. Given the significantly higher carbon footprints of North Americans, Europeans and the upper classes of emerging economies, it is morally problematic to demand behavior change from the poor to protect the environment. Poor households should not disproportionately bear the burden and the blame for global warming and they are (justifiably) not likely to be motivated to acquire improved cookstoves (or solar cookers and lanterns) for this reason. Several scholars have criticized ethnocentric and eco-imperialist tendencies within Western environmental discourses and emphasized that an economically and ecologically sustainable world must be built by confronting the excesses of the well-to-do and the powerful, not by depriving the most vulnerable of their right to build minimally adequate lives (Ross 1998; Silliman and King 1999; Hartmann and Barajas-Roman 2009). Organizations like TERI and SEWA very astutely emphasize monetary savings, better health and improved living conditions as the best reasons for poor households to acquire clean energy technologies. The research conducted to evaluate the Hariyali and LaBL initiatives indicate that these are indeed the main reasons why poor households choose to purchase these technologies.

Despite the modest successes of the LaBL and Hariyali initiatives in disseminating these technologies, there are persistent obstacles to the widespread diffusion of solar lanterns and improved cookstoves into poor households in India. This research revealed the high price of the technologies as well as the lack of adequate and appropriate financing to be the biggest impediment for their dissemination. The target end user of both solar lanterns and cookstoves is very poor and hence price-sensitive. The cost of outright purchase of the technologies is very often prohibitive (Clancy, Skutsch and Batchelor 2003). The existing repayment scheme for microcredit financing is designed to be accessible for low-income customers but may still be unaffordable for many urban and rural households. The fee-for-service rental model used by LaBL to disseminate solar lanterns is more affordable for most low-income rural and urban households but has its own limitations since renting households will over the longer term probably be interested in purchasing the lanterns instead of continuing to rent them. Although the rental model can, at least while the technology gains popularity, work for solar lanterns, it has

been known not to work well with solar cookers and improved cookstoves. Rural communities in India tend to be organized more rigidly along caste and religious lines. Social norms of pollution and purity make it difficult for energy sector organizations to offer cookstoves for rent, or even free of charge on a trial basis, in such communities (Abhishek Kar, interview, New Delhi, India, April 18, 2013).

Solar lanterns have gained popularity in low-income settings in India at a much faster rate than improved cookstoves for several other reasons. Since kerosene and other fuel for lighting is expensive, the men in the households, who are more often responsible for making purchasing decisions, may more easily appreciate the economic benefits to the family of acquiring solar lanterns. They are far less likely to appreciate the benefits of purchasing an improved cookstove since they are typically not responsible for cooking or for gathering firewood. The perception that the traditional three-stone stove is "free" whereas the improved cookstove must be purchased or financed - at what for many poor families is a large chunk of their monthly income - is the most widely reported barrier for its adoption. Moreover, the health benefits and improvements to living conditions are not sufficiently motivating for poor households that accept such hardships as inevitable.

As solar lanterns and cookstoves gain popularity in rural and urban settings, there may be a wider demonstration effect that motivates more poor households to acquire these technologies. The initial cost remains a significant barrier at the moment. It is a difficult concept for many people (and particularly men who are not subjected to the drudgery of spending hours collecting firewood daily) to grasp that paying for an improved cookstove (or solar cooker) is better than paying "nothing" for firewood. Poor households may be aware of the health consequences of using traditional stoves or cooking on open fires, just as they are often very aware of the dangers of deforestation since they are forced to live with outcomes such as soil erosion and flooding. However, health and environmental benefits are often not enough to motivate low-income households - that have many other unmet household needs - to purchase improved cookstoves.

