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Creating Opportunities for Women in the Renewable Energy Sector: Findings from Research in India

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Abstract

Concerns about environmental sustainability and fossil fuel insecurity have convinced many countries to transition to low-carbon energy supplies derived from renewables such as solar, bioenergy and wind. Since producing and distributing renewables is more labor-intensive than producing and distributing fossil fuels, this shift is creating new employment opportunities and also addressing energy poverty in remote or underserved rural and urban communities. Applying a gender lens to the enthusiasm for renewables, however, reveals a major problem since women are marginalized globally in employment in the renewable energy sector. In the absence of appropriately targeted training, education, apprenticeships, employment placement, financial tools and supportive social policies, transitioning to renewables may exacerbate existing gender inequities and also hinder poverty alleviation and human development goals. This paper identifies opportunities and constraints that low-income women in India face in accessing technologies and livelihoods in the renewable energy sector through empirical research conducted in collaboration with The Energy Resources Institute (TERI) and the Self-Employed Women's Association (SEWA). Available quantitative data on women's access to and employment in renewables is complemented with ethnographic data collected through interviews and focus groups with beneficiaries of the two projects as well as energy professionals and policymakers. Findings reveal that although women's access to renewables is limited by inadequate purchasing power and low social status, there is tremendous potential to create livelihoods for women in the clean energy sector in India. The same findings suggest that women can gain optimal traction from such initiatives only if there are wider socially progressive policies in place, including state intervention to create robust social welfare infrastructure

(including energy access programs), quality public services accessible to all, and all forms of state, collective and cooperative ownership.

INTRODUCTION

The transition to a low-carbon economy has become one of the topmost global priorities of the twenty-first century. Countries around the world are figuring out 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. 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 (see, for example, Hafkin and Huyer 2006; Rosser 2005) 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 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. 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 also hinder poverty alleviation and human development goals. Gender-blind approaches to economic development - 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.

To enable the transition to a gender-sensitive global green economy[i], there is a clear need (a) to understand and document the opportunities and constraints women face in accessing green technologies and livelihood opportunities and (b) to document and analyze grounded 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 that there is currently virtually no 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 called *Green Jobs and Women Workers: Employment, Equity, Equality* produced by the International Labour Foundation for Sustainable Development describes existing programs but does not provide empirical evidence about how well or badly such initiatives may be working to meet their stated goals (Stevens 2009).

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. I 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) any existing academic and practitioner literature that includes gender analysis of 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 were able to provide 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 five villages in Rajasthan to document end user benefits and constraints, and a series of five in-depth

interviews (three men and two women) to understand the opportunities and constraints faced by entrepreneurs who operated solar charging stations.

I complemented this data 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.

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, five solar panels and five 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 (3,654.52 USD), 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 five villages in Rajasthan included in the baseline study conducted by TERI in 2012 were selected purposively because two 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 has a negative impact on the lives and livelihoods of low-income women. 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 ten days on average by 137 members and judged for user-friendliness, fuel efficiency (with a variety of raw and processed fuel sources, including wood, charcoal, charcoal briquettes and other forms of biomass), 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 comprising a cook stove and a lantern costs about $100 (5,571.54 INR) and can be paid back in 16 installments of $7 (390INR) per month. Using financing provided by the ICICI Bank of India (and guaranteed by the International Finance Corporation), SEWA plans to reach 200,000 households over the next three years and 1 million households in the second phase. Hariyali is currently one of the largest green energy projects in the world (IFC South Asia 2011).

By 2012, five models of cookstoves and four 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. 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.[ii] In addition to scaling up access to decentralized renewable energy in India, SEWA hopes Hariyali will create a replicable environmentally-sustainable business model for application 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 (IEA 2010). But the International Energy Agency (IEA) estimates 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 within 2015. 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. Additionally, grid electrification does not always ensure equitable access for women and men. As an example, the grid in many rural communities often

extends only to spaces that are typically occupied by men, for example, the courtyards of households and agricultural areas (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 at least 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 of electricity is characterized by frequent voltage fluctuations and black-outs and because there are no other community-based renewable energy projects operating in these areas. The need for diversification of home energy products in India is borne out by national-level data. In 2012, for example, the annual market for solar lanterns and cook stoves was estimated at $500 million and $400 million respectively (The Hindu, May 24, 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 (see, for example, Chaudhuri 2007; Chaurey *et al* 2004; Reiche *et al* 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 were able to 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 and an assortment of other manual laborers, 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 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, Fernandez-Baldor *et al* (2013) 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. 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. 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 24 hours (Balakrishnan 2009). 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 (Vyas 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. 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. Once the wood has been collected, women must walk home carrying up to 40 kilograms of wood on their heads. With greater deforestation, availability of firewood is steadily 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. These include 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, for example, Fernandez-Baldor *et al* 2013 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 (Pachauri 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. 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. 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 (Kar 2013).

Solar lanterns have gained popularity in low-income settings in India at a much faster rate than improved cookstoves for a number of other reasons. Since kerosene and other fuel for lighting is so 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 has to 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 they will stop using them eventually and revert to their old stoves. 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 and improved cookstoves (Govindan 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 ensures that poor households purchase solar lanterns much earlier than cookstoves. 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 a drop in the bucket 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% of the investment that solar lighting does - is not promising. An energy-efficient cookstove can actually 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 low 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 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. In order 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 put incentives and subsidy structures in place that direct private investment to areas that would otherwise not be prioritized.

