

**United Nations Commission on the Status of Women**  
**Fifty-fifth session**  
**22 February – 4 March 2011**  
**New York**

## **INTERACTIVE EXPERT PANEL**

**Emerging Issue: Gender Equality and Sustainable Development**

### **EMPOWERING WOMEN WITH SOLAR IRRIGATION: THE SOLAR MARKET GARDEN ENHANCES FOOD SECURITY IN BENIN, WEST AFRICA\***

by

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\*The views expressed in this paper are those of the author and do not necessarily represent those of the United Nations.

# Solar Electric Light Fund

## **Empowering Women with Solar Irrigation:**

### **The Solar Market Garden Enhances Food Security in Benin, West Africa**

#### **Validation Overview, Pilot Report & Dissemination Detail**

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#### **I. INTRODUCTION**

Today, 1.6 billion people in the world live “off the grid” with no access to electricity. They turn to dangerous, unreliable, and, over time, expensive choices of kerosene lamps and diesel generators for light and power. In their 21<sup>st</sup> century fight with energy poverty, they should look to the sun. With the help of the Solar Electric Light Fund (SELF), they can.

In the Kalalé District of Benin, Africa, where 104,000 residents live in 44 villages, SELF has begun a “Whole Village” electrification program led by solar-powered drip irrigation. Kalalé is typical of the Sahel region: unpaved roads and no secondary school, hospital, or reliable electricity sources. Its agriculture is based on rain-fed crops such as cotton, maize, and, to a lesser extent, root crops. Vegetable and fruit production is very limited and malnutrition is prevalent.



"Thanks to solar power, the water we have for our crops is helping us not only to feed our families, but also to gain extra income to send our children to school."

- Member of the Bessassi Women's Farming Collective

In partnership with the Association pour le Developpement Economique Social et Culturel de Kalalé (ADESCA) and under evaluation by Stanford University, SELF designed its Whole Village program. The local community made clear that an agricultural component needed to be the introductory element and the World Bank's Global Development Marketplace awarded a grant to the project. The Solar Market Garden merges solar electrification for water pumping with drip-irrigation pioneered by the Niger-based International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). It is designed to yield produce for sale as well as consumption. The 2007 – 2009 Pilot Phase involved working with three women's cooperatives in two pilot villages, Bessassi and Dunkassa, to install Solar Market Gardens (SMGs) on three half-hectare plots. The success experienced to date has demonstrated that replicating the SMGs in additional villages can begin, as can extending electricity throughout the pilot villages.

About SELF: The Solar Electric Light Fund (SELF) is a nonprofit organization founded in 1990 that designs and implements sustainable rural solar electrification projects. Its clean energy solutions in 20 countries – created with community, government, and other institutional partners – have enhanced the health, education, agriculture, and economic growth of villages throughout the developing world.

**energy is a human right™**

## II. VALIDATION PHASE OVERVIEW

Based on the 2007-2009 Pilot Phase results, summarized below and detailed in the next section of this report, the second, Validation Phase of the project was initiated in 2010. It involved securing financing for a larger set of SMGs in eight more villages in Kalalé, with installation scheduled for 2011-2012. Such funding was received from the Nordic Environment Finance Corporation, the U.S. Africa Development Foundation, ExxonMobil Corporation, and other private donors, and planning has begun for the installations.

The project's evaluation partner, Stanford University's Program on Food Security and the Environment, completed an assessment and concluded that the SMG: "significantly augments both household income and nutritional intake," and added:

*"Scaling this technology will undoubtedly face challenges, but successful widespread adoption could be an important source of poverty alleviation and food security in the marginal environments common to sub-Saharan Africa."*

### **Solar Market Garden Results: Stanford University's Assessment\***

Three 0.5 hectare Solar Market Gardens have been in use since November 2007. Each garden is divided into 40 120m<sup>2</sup> plots; each of the 30-35 female farmers in the group has her own plot; the remaining plots are farmed collectively.

- Each SMG yields an average of 1.9 tons of produce each month.
- Women keep 18% of the crops they grow for household consumption.
- Significant income gains are realized from the sale of the balance (~\$7.50 per week).
- Project beneficiaries' daily standard of living has increased by \$0.69.
- Each SMG avoids a minimum of 0.86 tons of carbon emissions per year.
- Women in the groups report that they spend 50% less time watering than before.

\* Published in the February 2, 2010 edition of the Proceedings of the National Academy of Sciences, <http://www.pnas.org/content/107/5/1848.full?sid=c9d7fa-1883-4b1c-9258-97b5fd5a4439>.

Such results are why SELF won the 2010 Ashoka Changemakers' competition, "Women, Tools & Technology," sponsored by ExxonMobil. The women farmers and their daughters have also been freed of the burden of fetching water. The women participating in the SMGs report that they spend up to 50% less time working on their current plots than they had hand-watering their previous plots that were 10-30 times smaller. Furthermore, the women are thinking optimistically about pursuing additional microenterprises. Another key result has been the enthusiasm of the women for the project and their thinking about using solar power for microenterprises and the like. They are thinking, optimistically, about their future.

These results also have attracted the UN International Fund for Agricultural Development's interest in replicating the model beyond Kalalé. This matches SELF's additional goals for the Validation Phase; in addition to installing the eight SMGs, we seek to replicate the results of the Pilot Phase, ascertain incremental economies of scale, and further set the stage for bringing the model to scale.

**The Whole Village Complement:** In addition to the SMG Validation Phase, SELF is also working to bring solar power to electrify the first two pilot villages.\* Ultimately, all 44 villages in Kalalé will have Solar Market Gardens and solar-powered electricity. Critical to all phases of the project are local training and on-going support. The long-term goal for the program, particularly its SMG component, is to provide a development model for Africa.

\* Whole Village electrification includes solar power installations for the school, health center, water supply (pumping, storage, and distribution system), community and Internet centers, street and market lighting, and household solar LED lighting systems.

### III. PILOT PHASE – PROJECT REPORT, 2007 - 2009

#### **The Need for the Project**

1.6 billion people in the world live “off the grid” with no access to electricity. Most derive their livelihood from subsistence farming, yet their poverty is defined in large measure by poor nutrition and related health problems. Productive agriculture requires water delivered reliably to the fields – a serious challenge in areas with lengthy dry seasons, such as the Sahel. Irrigation solutions need energy to pump water, but rural villagers and farmers are rarely connected to the power grid. Diesel generators cannot alleviate this form of energy poverty; they are expensive to operate, polluting, and break down frequently enough to cause crops to wither and fail. Hauled water is entirely inadequate. An alternative is needed, which solar power provides.



