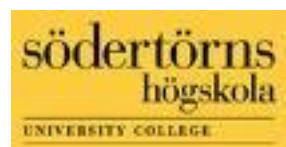


Energy, gender and poverty

- How can solar power meet women's electricity needs in poor rural areas in developing countries?

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"Poverty means, among other things, limited access to energy sources. Poverty influences and determines energy choices of poor households. There is a gender bias in rural energy poverty, too, because the main source of energy in poor rural households is not biomass - it is women's labor. The real energy crisis in rural areas is women's time."

-Elizabeth Cecelski, Director for Research and Advocacy, ENERGIA

ABSTRACT

Renewable energy technique is increasing in popularity and usage. But the world's current energy consumption is extensively uneven, and 1,6 billion people still live without access to electricity. The domestic work in rural areas is often very time and energy consuming; fetching water alone can take up to 5 hours or more per day. Due to gender inequality, women are the most responsible for the drudgery household work in rural areas in developing countries. Hence, women are more and worsely affected from the lack of access to electricity than men. Access to electricity can reduce the time consuming domestic chores with several hours per day. It can also benefit women's empowerment, because all the extra time can provide new possibilities and freedoms. Rural women's electricity needs are summarized by ENERGIA and UNDP. The needs can be divided in; mills for grinding, water pumps, indoor and street lighting and power for TV, radio, small enterprises etc. Solar power is an interesting alternative since it functions just as good off-grid and can be quickly installed. Solar powered waterpumps are a very good alternative whilst solar grinding mills are too cost intensive. Solar power provides affordable indoor and street lighting alternatives, thus street lighting can vary greatly in price. Solar power works good with smaller loads which requires constant power, such as a small refrigerator or a radio. The larger the loads, the greater the expences, so for large enterprices solar power is not yet a viable option. Hence, access to electricity is not enough, empowerment is just as important for women in order to actually gain more freedoms instead of more working hours due to extended hours of evening light.

Keywords: renewable energy, photovoltaic, gender, rural, development, solar power

SAMMANFATTNING

Förnyelsebara energikällor ökar både i popularitet och användning totalt sett. Men, den globala energikonsumtionen är mycket ojämn och fortfarande lever 1,6 miljarder människor utan tillgång till elektricitet. Hushållsarbetet på fattiga landsbygdsområden i utvecklingsländer tar ofta både mycket tid och energi att genomföra. Att endast hämta vatten för den dagliga konsumtionen kan ta över 5 timmar. På grund av en icke jämställd relation mellan kvinnor och män, är det kvinnorna som mest ansvariga över det tunga och tidskrävande hushållsarbetet. Därför påverkas också kvinnor mer av brist på elektricitet i hemmen.

Tillgång till elektricitet i hushållet kan markant minska arbetsbördan och antal timmar som hushållsarbetet kräver. Vidare kan det också påverka jämställdheten, kvinnors möjliggörande och friheter positivt, då kvinnor får en möjlighet att använda sin tid på andra sätt.

ENERGIA och UNDP har sammanställt vanliga elektricitetsbehov som fattiga kvinnor på landsbygden kan tänkas ha. Dom är uppdelade i; kvarnar för malning, vattenpumpar, belysning och el till TV, radio och små företagsverksamheter. Solenergi är ett intressant alternativ för elektricitet då det ej kräver någon uppkoppling till konventionellt elnät, och är enkelt att installera.

Soldrivna vattenpumpar fungerar väl men större kvarnar kräver för stor elkapacitet. Soldriven belysning är relativt billig, dock kan priset variera mycket. Mindre apparater kan med fördel drivas av solenergi, men ju större anordning desto större solpanelsystem krävs det, och desto dyrare blir det. Trots att en implementering av elektricitet genom solenergi kan fungera väl, är en fokus på genusproblematiken lika viktig. Utan ett förstärkande av kvinnors ställning både i hemmet och i samhället är det inte troligt att dessa extra timmar bidrar med nya friheter och möjligheter för kvinnor. Tvärtom kan kvinnors arbetsbörda i hemmet till och med öka, då en bättre belysning ju gör att det är lättare att arbeta sent in på kvällen.