Cooking with firewood provides food with a smoky flavor that energy-efficient stoves and solar cookers cannot replicate. People who are accustomed to eating food with a barbecued flavor will often either not purchase cookstoves, or will stop using them eventually and revert to their old stoves. Clancy, Skutsch and Batchelor (2003) also reported that solar cookers and household biogas systems have not been able to meet the demand for cooking energy because they require significant changes to cooking practices, or are too expensive. Even middle-class families in India had cooked on open fires or traditional stoves until the large-scale state-controlled introduction of liquefied petroleum gas (LPG) cylinders in the 1960s and 1970s. Large numbers of middle-class people initially expressed hesitation about using LPG because they, too, preferred the taste of food cooked in traditional stoves. Most were convinced to compromise their taste preferences only when government subsidies and easy availability made LPG significantly cheaper than other fuel sources available to middle-class families. Such a "tipping

point" has obviously not been reached for low-income households (Mini Govindan, interview, New Delhi, India, December 18, 2012).

Since renewable energy technologies entered the Indian market several decades later and within a more neoliberal economic climate, it has not and probably will not, benefit from the strong state intervention that made LPG the norm for cooking in middle-class homes in India. Men typically make major purchasing decisions in Indian families. This intra-household gendered power hierarchy (Kabeer 1996; Quisumbing 2003) ensures that poor households will purchase solar lanterns much earlier than cookstoves (Cecelski 2004). The commercial sector tends to take its cues from this hierarchy and this is certainly at least partially why investment in energy-efficient cooking technologies remains low compared to investment in solar lighting. The estimates about investment in solar lighting versus improved cookstoves vary widely. Even the most optimistic estimate provided by TERI - that cookstoves receive less than 5 percent of the investment that solar lighting does - is not promising. An energy-efficient cookstove can create much bigger improvements in health and living conditions for a poor household than a solar lantern can. However, because the end-user of a cookstove is usually a poor woman (with limited purchasing power and lower social status), the family's lighting needs and the greater economic power of the men in the households tend to be prioritized. The Companies Bill, adopted by India in 2012, which requires corporations to spend at least 2 percent of their net profit on CSR activities, could enable wider dissemination of less-profitable clean energy technologies, but it could also just end up promoting technologies that are already popular and profitable.

More than 500 million people in India live on less than USD 2 per day (Prahalad 2006) and the economies of scale that can be generated from catering to the "bottom of the pyramid" are not lost on private sector organizations and social enterprises. However, in the interest of maximizing short-term profits and building a competitive advantage with other commercial players in the energy sector, they will continue to pursue the "low hanging fruit" first. This will ensure that solar lighting will enjoy far higher levels of investment than cooking technologies. The allocation of resources for technology development should ideally be determined by the greatest benefit for the common good. The findings from this research indicate that this can only be achieved through strong public-sector intervention. To ensure that the technologies that can make the biggest differences in the lives of poor people are developed and disseminated, there is a clear need for governments to, at the very least, put incentives and subsidy structures in place that direct private investment to areas that would otherwise not be prioritized. Other researchers have urged governments to engage more directly and proactively in promoting pro-poor and pro-women energy policies (ENERGIA 2006b).

Creating economic opportunities for women in the energy sector

The LaBL and Hariyali projects have enabled poor households to become users of renewable energy technologies. Through financing and training, they have also created opportunities for smaller numbers of people to earn incomes from selling, renting and repairing solar lanterns and

cookstoves. SEWA Bank created specific energy loans to enable its members to access funding to become entrepreneurs as well as end users of renewable energy technologies. Through its CSR partnerships, LaBL can access private sector funding that ensures that a potential entrepreneur does not need to assume any of the initial costs of setting up a charging station. The in-depth interviews carried out with 5 LaBL entrepreneurs (3 men and 2 women) in rural Rajasthan confirm that operating a solar charging station provides a reliable source of income and other associated benefits of increased visibility and social status. SEWA members who have taken loans to start up entrepreneurial renewable energy ventures report similar benefits.

Although TERI's CSR partnerships and SEWA's microfinance loans are designed to enable low-income people to take up entrepreneurial activities, significant additional barriers remain for the poorest households in general and women in particular, in both rural and urban communities. Based on the most recently available data, only 32 of LaBL's approximately 640 entrepreneurs across India were women (Mini Govindan, interview, New Delhi, India, April 16, 2013). Similarly, of its 300,000-membership base in its home state of Gujarat, only 1,000 SEWA members had taken energy loans. It was not possible to disaggregate this data further to determine whether the loans were for the purchase of renewable technologies for household use or for entrepreneurial initiatives.