#### **The Pilot Location and Focus**

The Kalalé District in northern Benin, Africa is typical of the Sahel region; it has no paved roads, secondary school, hospital, or reliable electricity sources. Its agriculture is based on rain-fed crops such as cotton, maize, and, to a lesser extent, root crops. Vegetable and fruit production is very limited and malnutrition is prevalent.

In partnership with the local Association pour le Developpement Economique Social et Culturel de Kalalé (ADESCA) and under evaluation by Stanford University, SELF designed its Whole Village and Solar Market Garden program to electrify Kalalé’s 44 villages. In the preliminary planning discussions, the local community made clear that an agricultural component was the top priority; accordingly, the Solar Market Garden (SMG) became the lead element for the program. The two-year pilot phase for the SMG project was launched in 2007 with the installation of three 0.5-hectare SMGs in the villages of Bessassi (two surface systems – water drawn from a river or lake) and Dunkassa (one submersible system – water draw from a well) in conjunction with local women’s groups.



### **Project Abstract, Results Summary, and Beneficiaries**

Drip irrigation is part of a solution for small-scale agriculture in impoverished developing world communities far removed from any electric grid; it uses water, fertilizers, and labor (mostly female) efficiently. The challenges it faces include pumping water in the dry season and being able to irrigate enough land to grow sufficient food – not only to feed its users but also to generate income. SELF’s answer is to marry drip irrigation with solar energy to offer a reliable, long-term, sufficiently powerful, and green source of energy for the pumping. SELF has partnered with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to create the Solar Market Garden, the goal of which is to grow enough produce for sale as well as consumption. The SMG has now been successfully field-tested on three farms in Benin.

In the first two growing seasons, our evaluation partner, Stanford University, reports that each pilot SMG supplied an average of 1.9 tons per month of produce. Participating families report consumption of 1-2 kilograms of their own produce and project beneficiaries’ daily standard of living increased by \$0.69 relative to non-beneficiaries. (See the Project Impact section, p. 3, for elaboration.)

The project’s target beneficiaries are the 104,000 people of the Kalalé district of northern Benin, and the initial beneficiaries are the collective farmers and their families in the pilot villages.

Following successful field testing during this Pilot Phase, the project’s next phase is to replicate and validate this work in eight more villages. Not only do we seek to demonstrate SMGs’ suitability for enhancing food security and generating income, we need to demonstrate the model’s scalability – for the 34 other villages in the Kalalé district, for other districts in Benin, and for other sub-Saharan and developing nations. The project’s economic trajectory – the income-generating properties of SMGs, anticipated cost reductions as solar equipment prices decline, and the realization of economies of scale as it is ramped up – give cause for optimism that the SMG model can be both adopted and adapted for successful replication.



## The Project's Roots

In 2006, SELF Executive Director Robert Freling was contacted by [Dr. Mamoudou Setamou](#), a native of Kalalé who had received a Ph.D. in agricultural entomology from the University of Hanover in Germany. Dr. Setamou, now a Professor at Texas A&M University, had just returned from a home visit to Benin, where he had participated in a meeting of Kalalé's district council to explore alternative options for electrifying Kalalé's villages since the national grid was not likely to reach this remote part of Benin anytime soon. Intuiting that solar represented a way forward for his people, Mamoudou turned to SELF for help. Over the next few months, a plan was assembled, through the good offices of the local group ADESCA, to generate solar electricity for a wide range of end-uses—including schools, health clinics, water pumping systems, street lighting, and wireless Internet access—in each of the 44 villages that comprise Kalalé District. In terms of priority, however, an on-the-ground needs assessment revealed that the first concern among the local communities was food security: to find a way to overcome the endemic lack of water and agricultural produce that condemns the people of Kalalé to an endless cycle of poverty and poor health, especially during the 6-month dry season.

## Project Impact – Stanford's Assessment

SELF has partnered with Stanford University's Program on Food Security and the Environment (<http://foodsecurity.stanford.edu/>) to monitor and evaluate the economic, agricultural, environmental, health, and organizational impacts of this project. The two primary measures for assessment are: 1) increases in vegetable consumption and evidence of the attendant health benefits that result, and 2) increases in income as a result of food sales. These measures enable SELF to: (a) assess the impact of the pilot phase, (b) establish decision criteria and recommendations for scaling the project to other villages, and (c) refine the research design for the complete scale-up phase of the project. Stanford's monitoring effort has included initial household surveys in the two pilot villages and two "comparison" villages in November 2007, the collection of garden data (yields, sales, inputs), local market monitoring, and follow-up surveys in November 2008.

Stanford's recently completed assessment\* concluded that the SMG "significantly augments both household income and nutritional intake." It reported that, as measured in the November 2007 baseline survey, the median per capita daily consumption expenditure in pilot and

\* The data reported here is from a Stanford University study published in the *Proceedings of the National Academy of Sciences* on February 2, 2010. It can be found at: <http://www.pnas.org/content/early/2010/01/13/0909678107.abstract?sid=f6e98ccf-8fe7-4d2a-8e14-b2ad33e359f3>

control villages was just under \$1 (PPP, 1993 US dollars), over \$0.60 of which is spent on food, confirming that Kalalé's population is among the poorest on the planet. Furthermore, while virtually all of the households in Kalalé are engaged in agricultural and/or livestock production as a primary activity, most are net consumers of food, particularly of non-staples (proteins, vegetables, and fats). These households either rely on sales of cotton (grown across northern Benin) or draw down assets (usually livestock) to supplement poor production. Against this food- and nutrition-insecure backdrop, the SMG's impact has been striking:

#### Solar Market Garden and Assessment Facts

- Three 0.5-hectare systems were installed in two “treatment” villages with pre-existing local women’s cooperatives (two surface pumping systems, one groundwater pumping system).
- The 30-35 women per group each farm their own 120m<sup>2</sup> plot; the remaining plots are farmed collectively to fund group purchases and expenses.
- Stanford also monitored two “control” villages for matched-pair comparisons.
- Household surveys in treatment and control villages were conducted upon installation (November 2007) and after one year of garden operation (November 2008).