Nyckelord: renewable energy, photovoltaic, gender, rural, development, solar power

LIST OF ACRONYMS

AC – Alternating Current

DC – Direct Current

ENERGIA – International Network on Gender And Sustainable Energy

IPCC – Intergovernmental Panel on Climate Change

MDG – Millenium Development Goals

PSH – Peak Sun Hours

PV – Photovoltaic

RE – Renewable Energy

SEI – Solar Energy International

SHS – Solar Home System

SIDA – Swedish International Development Agency

STC – Standard Test Conditions

UN – United Nations

UNDP – United Nations Development Program

UNEP – United Nations Environment Program

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1. INTRODUCTION AND BACKGROUND

Introduction

Energy is critical for human survival and can be extracted from a variety of sources. Renewable energy technique (RE) generates energy from natural resources like the wind, the sun, geothermal heat, biomass and water. These resources are naturally replenished and hence considered as a sustainable energy option when properly extracted.¹ The two foremost advantages with RE is an extensive reduction in emissions of greenhouse gases and an increased energy safety. The development of renewable energy techniques rapidly grows just as its annual increase of usage. In 2008 global RE capacity reached 280 000 Megawatts which is a 16 percent rise in one year. And for the first time in modern age both the United States and the European Union now adds more capacity in RE than in conventional fuels. Solar power is the worlds' fastest growing RE technology with Spain and Germany as the premier consumers, but it's also increasingly popular in Japan.² Solar power has many technical advantages and considers as the most reliable energy source that currently exists.³

Hence, the largest growth of RE technology occurs in developed countries, where also the majority of fossil fuel usage takes place. Globally there is an extensive uneven energy consumption, and 1,6 billion people still live *without* access to electricity. These people are located in developing countries - especially in Sub Saharan Africa and Southeast Asia, but also in the Middle East and Latin America. In countries like Chad, Sierra Leone and Liberia on the African continent, only 3 percent of total population have access to electricity.⁴ In most developing countries rural areas have less access to electricity than urban and semi-urban areas, because the urban grid connection rarely reaches more remote and distant settlements.⁵

Besides the global uneven access to electricity, there is also a gender difference – men and women affects differently from lack of access to electricity, they have different energy needs and also uses it in different ways. Women suffer more from lack of access to household electricity than men - it's *women's time and energy* that's substituting the lack of electricity in rural household work.⁶

¹ Smil Vaclav, 2003

² Renewables Global Staus Report 2009 Update

³ SEI, 2004

⁴ Regarding fossil fuels, the African continent also stands for only 3,8 percent of global emissions of greenhouse gases.

⁵ Clancy, Skutsch & Batchelor, 2003

⁶ Cecelski, 2000

1.2 Background

Global poverty reduction is one of the world's largest present challenges. Currently 1,4 billion people live on less than 1,25 UDS/day, which is the limit for extreme poverty defined by the World Bank. Hence, the number of people living in poverty declines in most areas - except Sub Saharan Africa, where the condition increases. Poverty and lack of access to modern energy are complexly intertwined.¹

Energy is necessary for human survival and safety and provides an important tool for development, economic and social growth. A safe and reliable access to electricity is a crucial prerequisite in poverty reduction measures, thus not enough.² Household work, agriculture and fuel and water collection consumes a lot of time without access to modern energy. The daily collection of water or biomass alone often demands several hours of hard work.³ One of the Millenium Development Goals implemented by the United Nations in 2000 aims at halving the number of people living in extreme poverty by the year 2015. Access to modern energy is not one of the 8 MDGs, but the UN relased a complementary report in 2005 which emphasises the importance of modern energy in order to reach all the MDGs⁴. The UN concludes that none of the goals can be achieved without a substantial improvement in energy access in developing countries. Access to electricity is central in development measures, and with an emphasis to current emissions of greenhouse gases by the consumption of fossil fuels which leads to climate change, RE is preferred as an environmentally sustainable option. Solar photovoltaic energy is both the most reliable and popular RE technology, and geographically suitable for developing countries.⁵