The few women who do become entrepreneurs (through either LaBL or Hariyali) tend to be from better-off families in rural and urban communities. They typically take on entrepreneurship to supplement a male breadwinner's income, often alongside other economic activities. In the LaBL case, although the entrepreneur does not have to assume the cost of setting up a charging station, other factors such as poor and inadequate housing prevent the poorest people from becoming entrepreneurs. Setting up a charging station to house 50 lanterns requires a space within the home of at least 200 square feet and a tin roof on which the panels can be installed. The homes of the poorest families in rural and urban communities have neither. Since the poorest households in both urban and rural settings in India also often tend to be female-headed, it is easy to understand why poor women cannot expect to become entrepreneurs. This is not to undermine the success such programs have enjoyed in supporting female entrepreneurs who may experience deprivation and inequality along other intersecting dimensions of gender, caste and ethnicity. TERI's baseline study on women and renewable energy in rural Rajasthan, for example, describes the community visibility experienced by lower-caste *Gujjar* women because of their new roles as solar entrepreneurs. These women may not belong to the poorest households but they certainly experience other forms of social oppression and isolation that make their socio-economic and political empowerment laudable. It is still important to emphasize that even well-intentioned and progressive interventions fail to level the playing field for the poorest women.

SEWA does not have the CSR partnerships that TERI does so the best that it can offer is microcredit to enable women to become technology users and entrepreneurs. The solar entrepreneurs SEWA profiles on its website and on promotional material for the Hariyali

initiative are predictably women who have already succeeded in other enterprises and view renewable technologies as a good business opportunity. Rural households in India often have monthly incomes of less than INR 2,000 (USD 34). At USD 100 the cost of outright purchase of the Hariyali package (solar lantern and cookstove) is unaffordable for such households. Even with financing, such families are often unable to afford the 16 monthly installments of USD 7 per month since it adds up to almost one-fifth of monthly household income. The initial cost of acquiring even 10-20 solar lanterns to sell or rent would be an impossibly high burden for the poorest households to bear. Women from such households cannot become entrepreneurs because the burden of entrepreneurship and the risk associated with the loan would simply be too high for them. Milford Bateman and Ha-Joon Chang (2012) emphasize that microcredit is not an appropriate tool to support the development of small and medium enterprises. Interviews with microfinance professionals reveal that even women who are otherwise keen and motivated to support their families cannot be convinced to consider entrepreneurship because of the risk associated with the loan (Sarah Alexander, interview, Bangalore, India, August 31, 2012). The same risk ensures that spouses and families in both rural and urban contexts were more supportive of wage employment for women rather than entrepreneurship. It is unlikely that women from the poorest households will be able to benefit from the existing financial and institutional arrangements of either TERI or SEWA to consider entrepreneurship as a realistic strategy to improve their economic situation.

Most poor women are interested in the energy sector because of the potential for income generation but they are also extremely averse to financial risk. They are much more likely to pursue opportunities in the energy sector if they can earn incomes without becoming indebted. Acquiring new skills - such as learning to build and repair renewable energy technologies - may be better suited for their economic realities and limitations. SEWA is aware of these constraints and does already offer training in these skills, frequently in collaboration with other NGOs in India. As an example, an organization called Technology Informatics Design Endeavour (TIDE) has successfully trained women who formerly worked for daily wages as manual laborers to build smokeless *chulas* [stoves] from locally available materials. This has enabled women, who often lack basic literacy skills, to earn two or three times their previous incomes and relieved them of more physically strenuous and unsafe work.