#### Assessment Results

- Each SMG supplied an average of 1.9 tons of produce per month.
- Other agricultural production was not displaced.
- 18% of the produce grown was kept for home consumption; the balance was sold at market and generated income.
- Vegetable intake across all villages increased during the rainy season by approximately one serving per day (150 grams per person); by comparison, project beneficiaries gained the equivalent of 3-5 servings per day (500-750 grams per person), mostly during the dry season.
- Project beneficiaries' daily standard of living increased by \$0.69 relative to non-beneficiaries.
- Use of income earned “significantly” increased the purchase of staples, pulses, and protein during the dry season and oil during the rainy season.

- Before SMG installation, 4% of participating planned to pay the fees to send their children to school; after one year, this figure rose to 22%.
- The estimated payback period for a Solar Market Garden is 2.3 years.
- In comparison to a comparably situated and used liquid-fueled pump, each SMG avoids a minimum of 0.86 tons of carbon emissions per year.

Furthermore, almost all agriculture in rural West Africa is rain-fed; production thus stops during the six-month dry season. During this harsh time, some women and young girls will haul water for several hours each day in an attempt to hand-water small plots of vegetables. The SMG provides an obvious improvement to this traditional method, allowing cultivation of a much larger area with a labor-saving technology that frees women to engage in other activities and girls to attend school.

Women participating in the Solar Market Garden pilot have already reported in interviews that they spend up to 50% less time working on their current plots than they had hand-watering their previous plots (which were 10-30 times smaller). Additionally, they report that they spend the time in the gardens engaged in more income generating activities – including seed replication for sale to other farmers – than simply hauling water as they had before.

### Challenges

Collecting data in rural areas, where education and literacy rates are very low, presents understandable challenges. In a feedback session, enumerators for the household survey commented that the conditions in Kalalé were some of the harshest they had encountered in their survey work. Beyond such difficulties, the evaluation effort faced two major challenges:

- (1) underreporting of results, due to the women being fearful of either becoming targets of theft or having the technology appropriated by their husbands. Local staff went to great lengths to meet with the women and ensure both their confidentiality and protection. Reporting has improved but must be monitored closely.
- (2) market monitoring also proved difficult; among the small population in the district that can read and write, there are even fewer with access to transportation to visit markets reliably. Originally, teams of “market collectors” (who collect stall use fees from the various markets for the district administration) and bush taxi drivers were hired and trained, effectively “piggybacking” the market surveys on their ordinary weekly rounds. (Transportation infrastructure has an additional impact, as it is assumed that the farmers would earn even more income if the farmers’ produce could be taken to more distant or larger markets.)

The Songhai Center, another project partner (see next section below), has now recruited a candidate available to oversee market monitoring and to help the women track their yields, earnings, and expenses.

### Assessment Conclusion

*“Scaling this technology will undoubtedly face challenges, but successful widespread adoption could be an important source of poverty alleviation and food security in the marginal environments common to sub-Saharan Africa.”*

## Project Partners and Funders

In addition to working with its local partner ADESCA, SELF has established several invaluable partnerships that have strengthened the project, helped attract new resources, and increased the organization's capacity for scaling up the project. Most importantly, the International Crops Research Institute of the Semi-Arid Tropics (ICRISAT, Niamey, Niger -- <http://www.icrisat.org>) has been actively involved in project implementation (e.g., agronomic expertise, reservoir and drip-system design, and training and capacity-building for the women farmers) and impact evaluation (e.g., facilitating data collection).



As mentioned above, SELF has partnered with Stanford University's Program on Food Security and the Environment for project monitoring and evaluation. Because this study will (a) help define, both quantitatively and qualitatively, the potential of solar electrification in improving livelihoods in the poor, agriculturally dependent communities of rural Africa, and (b) develop tools and methods applicable to other technology-based interventions in the developing world, we anticipate high interest in the results from the development community at-large.

L'Institute pour le Recherche Empirique d'Economie Politique (IREEP, Cotonou, Benin - <http://www.ireep.org>) maintains a network of trained enumerators capable of organizing and executing surveys and interviews around the country. IREEP enumerators helped finalize the baseline survey instrument, translate it into local languages, and administer the questionnaires.

Songhai Center (Porto Novo, Benin -- [http://www.songhai.org/songhai\\_en/](http://www.songhai.org/songhai_en/)) is a center for training, production, research and development of sustainable agricultural practices in Africa.

SNV – Netherlands Development Organization (Parakou, Benin – <http://www.snvworld.org>) provides capacity-building services to local organizations and has helped ADESCA and the women's collectives to organize legally and to register with the government.

Government support for the project has been sought and received at every level. SELF Executive Director Robert Freling has met three times with the President of Benin, Yayi Boni, who endorses the Solar Market Garden. As indicated in the above section on the project's roots, critical local support was received early on from Kalalé's district council (commune), particularly from the three mayors in office over the project's duration to date. The mayor at the time of the project's launch actively assisted in selecting the pilot villages and another participated in applying for and receiving World Bank funds

through the Global Development Marketplace. At the Department level (Kalalé's is Borgou), the chief executive officer was informed of the project and offered his support. On the national level, representatives at the Agency of Rural Electrification and Energy Expertise in the Ministry of Mines, Energy, and Water have been contacted regularly, have supported the project, and have asked to be kept informed.

Funders for the project include: Body Shop Foundation; Conservation, Food and Health Foundation; International Foundation; Ruth & Harold Launder's Charitable Trust; TRA Fund; the World Bank's Global Development Marketplace; and other SELF supporters.



### **Financial and Operational Results**

The first two years of operation, 2007 – 2009, cost \$268,406. The major expenses were for the solar equipment, training and farming expertise, and borehole survey and drilling. Schedule adjustments occurred in response to the following on-the-ground developments: 1) the need to follow the lead of local partners and work with them to increase their knowledge and ability (e.g., in crop selection); 2) a need to roll out the expansion more gradually given variable funding (as reflected in lower overall project expenditures), and 3) a need to sustain more focused attention on the drip irrigation component of the project to ensure its long-term success. As this work is scaled up, cost

savings are anticipated from economies of scale being realized, equipment prices declining, and increased donations of equipment.