Another huge challenge is *gender inequality* - a global phenomenon that exists both in developed and developing countries. Gender inequality can be measured and defined in several ways, but the basic idea is that there are both concealed and obvious disparities between men and women as individuals due to gender roles.⁶ Thus, gender inequality is often more outspread and severe in developing countries. Women are more negatively affected both from poverty and lack of access to electricity than men, and they maintain less freedoms because of the existing gender roles.⁷ Not being gender -sensitive in rural electricity implementation can even further reduce the quality of women's lives, though the male situation almost always improves. So far, most energy projects and measures that provides poor rural areas with electricity doesn't consider these gender differences.⁸

¹ Clancy & Skutsch

² UNDP, 2005

³ Cecelski, 2000

⁴ UNDP, 2005

⁵ SEI,2004, Smil 2003

⁶ Cecelski, 2000, Momsen, 2004

⁷ Cecelski, 2000, Sen 1999

⁸ UNDP & ENERGIA Toolkit and Resource Guide

2. PROBLEM FORMULATION

2.1 Problem

*"Poverty means, among other things, limited access to energy sources. Poverty influences and determines energy choices of poor households. There is a gender bias in rural energy poverty, too, because the main source of energy in poor rural households is not biomass - it is women's labor. The real energy crisis in rural areas is women's time."*¹

Lack of access to modern energy in developing countries holds several consequences. Living without electricity makes household work very time- and energy consuming, especially in rural areas. It is very hard to escape poverty if there is no spare time for economical, social or educational activities.² Due to an existing gender inequality women are most responsible for the household work. The extensive time that women have to invest in everyday household duties makes them less free than men, and complicates possibilities of development.³ And because of the uneven distribution of household work, men and women have different electrification needs.⁴ The UN and the Millenium Development Goals do not emphasise access to electricity for all rural households, though all urban households.⁵ But, I consider it equally important to highlight electricity possibilities in poor rural households. Concerning a sustainable development and a relatively fast electricity implementation, solar power have several advantages. Solar energy is claimed to be the most reliable energy source existing today, and can produce electricity completely off-grid⁶. A proper solar power system can be designed and installed in just a few days when having all system components available. My aim is to analyse rural womens´needs of electricity, and then investigate wether solar power can provide any of these needs from a geographical, technological and economical perspective, with support from the following research questions:

¹ Elizabeth Cecelski, Director for Research and Advocacy, ENERGIA

² Cecelski, 2000

³ Momsen 2004, Sen 1999

⁴ Cecelski, 2000

⁵ Energy Services for the Millenium Development Goals 2005

⁶ SEI, 2004

2.2 Research Questions

-What are the typical electrification needs of poor women in rural areas in developing countries?

- How can solar power technology meet these needs?

-How can poor, rural women in developing countries receive access to the solar power technique?

2.3 Purpose

The aim of this study is to analyse possibilities and limitations regarding rural Photovoltaic System Design from a gender-sensitive perspective, with a focus is on poor women living in rural areas in developing countries. Access to electricity can give a noticeable time reduction in household work, thus creating new freedoms and enhance gender equality.¹ Hence, my overall purpose is to highlight those who work the hardest in this world but retrieve the least for their efforts – poor, rural women in developing countries.²