Organizations in the energy sector can enable women to try out new livelihood opportunities. The energy training provided by Indian NGOs like TIDE and Bharatiya Agro Industries Foundation (BAIF) tends to include practical technical modules and business operation components. These organizations have been able to break down the training into components that are not intimidating even for women who are not literate. For cookstove construction, for example, women are given kits that consist of molds and locally-available materials such as mud, bricks and cement pipes. The demonstration effect of women with limited education and social privilege earning a living by constructing stoves for a fee frequently motivates other women to pursue the training. Upon completion of training, women may also choose to organize

themselves in other ways to optimize earning potential. For example, a group of women trained by TIDE to construct biogas cookstoves set themselves up as a cooperative. They travel in groups of two or more to build stoves in distant rural areas (Alexander, interview).

In addition to construction, installation and repair of technology, there are opportunities for low-income women to earn commission-based incomes in the renewable energy sector though activities such as educating people about the health risks of smoke inhalation and the environmental dangers of emissions, creating awareness about the benefits of using renewable energy technologies, conducting energy audits of homes and businesses to demonstrate opportunities for reducing energy consumption and waste, and connecting potential customers of green technologies with financing opportunities available through banks and NGOs.

The numbers of people who lacked access to electricity and clean cooking technologies in India are 404 million and 855 million respectively (IEA 2010). Although SEWA and TERI have enjoyed modest success in disseminating solar lanterns and cookstoves, there are at least 120 million more households that could benefit from these technologies. Interviews conducted with professionals in the energy sector revealed that private sector organizations and social enterprises will play a major role in building market value chains not just for the delivery of technology but also for its maintenance, repair and replacement (Harish Hande, interview, Bangalore, India, August 21, 2012; Ibrahim Rehman, interview, New Delhi, April 18, 2013). Finding appropriate modes of communication to convince large and diverse numbers of people to acquire unfamiliar technology is a tremendous challenge for organizations in the energy sector in India. Newspapers rarely reach rural customers. Television does but access is often weak due to the unreliability of electricity. The promotion and marketing of these technologies, especially in rural communities, must be carried out through more human resource intensive means such as travelling exhibitions, demonstration centers and vans, combined with entertainment, games, songs and drama.

Many private sector organizations, social enterprises and NGOs in the energy sector have created opportunities for women to earn incomes through such activities. For example, Envirofit, a social enterprise that also operates in many other Asian and African countries, employs men and women from poor urban and rural communities in India to demonstrate the use of the energy technologies (through street plays, theatre and village fairs)[2] and pays commissions for each unit sold. SELCO Solar provides commissions for connecting potential customers with bank-financed solar energy schemes. Because women are typically responsible for cooking for their families, they do have a comparative advantage in reaching out to other end-users of cookstoves.

[2] A 2009 PBS documentary captured part of a street play in which a woman points out to her husband that he has moved into the 21st century with his acquisition of a TV and mobile phone but she continues to remain in the 18th century with her use of a traditional mud stove in the kitchen. She proceeds to inform him that purchasing an improved cookstove would provide economic, health and environmental benefits for the entire family. The documentary can be viewed online at http://www.projectsurya.org/

Even organizations that do not have any aspirations to reduce poverty or promote gender equality have found it difficult to ignore the instrumental value of involving women in the energy supply chain. As an example, SELCO's decision to train female technicians in the early 2000s was (at least initially) simply a means to accomplish its business goals. Technicians needed to enter the homes of customers to repair solar lanterns and cookstoves. Since it was considered inappropriate for male technicians to enter the homes of customers while male family members were away, training female technicians became the most practical solution. When gender inequality is viewed as a structural issue, as it should be, it is difficult not to be intellectually uncomfortable with the instrumental deployment of women in awareness generation, marketing and dissemination initiatives for improved cookstoves. At the same time, it is important to acknowledge the creation of better-paid and less menial livelihoods for poor women.