### **Additional Project Information**

The project's two-year pilot phase was marked by the installation in late 2007, usage and training in 2007 – 2009, and monitoring in 2008 and 2009. The SMG remains a distinct program priority in Kalalé while also serving as the lead element for eventual Whole Village electrification for each of the 44 villages in the district. Whole Village components will include solar electrification of water pumps, street lighting, Internet communication, portable home solar lighting systems (LEDs), and public spaces including schools, health centers, and microenterprise and other community centers.

The first two years of operation of the SMGs have proceeded relatively smoothly. Maintenance and supervision of the project is entirely local, with support from ICRISAT and SELF technicians. SELF focused efforts on capacity-building efforts for our local partner organization in the past year, with great success. Administration, bookkeeping, and communication have all improved to the point where all parties involved feel comfortable with project expansion. Most important, our local project team is now prepared to train the additional staff needed to expand to more villages.

SELF's and ICRISAT's training services alone have helped build capacity significantly:

- 100 women in the 3 farming collectives have received training on soil preparation, nursery formation, irrigation, pest control, seed replication, organization management, and marketing. These trainings have been conducted every 6-8 weeks by ICRISAT.
- 5 technicians were trained to install and maintain solar-powered pumps.\*
- 3 masons were trained in reservoir construction.
- A local project management team (project manager, agricultural technician, and solar technician) was hired and trained to run the project locally.

In addition, the Project Partners and Funders section above indicates how SELF is working with local or locally based organizations to develop on-the-ground capacity.

Perhaps most intangibly but also most rewardingly, the women are expressing enthusiasm for the project and how further adaptations can help their families and their lives. They are thinking optimistically of the future. As SELF Executive Director Bob Freling wrote in his blog following a June 2009 assessment trip, "it appears their entrepreneurial spirit has been kindled!" <http://www.bobfreling.com/>.

### **About SELF and Key Project Personnel**

The Solar Electric Light Fund (SELF) is a nonprofit organization founded in 1990 that designs and implements sustainable rural solar electrification projects. SELF serves impoverished, off-the-grid communities in its fight against energy poverty and climate change. Its clean energy solutions in 20 countries – created with community, government, and other institutional partners – have enhanced the health, education, agriculture, and economic growth of villages throughout the developing world. For example, SELF has recently electrified 40 health facilities in 10 projects in six countries;

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\* It is worth noting that, unlike more complicated photovoltaic (PV) systems that use batteries to collect and discharge power (which introduces more technical load management issues and the risk of draining and ultimately damaging the batteries), the SMG directly powers the pumping system. Accordingly, it is an easier system to use and maintain.

three villages in Nigeria; four schools in South Africa; and three pilot drip-irrigation systems in Benin.

Personnel working on this project include:

- Robert Freling, SELF Executive Director since 1997. During his stewardship, SELF has completed solar energy projects in more than 15 countries. He is the recipient of the 2008 King Hussein Leadership Prize.
- Jeff Lahl, Project Director, has 20 years' experience in solar technology, training, and international development.
- Dov Pasternak, lead horticultural and irrigation consultant, ICRISAT, has been working with drip irrigation and vegetable production since 1964. He has consulted in over 14 countries.
- Jennifer Burney, Postdoctoral Researcher, Program on Food Security and the Environment, Stanford University, provides her agricultural and evaluation expertise during multiple site visits throughout the year.

### **The Solar Market Garden – The Next Phase: Validation**

The results reported above provide us with great confidence going forward as we seek to scale up the project. SELF has phased this ambitious work to allow for the required financial and local resources to be assembled. We have determined that the next Validation Phase should consist of installing SMGs in eight more villages over the next two years, funding permitting. The first-year budget of \$242,946 is for SMGs in two villages (3<sup>rd</sup> and 4<sup>th</sup> overall).

Longer term, the Scaling Phase would extend SMGs to the remaining 34 villages. Much as SELF catalyzed the use of Solar Home Systems in the developing world in the 1990s and spun off a successful commercial enterprise (SELCO), we anticipate that public and/or other larger sources of capital will be brought to bear on this model as it is further tested and its results disseminated. Larger private funders, international development institutions, and public agencies are being introduced to this work in conjunction with its pending ramping up.

#### **IV. DISSEMINATION DETAIL**

##### **External Publications (partial listing)**

“Solar Market Gardens: Increasing Access to Energy, Water, and Food,” *State of the World: Innovations that Nourish the Planet*, Sidebar feature, p. 45, Worldwatch Institute, 2011.

“Solar-powered drip irrigation enhances food security in the Sudano–Sahel,” *Proceedings of the National Academy of Sciences*, February 2, 2010. [http://www.self.org/PNAS\\_Article\\_Solar\\_Market\\_Garden.pdf](http://www.self.org/PNAS_Article_Solar_Market_Garden.pdf)

“Solar-powered irrigation systems improve diet and income in rural sub-Saharan Africa, Stanford study finds,” *Stanford Report*, January 6, 2010. <http://news.stanford.edu/news/2010/january4/solar-irrigation-africa-010610.html>

“Innovative Solar Powered Drip Irrigation Program Doubles African Farmer's Income, Prevents Malnutrition,” *planetgreen.com*, Jan 25, 2010. <http://planetgreen.discovery.com/food-health/innovative-solar-powered-irrigation.html>

“Watered by the Sun,” *Seed Magazine*, April 5, 2010. [http://seedmagazine.com/content/article/watered\\_by\\_the\\_sun/](http://seedmagazine.com/content/article/watered_by_the_sun/)

“Women, Tools, and Technology” feature, in *Building Projects for Change*, a 2010 publication of the Women’s Refugee Commission.

##### **Development Agency and Prospective Partner Meetings (partial listing)**

- Coopération Technique Belge, Belgian Development Agency (BTC); **site visit, April 2010.**
- International Energy Agency’s Energy Business Council (IEA EBC); May 18, 2010.
- UN International Fund for Agricultural Development (IFAD); March 15, 2010, led to June 2010 site visit - **led to consideration of \$500,000 grant, decision pending.**
- UN Development Fund for Women (UNIFEM); December 1, 2009.
- UN Food and Agriculture Organization (FAO); March 16, 2010.
- UN Industrial Development Organization (UNIDO); began February 19, 2010.
- US African Development Foundation (USADF); in US, began August 31, 2009; in Benin, April 26, 2010 – **led to \$250,000 grant to local partner, ADESCA.**
- US State Department; several, 2009 – 2010, including a briefing for a working group on leapfrogging technology in Africa; July 16, 2010
- US Millennium Challenge Corporation; staff presentation, December 16, 2010.