2.4 Restrictions

All humans benefit from, and need access to modern energy. There are numerous ways of working with poverty alleviation and women's empowerment, but I choose to focus on possible effects of rural electricity implementation. My starting point is that men and women shall receive equal opportunities in order to improve their living conditions and to climb out of poverty. Current energy implementations in rural areas are rarely gender sensitive, which usually benefit men more than women³. Having a gender perspective does not mean to solely focus on women, it's about analysing society from the relationships between women and men. But, when focusing on rural household electricity needs, women are a key target since they are both the main producers and users of energy.⁴ Men's electricity needs are equally important, but I choose to highlight and focus solely on the electrification needs of poor women. Regarding rural women's needs, a well-known and a fundamental energy issue is left out; cooking, which is one of the major energy problems that rural women struggle with. But, the agreement on the inefficiency of electricity cooking is large enough not to automatically intertwine in electricity needs.⁵ Proper energy for cooking is embraced in the Toolkit from where my information is gathered. I also restrict my analysis to rural areas. This is

¹ Clancy, Skutsch & Batchelor 2003, Amartya Sen 1999

² Cecelski, 2000

³ Cecelski, 1987

⁴ Clancy, Skutsch & Batchelor 2003

⁵ Cecelski, 2000

because rural areas in developing countries have less access to electricity than urban and semi-urban areas.¹ Regarding electricity supply several delimitations are made. First of all, my focus is on alternative energy sources, because of several serious implications that fossil fuel burning features. Burning fossil fuels leads to a global climate change with severe consequences are likely to be more severe in areas where the majority of poor people live; Africa and Southeast Asia.² Since climate change threatens to push more people into poverty, it feels irresponsible and as a short-term solution to consider fossil fuels as the major source of modern energy, if and when there are alternatives. The large demand for oil also contains political tensions, and the price per barrel constantly fluctuates, thus making it a less reliable source of energy. Besides this, the scarcity of oil is highly debated.³ Renewable energy sources can often be installed quickly, without any great need of infrastructure or grid connections.⁴ There are several renewable energy alternatives, thus I do not have the contingency to discuss and analyse them all, and choose to focus solely on solar power.

2.5 Disposition of the thesis

In the first chapter I discuss the current development of RE technique, and highlights its globally uneven spread. Then an introduction on global energy poverty and gender mainstreaming follows. The third chapter discusses literature, references and my chosen theory that provides as a foundation throughout the thesis. A method discussion is introduced in the 4th part, followed by chapter 5 where some conceptions are discussed; rural poverty and energy, gender inequality, the importance of empowerment and finally a solar power presentation. The 6th chapter presents my results and analysis by presenting answers to my research questions. It continues with a brief presentation on the economics of kerosene and diesel compared to solar power, followed by a discussion on possibilities for rural women to obtain solar power technique. In the 7th chapter my closing discussion takes place, followed by my finishing conclusions in chapter 8. Chapter 9 shows my literature and references.

¹ Clancy, Skutsch & Batchelor, 2003

² Smil, 2003

³ Lallement, 2008

⁴ SEI, 2004

3. LITERATURE AND THEORY

Literature and references

This research aims to involve three distinct yet complex intertwined subjects; renewable energy technology, poverty alleviation and development, and the importance of gender equality and women's empowerment. Working with these extensive subjects together in a limited amount of time and space, I am aware of the risk of only scratching on its surfaces, without reaching any further conclusions or even a decent representation. Thus I find it too interesting and important not to try. Hence, my literature and references as well derives from three distinct subjects of areas. Regarding RE technology –in this case solar power, my emphasis has been to collect data from internationally bound manufacturers and corporations, at least partly involved in development projects. When possible, I prefer to collect data from case studies and projects rather than profit oriented corporations, and have carefully used their information. One example is the international manufacturer Sol®, currently active in 61 countries around the world. Besides a profit oriented business, they are also partly involved in charity and development projects.¹ Much technology information derives from the Photovoltaic System Design Manual by SEI, which is an organization working with educating renewable energy techniques. Solar technology is discussed as a means for development, whereas much of the theoretical inputs and information is collected partly from Amartya Sen, and partly from global institutions as UN, the World Bank and FAO. The institutions are well provided with resources, knowledge, data and experience in their global work, reviews and investigations, thus I consider them to be reliable sources. My theoretical focus on development as freedoms is based on the development philosophy of Amartya Sen - a prominent Indian economist currently working at the University of Harvard, with a focus on welfare economics in developing countries. In 1998, Sen won the Nobel Memorial Prize in Economic Sciences for his efforts and focus on a broader development perspective than purely the economical. A year later “Development as Freedom” was released. Sen has contributed much to this world both with his visions on development and the importance of women's empowerment. Thus, the data and theories on women's empowerment and gender equality ranges both from Amartya Sen and ENERGIA; the International Network on Gender And Sustainable Energy. ENERGIA actively works and lobbies towards the goal of enhancing gender equality and female empowerment through a focus and implementation of sustainable energy sources.² Elizabeth Cecelski is an international expert on gender and energy issues, and one of the members of ENERGIA Advisory Group. Amongst her wide range of professional experience, Cecelski has worked together with organizations such as UNDP and the World Bank as a gender, energy and development consultant.