The instrumental deployment of women for selling and promoting improved cookstoves does lead to a problematic tendency within the energy sector - including within TERI and SEWA - to classify poor households' needs for cleaner cooking technologies as "women's needs." Development scholars such as Molyneux (2007) and Joshi (2013) emphasize that categorizing goods and services that everyone needs to survive - water and sanitation are other good examples - as "women's issues" only serves to maintain the sexual division of labor and to reinforce entrenched gender inequalities. Making normative assumptions about women's nurturing roles actively perpetuates and deepens gender divides through a feminization of responsibilities and obligations. The energy sector must actively resist the rhetoric of cooking technologies as women's needs. They must describe and promote them as general human needs. It is well-established that there is a material and an ideological basis for gender inequality. If we want to influence sustainable improvements in women's lives, we must be concerned with more than just enabling women to cope with the status quo and to perform their traditional roles better, since empowerment and coping are distinctly different. Elson (1995, 193) elaborates: "It is not a matter of wanting organizations that empower women as opposed to enabling them to cope, but of wanting organizations that seek to empower women as well as enabling them to cope - organizations that have the goal of transforming gender relations through practical action." Other authors emphasize that for transformative social change to occur we must necessarily strike a balance between "the politics of the feasible and the politics of transformation (Rai 2002)." As Molyneux (1998, 78) contends, "clearly practical interests can, at times should, be the basis for a political transformation."

Women have always played crucial roles in the energy sector through informal decision-making about activities such as firewood collection, storage and planning for domestic use. There is also growing evidence of the importance of women's formal engagement in the energy sector. The number of organizations working in the energy sector in India is still very small so there is room for more innovation in this sector for the creation of training, apprenticeship and employment opportunities. Women who have been trained to build, install and repair technology continue to face the challenge of finding permanent employment with their newly acquired skills as they are

often only able to earn incomes on an intermittent basis through contracts and orders placed by social enterprises, non-profits and government agencies. The creation of permanent and stable sources of income for trained women remains a challenge. It highlights the need for the state to provide adequate social security to protect against vagaries in the market, natural disasters, illness, maternity, old age, job losses and other risks to people's wellbeing. Poor women can gain optimal traction from green initiatives only if there are wider socially progressive policies in place, including robust social welfare programs, quality public services accessible to all, income and wealth redistribution, and all forms of state, collective and cooperative ownership. Other researchers have emphasized that women's ability to take advantage of economic opportunities offered by new energy options is often constrained by legal or social barriers that limit their property rights, land tenure, and access to credit. It is crucial that we go beyond energy sector planning to expand women's opportunities for economic empowerment (ENERGIA 2007).

In addition to creating opportunities for women in technology installation, repair, dissemination, awareness generation and marketing, there is a growing need within the energy sector to involve women in the formal engineering aspects of technology design and innovation. Diversity in gender (and race and ethnicity, depending on the setting) is beginning to be understood as critical to designing technologies. There is increasing awareness that having large numbers of male engineers and technical designers often result in larger numbers of technologies that may be useful from a male perspective but that fail to address important issues for women users. This may also explain why there is so much more technical innovation in solar lighting than there is in clean cooking technology.[3]

A growing awareness of the need for women to be part of the energy sector at all levels has led organizations such as SELCO Solar to pay more attention to including female engineers in its design teams. Unlike North America and Europe, where women remain a minority in engineering programs (Clancy and Roehr 2003), comparatively large numbers of middle-class Indian women study engineering (Parikh and Sukhatme 2004). As elsewhere else in the world, female engineers in India continue to experience glass ceilings and employment discrimination in various forms, but recruitment is not a challenge for the energy sector because of the large numbers of women earning engineering degrees. Although it is certainly possible for male engineers to design appropriate technologies for (typically) female end-users, female engineers do often have a more nuanced understanding of other physical and biological constraints faced by women. As an example, the need for child safety devices - to enable end-users to use cookstoves safely in their homes - was identified by a female member of a SELCO design team who observed the difficulties women faced in cooking with small children nearby (Alexander, interview). Several studies have explored how technological designs might differ depending on the sex of the designer and the user (MacKenzie and Wajcman 1999). As with creating opportunities for women in the lower levels of the energy sector, it is sound business strategy to

[3] I attended a clean energy exhibition in New Delhi in 2013. There were hundreds of applications of solar energy (for lighting and other purposes) on display but fewer than 10 models of cookstoves.

involve larger numbers of women as innovators, designers and policy makers in its upper echelons.