##### **Clinton Global Initiative**

SELF made a pledge to the Clinton Global Initiative (CGI) in 2006 to implement the SMG project. Because of the success achieved, SELF was one of only a handful of organizations invited to report on its earlier pledge to at CGI’s 2009 Annual Meeting. To see the 3-minute presentation at CGI, go to: [http://www.clintonglobalinitiative.org/ourmeetings/2009/meeting\\_annual\\_webcasts.asp?Section=OurMeetings&PageTitle=Webcast&Video=Archive&Day=2#video](http://www.clintonglobalinitiative.org/ourmeetings/2009/meeting_annual_webcasts.asp?Section=OurMeetings&PageTitle=Webcast&Video=Archive&Day=2#video) (at 13:30 into the program, “Innovation Breakout Session: Driving Disruptive Innovation from the Base of the Pyramid”).

##### **Videos**

Three videos – produced by SELF, Stanford University, and the French television “Earth from Above” (Vu du Ciel) – are available at <http://www.self.org/benin.shtml>.

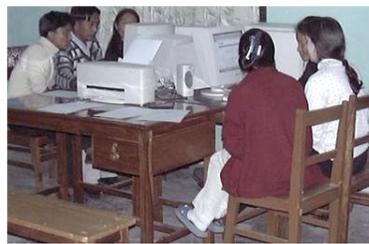
##### **SELF’s Website, Blog entries, and Press Releases (partial listing)**

- Benin project page, SELF website: <http://www.self.org/benin.shtml>.
- Bob Freling blog entry, <http://www.bobfreling.com/2010/01/stanford-study-validates-part.htm>

##### **Competitions and Awards for the Solar Market Garden (pilot phase)**

- *Ashoka Changemakers*: Winner, 2010 Women|Tools|Technology Global Challenge. June 2010, <http://www.changemakers.com/en-us/technologywomen>.
- *Tech Museum*: A 2008 Economic Development Laureate, and a 2010 Environment Nominee.
- *World Bank Global Development Marketplace*: 2006 Winner of \$100,000 grant competition. <http://web.worldbank.org/WBSITE/EXTERNAL/OPPORTUNITIES/GRANTS/DEVMARKETPLACE/o,,contentMDK:21426586~pagePK:180691~piPK:246778~theSitePK:205098,00.html>.

# Renewable Energy, Empowered Women



## A SELF WHITE PAPER

Spring, 2003

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# Solar Electric Light Fund

*Renewable Energy, Empowered Women*

## ■ Background: The Many Divides

The digital divide captures many of the headlines, but the new century and millennium are riven by many other, equally serious inequities which, like the digital gap, are at their most extreme in developing nations. Among these are divides based on culture, economy, environment, gender, and – in a sense that goes beyond computers and the Internet – technology.

All these divides interlock with and reinforce each other. Finding ways to close and heal them is the urgent imperative of our time.

SELF, the Solar Electric Light Fund, takes its mandate from the words of Freeman Dyson, the Templeton Prize-winning physicist and SELF board member, who wrote in his recent book *The Sun, The Genome and The Internet* that "The new century will be a good time for new beginnings. Technology guided by ethics has the power to help billions of poor people all over the earth."

Narrowing the technology divide can also reduce other, interconnected divides. SELF works at the very base of the technology divide, the lack of electrical power.

Today, two billion human beings still live without electricity, primarily in developing nations' remote and rural reaches. For many of these people, connection to a utility grid is nowhere on the horizon. Their countries' economic struggles, high foreign debt, and public health burdens make grid extension, at as much as US\$20,000 a kilometer, far too expensive. The cost to the planet of bringing conventional, fossil fuel-fired electrification to so many people is also forbidding. The evidence for global warming – both lofty and peer-reviewed, and down-to-earth and common-sense – is now unassailable.

## ■ Energy and the Gender Divide

With or without electricity, homes must be illuminated and heated. Meals must be cooked. Water must be secured.

In the rural developing world, these burdens fall most heavily on females. Invariably, it is women and girls who each day must seek out wood or dung or some other biomass that can be burned for light or heat. Or who must find water, and then shoulder it home in back-breakingly heavy pots. The gender division of labor in rural Tanzania, depicted in the chart below, is typical throughout the Global South.

The effort of gathering fuel and hauling water is becoming even more arduous as population growth and environmental degradation relentlessly reduce supplies. The United Nations Development Programme (UNDP) estimates that the proportion of rural women encountering fuelwood scarcity is 40 percent in Latin America, 60 percent in Africa, and nearly 80 percent in Asia. The effort of securing fuelwood can take a woman between 1 and 5 hours every day.<sup>1</sup>

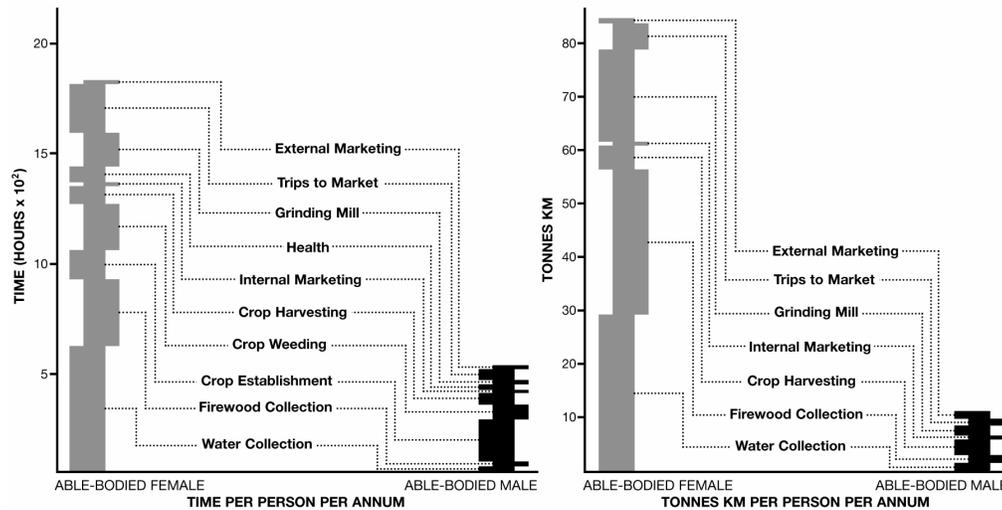
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<sup>1</sup> See *Human Development Report 1995: Gender and Human Development*, United Nations Development Programme, at <http://hdr.undp.org/reports/global/1995/en/default.cfm>.