¹ Sol®

² ENERGIA

Theory

Development as freedom functions as a highly topical theoretic perspective when dealing with access to electricity and female empowerment. Freedom can be both an important tool as well as a goal for development. Amartya Sen divides these unfreedoms into five distinct types: social opportunities, economical facilities, political freedoms, protective security and transparency guarantees. It ranges from famine and lack of health care to a denial of civil and political rights, poverty, insecurity and gender inequality. Despite distinct areas, all freedoms are intertwined and one freedom can foster the development of another. On the other hand, economical unfreedom can foster social unfreedom and likewise.¹ Hence, development is more than economical growth – it's a process that enlarges access to real freedoms, which becomes both the means and the principal ends. This theoretical perspective portrays an agent-oriented view instead of passive recipients, as earlier development strategies fairly often have. Enjoying these freedoms means that humans have a possibility and a right to choose; occupation, life, experiences and by reaching that fulfillment, society often receive positive effects in return. Thus, it's a government's responsibility to take action for its citizens. There are important linkages between social arrangements and the ability of individual actions. The common goods should be highly prioritised, covered by taxes.²

Due to poverty, lack of access to modern energy and gender inequality³, rural women may suffer from several unfreedoms. Regarding social opportunities, culture and social constitutions may hinder women from gaining the same benefits as men do, regarding health care, education etc. It's harder to gain economical facilities since a majority of many women's time is spent on reproductive, unpaid work. Sometimes women are forbid to spend time with men outside the family. The husbands are often in charge over household's finances. Women are often less involved and allowed in the community's political life, thus less female influence. Continuously, the protective security is often less developed for women. Many governments and communities are strongly patriarchal, thus the social safety net is usually not as strong and protective. Rural women poses a risk of becoming less secured with transparency guarantees since much of the societal information comes from the husband, not directly from society. Without these freedoms, millions of women (and men) are forced to fight for survival, simultaneously as the richer parts experience a material abundance and freedoms to choose how life should be. Sen argues that women's increased participation in the community enhances the entitlement to land ownership and positively affects societal and economic activities. When more freedoms become obtained, the possibilities for

¹ Sen, 1999

² Sen, 1999

³ With gender inequality, I assume that there are both concealed and obvious disparities between male and female individuals due to gender, that are roles constructed both biologically and socially, through traditions, culture and religion. This inequality manifests in numerous ways in everyday life, and is a global phenomenon. It is also grounded in stereotypes, which has put different qualities on men and women. Gender inequality affects both men and women.

individuals to transform into active contributors to society increases. This is very important because in the end, it is the individuals who determine where development is aiming towards. Besides poverty, gender inequality further restrains women from obtaining these freedoms. ” *The extensive reach of women’s agency is one of the more neglected areas of development studies, and most urgently in need of correction. Nothing, arguably, is as important today in the political economy of development as an adequate recognition of political, economic and social participation and leadership of women.* ”¹