Other state-level and federal initiatives aimed at improving representation and removing barriers for career advancement for women in engineering and policy making will also benefit the energy sector. Many equity and access policies adopted to promote gender equality tend to be linear and positivist. They do not seek any special privileges for women and simply demand that everyone receive consideration without discrimination on the basis of sex. They are criticized widely because they fail to address the wide range of social and institutional factors that prevent women from succeeding and because they do not demand preferential pro-women hiring practices to correct historical and current injustices and inequalities. Having said that, it is important to emphasize that even such simplistic liberal policies can improve women's access to opportunities in sectors that are almost completely male-dominated. Clancy and Roehr (2003) arrive at a similar conclusion about the energy sector in North America and Europe.

More comprehensive and finely-tuned policies that take structural constraints into consideration will optimize women's performance and advancement in the energy sector. Government spending through stimulus packages and public procurement can also address gender inequality (Stevens 2009). Contractors for public agencies should be required to adopt affirmative action goals to correct the under-representation of women in their workforce. Green stimulus spending should come with conditional requirements for the recruitment and retention of women.

It has become standard practice within development circles to emphasize economic opportunities for women as a means to broader objectives such as poverty reduction and environmental protection. This is self-evidently justified since women make up 50 percent of the world's population. However, the logic for empowering women is based on very essentialist assumptions about women's empathy for nature and their tendency to spend most of their income on the collective needs of the family and on equally problematic assumptions about men's need to dominate nature as well as their tendency to spend more on themselves and less on their families. Many scholars and practitioners have criticized such assumptions because they reinforce and perpetuate grossly unjustifiable and simplistic stereotypes about "Third World" men and women (Silliman and King 1999; Chant and Sweetman 2012). Poor men and women support themselves and their families as well as they can with the means available to them. We should not focus on creating quality employment opportunities for women in the green economy because they are more benevolent than men or better capable of taking care of their children. The growth of the global green economy should benefit both women and men but we must be proactive about enabling women to establish a stronger equity stake to compensate for historical and contemporary economic injustices and unequal outcomes. This will require more explicitly concrete pro-women actions and policies. Simply creating opportunities for training and employment in new fields and suggesting that women are not unwelcome in them is not enough.

Conclusion

Discussions about women and energy are not new. Most research in the social sciences has stressed the importance of energy access in improving poor women's lives. Previous research has focused on women mostly as end users of technology whereas this research attempted to also understand women's potential as entrepreneurs, facilitators, designers and innovators in the energy sector. Although women's access to green technologies is limited by inadequate purchasing power and low social status, there is tremendous potential to create livelihoods for women in the energy sector. However, women can gain optimal traction from green initiatives only within the context of wider socially progressive pro-women policies.

Other social scientists studying the gender distribution of global employment patterns have pointed out that historically and at the present time, the technology workforce represents a vertically and horizontally gender-stratified labor market, with women concentrated in the lowest-paid positions, closest to the most menial and tedious components and furthest from the creative design of technology and the authority of management or policymaking. Findings from this research suggest that a similar destiny will fulfill itself in the renewable energy sector if we do not explicitly and proactively address issues of gender equity at all levels.

The green economy will create 60 million new jobs in the next 20 years, mainly in technology and infrastructure (ILO 2009). Forty percent of green employment will be linked to investments in renewable energy – wind power, solar, biomass, small-scale hydropower and geothermal (EmployRES 2009). That there is tremendous potential to create quality employment opportunities for women is worth celebrating but it is also important not to exaggerate the ability of green technologies to reduce gender inequality in the absence of other supportive social and economic policies and political awareness-raising about gender equality. Innovations and employment in other industries - electronics and information technology are good examples - have not led to overall restructuring of established gender divisions of labor or unequal gender relations. There is a material and an ideological basis for gender inequality and we must necessarily challenge both to create transformative differences in women's lives.

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