Water scarcity is equally serious. It affects 32 percent of rural women in Asia, 45 percent in Latin America, and 55 percent in Africa. The median time investment by women in water collection during the dry season is 1.6 hours.<sup>2</sup>

CHART: Rural transport activities by females and males in rural Tanzania. (Source: *Energy After Rio*, 1997, United Nations Development Programme)



The time women spend in the drudgery of finding and transporting fuel and water is time lost to other activities, including microenterprises that could generate additional family income. There can also be negative effects for children if they are enlisted to help, and in doing so sacrifice schooling. To the degree that this involves girls more than boys – and it usually does – gender disparities in literacy and employment prospects result. In some developing nations, girls spend 3.5 times as many hours in wood and water collection as boys (and 7 times as many hours as adult males).<sup>3</sup>

Since they are almost exclusively responsible for cooking, women and girls also suffer inordinately from the extreme indoor air pollution created by biomass and kerosene burning. As summarized in the April 2001 issue of the journal *Environmental Health Perspectives*:

*Epidemiologic studies in households in developing countries have strongly linked exposure to indoor air pollution from solid fuels to acute lower respiratory infections (ALRI) in children, chronic obstructive lung diseases and associated heart conditions, and lung cancer. Growing evidence also implicates asthma and tuberculosis (TB) as well as the nonrespiratory conditions of cataracts and adverse pregnancy outcomes (stillbirth, low birth weight, and infant death).*

*Of these, ALRI appears to have the greatest health impact in terms of the number of people affected and the number of life years lost. Overall, studies indicate that exposure to wood smoke from cooking fires in poorly ventilated conditions may increase the risk of a young child contracting a serious respiratory infection from two to six times. Adults suffer the ill effects of severe indoor pollution as well. Strong links have been found between chronic lung diseases in women and exposure to smoke from open cooking stoves. Transition up the energy ladder from dirty to clean fuels will greatly reduce the threat from indoor air pollution in developing countries.<sup>4</sup>*

### ■ Up the Energy Ladder

Since 1990, the Solar Electric Light Fund has been showing the role that solar photovoltaic and other renewable energy technologies can play in improving the lives of rural people in developing countries.

<sup>2</sup> See *The World's Women 2000: Trends and Statistics*, United Nations, at <http://unstats.un.org/unsd/demographic/ww2000/overview.htm>.

<sup>3</sup> Ibid, footnote 1.

<sup>4</sup> See <http://ehs.sph.berkeley.edu/krsmith/publications/ehp.pdf>.



SELF's projects have now reached 13 developing nations on four continents. Christopher Flavin, president of the Worldwatch Institute, recently remarked that "I know of few small non-profits with SELF's impact." Mikhail Gorbachev, presenting SELF with the 1998 Green Cross Millennium Award for International Environmental Leadership, praised the organization's "dedication, leadership, and vanguard efforts in creating a value shift for the new millennium." In 2002, SELF was selected from among nearly 500 nominees as one of 25 Laureates in Silicon Valley's Tech Museum of Innovation Awards.

Because energy in the rural developing world is inextricably a women's issue, all of SELF's projects have had women as beneficiaries. But some projects have gone farther, involving local women very centrally as project planners and leaders. Since it is women who have the biggest personal stake in a positive outcome, it is perhaps not surprising that these projects have been among SELF's most successful.

### ■ Looking Backward: Women-Led SELF Projects in Vietnam and South Africa

#### VIETNAM

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In 1994 SELF launched a first-of-its-kind household solar photovoltaic project in Vietnam in association with the Vietnam Women's Union (VWU).

The VWU is a nationwide social service organization with eleven million members. It works to improve the knowledge and capacity of women, to support income-generating activities, to improve health care, family planning and nutrition, and to mobilize women to participate in creating new laws and public policies.

Then four years old, SELF had conducted successful projects in China and Sri Lanka that innovatively used microcredit to make solar home systems affordable to poor, rural families. The VWU wanted to replicate these successes with pilot solar home electrification projects in the provinces of Tien Giang and Tra Vinh in the Mekong Delta, and in Hoa Binh Province near Hanoi.

SELF dispatched its then-technical manager, Marlene Brown, to work with the VWU to train 25 Vietnamese women as solar technicians. In addition, the VWU trained 20 "motivators" to sign up families and collect down-payments.

The microcredit system was structured such that purchasers put 10% down, followed by monthly payments of \$3 to \$4 over four years. Because the installments were about the same sum families were already spending on the smoky, polluting kerosene commonly used for lighting in Vietnam, late payments were rare, and defaults even rarer. As the loan fund was replenished, additional loans were made. Soon, hundreds of households were getting the benefit of clean solar electricity from photovoltaic systems sold and serviced almost exclusively by women.

Coupled with larger solar power units that SELF helped the VWU to install in community centers and village markets, these household systems have improved women's and children's health, facilitated literacy and learning through bright lights and educational television, and assisted in development of small-scale garment-making businesses.

The project has also empowered Vietnamese women to participate in the development of their nation's energy policies. Mme. Nguyen Thi Minh Phuong, a member of the presidium of the VWU, has observed that by showing women's capacity to implement energy projects, the collaboration with SELF has given women influence in energy planning that they never before enjoyed.