3.3 Similar studies

There are numerous studies on poverty alleviation and gender inequality. But there are less research on the energy, poverty gender nexus.² Rural energy poverty too, has been somewhat neglected in the development areas. The energy sector has traditionally been aimed at more high-tech, large-scale and capital intensive projects and installations. Not only women’s needs have been neglected but also the energy needs of indigenous and local communities.³ Thus, the subject begins to receive more attention, and both UN, the World Bank, FAO and similar international organizations are paying more attention to the linkages. There are studies with both positive and negative outcomes on electricity implementation, thus showing the complexity of the subject. The Baker Institute Energy Forum highlights the importance of a gender perspective in energy implementing, and also has a program for study on women and gender. The importance of gender mainstreaming has gained more focus in several international conferences, for exemple the forth conference on women in Beijing in 1995. The third Goal of the Millenium Development Programme is to promote gender equality, while the first one is to eradicate poverty. ENERGIA has released many reports on gender mainstreaming and the importance of sustainable energy. It’s complexity lies in the complex connections between the three earlier distinct areas. The UK Department For International Development, DFID, provides funding for research on this particular area of subject, and has released several reports, focusing both on energy poverty and connections between gender, energy and poverty. Several African governments and institutions have increased their focus on gender in the rural energy problematique, for exemple Botswana, Uganda and South Africa, and similar trends are found in Latin America, Asia and the Pacific⁴.

¹ Sen, 1999

² Obeng, George Yaw & Evers, Hans-Dieter, 2009

³ Cecelski, 2000

⁴ Dutta, 2005

4 METHOD

4.1 Possible methods

There are several methods for analysing solar power from a women's perspective. An interesting method is to do a direct case study by visiting one or more areas where energy poverty is a reality. In that way, interviews and a local analysis probably give a more realistic data. That would also provide me as a Westerner a further face-to-face information and experience on extreme poverty, and thereby possibly another procedure and research focus. Another method alternative is a literature study focusing solely on one or two case studies regarding rural solar power implementation projects, for example one case study applying a gender perspective as a foundation, and one energy project that doesn't. Then, the research is more focused on possible effects of implementing a gender perspective.

4.2 Choice and motivation of method

My aim is to reach a comprehensive understanding through my research questions, whereas I choose to work according to a descriptive method with a qualitative approach. A descriptive method is useful when the main objective is to reach an overview and a generalization of the results. Using a qualitative approach, validity and reliability is important throughout the process. My educational experiences towards gender equality, poverty and energy are fairly similar; I haven't study any of these approaches in further detail, only in shorter courses, thus I consider my objectivity towards the complex area to be valid. In order to complete this study, the first task is to find out which electricity needs rural women in developing countries might have, and to explain the foundation on these particular needs to gain a more complete analysis. And, since I do not have the contingency to do a direct case study I choose to trust the Toolkit and Resource Guide, summarized by ENERGIA and UNEP. I do recognize that rural women's electricity needs may vary a lot, and use the information as guidelines, not as definitive. In order to present why these needs are important most of the literature and data derives from ENERGIA, and where the information was missing, I continue the search through similar sources of information. After analysing the common average electricity needs, I need to re-define them into technical solutions, which is made with support from Solar Energy International. My second research question aims to discover how solar power technology can meet the electricity needs, which is performed through four subordinate questions; Does the technique exist? If the technique exists - how does it function? What are the average expences? Are there any innovative/ more affordable techniques which provides a similar service? Through the last subordinate question I wish to inspire the reader of an interest in the current rapid development of affordable solar power, but also attend the importance of flexibility in rural