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 is able to 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 (Govindan 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 as a means 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 are 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 in particular 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 worth mentioning that even well-intentioned and progressive interventions more often than not fail to level the playing field for the poorest people in general and for women in particular.

SEWA does not have the CSR partnerships that TERI does so the best that it can offer is financing to enable women to become 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 2000 (USD 37). 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 $7 per month since it comprises a fifth of monthly household income. The initial cost of acquiring even 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. 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 (Alexander 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 also relieved them of more physically strenuous and unsafe work.[iii]

Organizations in the energy sector can enable women to try out new livelihood opportunities. The energy training provided by Indian NGOs like TIDE, Bharatiya Agro Industries Foundation (BAIF) and Shri Kshethra Dharmasthala Rural Development Project (SKDRDP) 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 2012).

In addition to construction, installation and repair of technology, there are opportunities for low-income women to earn livelihoods 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 a consensus 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 (Hande 2012; Rehman 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, has to be carried out through more human resource intensive means such as travelling exhibitions, demonstration centres 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)[iv] and pays commissions for

each unit sold. SELCO Solar, a social enterprise based in Bangalore that develops solar technology for low-income communities, provides commissions to women 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.

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 in the absence of male family members, training female technicians became the most practical solution. When gender inequality is viewed as a structural issue, as it is and 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 difficult not to be pleased about 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 – in which both TERI and SEWA play a role - to classify poor households' needs for cleaner cooking technologies as "women's needs." Development scholars such as Maxine Molyneux (2007) and Deepa 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) 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 (193)." 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) contends, "clearly practical interests can, at times should, be the basis for a political transformation (78)."

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 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 constructive state intervention, robust social welfare programs, quality public services accessible to all, income and wealth redistribution (including land reform), and all forms of state, collective and cooperative ownership.

In addition to creating opportunities for women in technology installation, repair, dissemination, awareness generation and marketing, there is a growing perceived need within the energy sector to involve women in the 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.[v]

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, comparatively large numbers of middle-class Indian women study engineering. 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.[vi] 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 in close proximity (Alexander 2012).The solar suitcase used by midwives and physicians to perform C-sections and other emergency surgeries in settings without reliable access to electricity is another example of a technology developed by a team comprised of a female gynecologist and a male inventor. A number of studies have explored how technological designs might differ depending on the sex of the designer and the user (see, for example, MacKenzie and Wajcman 1999). As with creating opportunities for women in the lower levels of the energy access value chain, it is sound business strategy to involve larger numbers of women as innovators, designers and policy makers in its higher 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 based on linear and positivist liberal principles. 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 also because they do not demand preferential pro-women hiring practices to correct historical and current injustices and inequalities. I would argue that even such simplistic liberal policies can improve women's access to opportunities in sectors like energy that were until recently almost completely male-dominated.

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. 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 the development community 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. 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

The extant literature on the green economy is fractious and contradictory. The most optimistic supporters herald it as the "pathway to sustainable development and poverty eradication" and as "a new economic paradigm in which material wealth is not delivered perforce at the expense of growing environmental risks, ecological scarcities and social disparities" (UNEP 2011). At the other end of the spectrum, there are critics who argue that the green economy is a sophisticated effort to demonstrate that it is possible to resolve the problems of the world without altering the existing power structures and without challenging the relations of domination and exploitation (Lander 2011). Prominent opponents of the green economy describe it as an elaborate scam to justify the corporate hijack of the world's remaining resources. A range of other opinions offer varying levels of support and skepticism for the potential of low-carbon economies to reduce

poverty and deliver social justice (see, for example, Morriss *et al* 2009; Verzola and Quintos 2011). Debates about whether the transition to a global green economy will result in net job losses or gains are equally divisive and fail to provide adequate empirical evidence to support either position. What the diverse and contentious body of knowledge on the green economy does agree upon unanimously is that we must reduce our dependence on fossil fuels and develop renewable sources of energy. This provides the clearest intellectual and practical rationale for increasing access and opportunities for women at all levels in the renewable energy sector.

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 is estimated to create 60 million new jobs in the next 20 years, mainly in technology and infrastructure (ILO 2009). It is estimated that 40 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 in the green economy 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 supporting 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 sexual 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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[i] I use the terms "green" and "low-carbon" economy interchangeably in this paper. There is a lot of debate and contradiction about the definition of these terms. For the purposes of this paper, I define a green economy 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.

[ii] 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 (Lander, 2011). In a similar vein, Verzola and 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 and the moral logic of enabling a member-based organization of poor self-employed women to benefit financially from their efforts to reduce GHG emissions.

[iii] Women trained by this program reported being able to construct two stoves a day and earning INR 150-200 per stove.

[iv] Project Surya, TERI's cookstove initiative relies on similar strategies for dissemination of cookstoves in rural communities. 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/

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

[vi] From less than 1% in the 1970s, enrolment of women in engineering degrees in India had grown to 15% in the early 2000s (Parikh and Sukhatme, 2002). The most popular specializations for women also bode well for employment in the renewable energy sector. Thirty seven percent of electronics engineers in India are women. The figures for civil engineering, computer engineering, electrical engineering and mechanical engineering are 19.7%, 17.8%, 16.1%, and 9.3% respectively (ibid).