Outside evaluators presented their findings about the project in the July 1997 newsletter of Energia, an international group that grew out of the 1995 Beijing Conference on Women, and which links individuals and groups concerned with energy, environment and women:

*The VWU Solar Energy project is a remarkable project in many ways. In our view, it is exceptional that women have been trained in PV technology, and are successfully promoting, selling, installing, maintaining and using photovoltaic SHS [Solar Home Systems].*

*Not only is the project completely implemented by women, it is also implemented on a commercial basis with full cost recovery. Although initial funds were made available by American donors, the users pay back the costs of the systems over a period of four years, thereby renewing the fund and enabling more households to purchase a SHS...*

*It is interesting to take a closer look at the Vietnam solar energy project from a gender point of view, and use this example to discuss what 'women and energy' can mean.*

*When thinking of how to integrate women in an energy project, the first association that many people have is that more women should be involved in the project. The VWU project is a clear and successful example of such involvement by women. The women of the VWU are doing the marketing of the SHSs. They are evidently doing a good job; new households are constantly signing up for purchasing SHSs. Probably because the "saleswomen" of VWU know the energy needs of women best, they are very effective marketers.<sup>5</sup>*

On the strength of its continuing achievements in solar electrification of rural Vietnam, the Vietnam Women's Union was presented with a 2002 Energy Globe Award, known as the "Sustainable Energy Oscar." The award was conferred by Mikhail Gorbachev on March 6, 2002 at a gala ceremony in Linz, Austria.<sup>6</sup>

### **SOUTH AFRICA**

When apartheid collapsed in 1994, only 12 percent of rural black households had access to electricity. Given the acute need for power, and the prohibitive cost of universal grid extension, in 1996 SELF was invited by South Africa's Ministry of Energy to lead a pilot solar electrification project in the community of Maphephetheni in KwaZulu/Natal's Valley of a Thousand Hills.

The Zulu Nkosi (or chief) of Maphephetheni was a young progressive who saw the solar electrification project as a means to help the area's women not only lessen their dependency on inferior energy resources, but to gain new skills and employment opportunities as solar technicians.

As in Vietnam, SELF worked with area women to establish a revolving microcredit program to support sales of solar home systems, with 10% down and three-year repayment periods. A Women's Solar Cooperative was organized to both administer the loan program and handle system installation and upkeep.

Solar power was enthusiastically embraced by all involved. In addition to the economic benefits that accrued to the women trained as solar technicians, a scholar who recently analyzed the project's long-term effects noted the income-generating uses to which solar home systems are put, including providing lighting for the weaving of grass mats, and for the keeping of books in a gardening enterprise.<sup>7</sup>

Success in the household use of solar power also stirred interest in community applications of the technology. This ultimately led to SELF's solar electrification of the community's Myeka High School, again using the technical talents of local women. It may be no exaggeration to say that today Myeka is the most famous solar-powered school in the world. Its tremendous advances even drew the attention of *The New York Times*. As reported in the *Times* of September 9, 2001:

<sup>5</sup> See <http://www.sms.utwente.nl/energia/july1997/solarenergy.html>.

<sup>6</sup> See [http://www.esv.or.at/aktuelles/energyglobe/globe02/winners\\_e.htm](http://www.esv.or.at/aktuelles/energyglobe/globe02/winners_e.htm).

<sup>7</sup> See Annecke, Wendy 1998. "Assistance to NREL in determining the non-economic determinants of energy use in rural areas." Energy and Development Research Centre, University of Cape Town.



*Now that the students can download materials from the Internet and have access to the [distance education resources of the] Learning Channel, the graduation rate has shot up [from 30] to 70 percent. Some students have won science awards, and many are applying for college. "I never thought the sun could do all this," said Melusi Zwane, Myeka High School's principal... "Everything comes from power."<sup>8</sup>*

Perhaps even more moving are the observations of young Samantha Dlomo, a Myeka student whose essay about her school experience won a global competition staged by the International Solar Energy Society. This achievement brought Samantha, who had never been more than a few kilometers outside her village, halfway across the planet for an awards ceremony in Mexico City. Here's what Samantha wrote in her essay:

*Solar energy has not only changed my school life, it has brightened up my future as well. I am sixteen years old and have lived in the rural area for the past fourteen years. In all these past years I used a candlestick to study and do my homework. The chalkboard has been the mainstay teaching aid at school.*

*When a few solar panels were installed at school, I did not have even a faintest notion of how it was going to work. A few months later we received an overhead projector. That was the beginning of a new school experience. The following equipment was later received: 20 computers, two television sets and a video machine. Recently we have been connected to the Learning Channel Campus and the Internet through the satellite.*

*Learning is now going to be research orientated. That is we shall use worksheets and we shall use the Internet as the main source of information. In the past we spent much of our time copying notes from the chalkboard.*

*The school has set itself a new vision for the new millennium. By the year 2005 it wants to produce learners who will follow careers in the field of Science, Technology, Engineering, Medicine and others. This was a far fetched dream a few years ago.*

*I have learnt that the electricity generated from coal and water is a hazard to our planet. On the other hand I have learnt with amazement of how the use of solar electricity could save the world from pollution. I have taken a decision that I will do whatever it takes to contribute to the campaigns aimed at saving our planet from the hazard of pollution.*

*Solar energy has brightened my future and it is destined to brighten the future of millions of others.<sup>9</sup>*

### ■ Looking Forward: Women-Led SELF Project in Tanzania

The exceptionally strong outcomes of SELF's projects in Vietnam and South Africa argue strongly for putting women at the center of project leadership whenever possible, a commitment made explicit in SELF's new three-year Strategic Plan. 2003 will present two such opportunities for women-driven efforts:

#### TANZANIA

The Kigoma region of northwestern Tanzania is desperately poor, with a per capita income under US\$100. In the most recent census in 1988, the region's population stood at 1,000,000. Today's number is certainly dramatically higher, both because the area has Tanzania's highest fertility rate, and because of a massive influx of refugees fleeing strife and genocide in Rwanda, Burundi, and the Democratic Republic of Congo, Kigoma's neighbors around Lake Tanganyika. 85 to 90 percent of Kigoma's people reside in rural areas, virtually always without electricity.

The region's population surge has exacted a harsh toll on the local environment, with a deforestation rate twice the national average. The Miombo woodlands that once blanketed the area have been reduced to just 46% of their original extent, with consequences for women all too sadly predictable.

<sup>8</sup> Read the full text of this lengthy article at [http://www.self.org/news/nyt\\_solar\\_power\\_is\\_reaching\\_where\\_wires\\_cant.pdf](http://www.self.org/news/nyt_solar_power_is_reaching_where_wires_cant.pdf).

<sup>9</sup> Samantha's essay and beautiful drawings of the school and the solar power project are at this sizable address on the ISES website: [http://www.ises.org/ISES.nsf/5c990687ba31ff01c12568b3004ef917/6908fc3d975fe818c125694a00257653/PageContent/M3/Pages\\_03-05\\_Myeka\\_Secondary\\_school.pdf?OpenElement](http://www.ises.org/ISES.nsf/5c990687ba31ff01c12568b3004ef917/6908fc3d975fe818c125694a00257653/PageContent/M3/Pages_03-05_Myeka_Secondary_school.pdf?OpenElement).



The Kigoma region is famous as the home of the Gombe Stream Research Centre, where Jane Goodall and her colleagues have spent four decades in trailblazing research on chimpanzees, our closest genetic relatives. Among the discoveries to emerge from Gombe are that chimps make and use tools, hunt and eat meat, come together in family groupings in periods of stress, and at times succumb to the same warlike ways as human beings. The late biologist and author Stephen Jay Gould said that "Jane Goodall's work with chimpanzees represents one of the western world's greatest scientific achievements."

No less than for humans, the loss of forest in the Kigoma region poses dire challenges for chimpanzees, whose very survival may hang in the balance. Africa's wild chimpanzee population, at least 1 million animals in 1960, is today fewer than 200,000. "Because chimpanzees are very slow breeders and give birth only at five-year intervals," worries Goodall, "the species could be on its way to extinction if nothing is done to protect the animals and their habitat."

Recognizing that the welfare of chimpanzees and humans are indissolubly linked, in 1994 the Jane Goodall Institute joined hands with local leaders to create TACARE, The Lake Tanganyika Catchment Reforestation and Education Project. TACARE seeks to arrest the rapid environmental degradation of the Kigoma region by improving the lives of the area's people and – particularly and explicitly – its women.

TACARE is at work on many fronts in thirty villages throughout the Lake Tanganyika watershed. It is delivering conservation education, helping women grow fruit trees and vegetables, and promoting reforestation. It is running a very successful family planning program,<sup>10</sup> teaching young people how to avoid AIDS, underwriting scholarships for academically-gifted girls to attend secondary school, and championing women-led microenterprise.

Additionally, TACARE is actively seeking ways to ease the energy burden on Kigoma's women. It has so far introduced fuel-saving stoves in 22 villages, and now seeks to disseminate the benefits of solar energy. In this task it has asked the assistance of the Solar Electric Light Fund.

SELF and TACARE have conceived a phased solar electrification project that will begin at the Gombe Stream Research Center, then radiate outward to surrounding villages. Women will be not only key project beneficiaries, but also project leaders.

In the first phase, SELF staff will team with locally-recruited women and men to install solar arrays at the Research Centre. These local recruits will receive intensive training in their KiSwalihi language in how solar power works, how it is implemented, and how systems are properly maintained.

Upon the completion of this phase, this vanguard group of local technician-evangelists will fan out to the TACARE villages, spearheading broad-based solar-electrification of homes and community institutions such as schools, health clinics, tree nurseries, and microenterprises.

One very exciting new microenterprise will be directly spawned by the project itself: a women-run business that will produce energy-efficient lamps and lighting fixtures ideally suited to use with solar power. These innovative lamps will be based on clustered light-emitting diodes. Optimism for the success of such a lamp-making venture is founded on the very positive results of a quite similar undertaking involving rural women in Bangladesh, recently described by the UNDP in its excellent publication *Generating Opportunities: Case Studies on Energy and Women*. Among the conclusions of that case study:

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<sup>10</sup> Read a recent U.C. Berkeley evaluation of this program at <http://big.berkeley.edu/tacare.pdf>.



*Lamp production provides a new opportunity for women to earn a living, one in which their labour is highly valued. Non-farm labour among women was not significant in the area prior to the project. Now their employment prospects have increased.*

*Besides increasing the non-farm skills of rural women, the project has also allowed them to generate income, play a role in decentralised energy service delivery, improve their quality of life through better lighting, and raise their status in the household and community...*

*Women who are involved with lamp construction and, by extension, with addressing the overall energy needs of the region, are being heard more. Project participants and their associates now run meetings to discuss prospects and problems in microenterprise operations, regional sales and electrification issues.*

*The husbands of the project members offer assistance to the working team of women, especially in marketing and sales. Individually and collectively, the women are encouraged to bring their husbands to monthly meetings with the marketing manager in order to discuss potential business prospects. Such interactions have been found to build women's confidence, and interest in the project among the men. As a result, the project has been successful in removing some of the social and cultural discrimination experienced by women.*

*Regular participation in project activities requires women to spend time outside their homes, thereby overcoming a traditional social barrier. In addition, other family members are found to support the women by taking on household responsibilities in order to help them participate in training and production activities. With the electric lamps, housework can be done at night and women can restructure the time they spend on household activities... Such shifts in priorities of households in remote rural areas of the country are a sign of the social changes achieved by the project.<sup>11</sup>*

The observation regarding the supportiveness of men is especially encouraging, since both Bangladesh and Tanzania are nations where male privilege is pronounced. Further evidence of the viability of a women-led microenterprise in Tanzania comes from a study, *The Role of Women in Sustainable Energy Development*, from the U.S. National Renewable Energy Laboratory:

*Although conflicts and differences of interests between women and men can and do exist, men often support the efforts of women to save time and improve their families welfare. Even in a country like Yemen, the openness of both women and men to women's role in renewable energy was evident in a baseline survey for a biogas project: It revealed that women were ready to acquire new skills and knowledge that would improve their lives and that of their families. It also indicated that the male heads of households welcomed the release of women from their difficult tasks, within and outside the home, and the utilization of the time for education and improvement of family conditions.<sup>12</sup>*

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### ■ Conclusion: Divides United

Renewable energy cannot by itself span all the daunting divides and fault lines that make our age so unsettled and, at times, so frightening. But, together with goodwill, such technology can and should play a significant role.

All humanity deserves electricity to reduce drudgery, to purify water, to light and heat their homes, to refrigerate vaccines, to use modern communications, to discover and reach their full potential as people. Developing world women are particularly harmed by lack of electricity, and their empowerment with renewable energy will pay immense dividends. Join SELF in reaching across this divide.

It is fully within our power.

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<sup>11</sup> See [http://www.undp.org/seed/eap/publications/2001/files\\_2001a/03\\_bangladesh.pdf](http://www.undp.org/seed/eap/publications/2001/files_2001a/03_bangladesh.pdf).

<sup>12</sup> See <http://www.nrel.gov/docs/fy00osti/26889.pdf>.