electricity implementation. Regarding the limited extent of my technical analysis, I consider these four questions to be sufficient and valid. Thus, during this part of the research several issues emerge. My first aim is to collect data from a variety of recently evaluated case studies performed in different developing countries. In this way I want to increase the reliability by presenting real-life scenarios, preferably followed by evaluations on the rate of success. And, I want to avoid using a lot of information from corporations, since the interest of profit may reduce the objectivity and reliability. Both ENERGIA and UN as well as other organizations do publish completed and evaluated electricity projects. Hence, the technology and expenses are rarely presented in further detail, and in most cases the projects are implemented at community level. Despite an extensive research, I did not find enough case-study data at household level - which is in itself interesting since it can partly confirm the lack of international focus on gendered rural household electricity implementation. Since I focus more on financial expenses and electricity needs at a household level, I am forced to collect new data regarding most of the information. Instead of purely case studies and projects, I base much of my technological information from Solar Energy International, and when needed, the financial data derives directly from a variety of solar manufacturers. Thus, data on evaluated energy projects are not completely excluded, since they can contribute with interesting inputs. Regarding manufacturers and corporations, my aim is to mainly collect data from those who are at least partly active in developing countries, thus contributing with a more accurate and realistic information. Overall, most of the data derives from SubSaharan Africa, India and Southeast Asia. My intentions towards the origin of the data have been objective, but during my collection of data I discovered that the majority derives from those parts of the world. A reasonable explanation is because that there's where the lack of access to electricity is most abundant. Besides the theoretic perspective of development as freedom originated from Amartya Sen, my research is made through a gender perspective. It might be problematic, thus gender equality is a normative and ideological standpoint not universally shared. It assumes that the world functions in a certain manner. Thereby it can be questioned whether my interpretations and selection of data is objective. Thus, I rely on the empirical and statistical data of gender differences regarding poverty and energy, and consider these inequalities as a justified foundation to apply a gendered perspective. Without this perspective, the research would have neglected the social discourse surrounding rural household work, thus reduced to a simplified technical analysis alone. The third question presents different approaches on how rural women might reach the technology. Unlike my previous question, the information on microfinance and government incentives is extensive. I'm forced to choose, and sieve the technical information by focusing on a brief, comprehensive presentation. When needed, I focus on the founders or a certain organization, as with microfinance. Since there are over 400 MFIs active, my discussion derives from the Grameen Bank, the "mother" of MFIs.

5. CONCEPTS

5.1 Rural poverty and energy

About one fifth of the world's population experience extreme poverty, with the majority living in rural areas.¹ There is a difference between urban and rural poverty; rural areas are often worse affected by poverty than urban. This is because the lack of proper health care, protection, shelter, transport and communication is more persistent in rural areas. *Energy poverty* is a term used for lack of access to energy services in developing countries, and highlights the difficulties of performing household work like water fetching, land tilling, cooking and grain grinding without access to proper energy.² There is not much sparetime for education or economic activity, thus making it harder to escape poverty. Besides this, the high reliance on biomass fuels negatively affects natural resources and thus environmental sustainability. Currently 1,6 billion people live without access to electricity, and about 2 billion people rely on traditional biomass - crop residues, animal dung and wood, as their primary source of energy.³ It's expensive and time consuming to develop grid connections to remote rural areas in most developing countries, which are often faced with limited infrastructure. State energy policies also affects the development of grid connections, and rural development has sometimes been neglected because of regulatory constraints, environmental concerns and a more persistent risk of failure. So far, energy poverty has also been somewhat invisible in development measures.⁴

Gender, energy and development

Gender inequality

Analysing rural women's electricity needs from a gender perspective implies that the needs derive from diverse socially constructed gender roles, not the biological definition of "women".⁵ Women's needs have often been neglected due to culture, social traditions and established conventions, and no country in this world has yet reached a full gender equality.⁶ Globally being the same phenomenon, gender inequality affects women and societies differently depending on societal circumstances. Women constitute a majority of the world's poor; about 70 percent of the world's poor are women, and one in five households are female-headed.⁷ There is a gender difference regarding cash income, economical activity and involvement in productive versus

¹ Clancy, Skutsch & Batchelor, 2003, FAO, 2006

² Energy Services for the Millenium Development Goals, 2005, Clancy, Skutsch & Batchelor 2003

³ FAO, 2006

⁴ Clancy, Skutsch & Batchelor, 2003

⁵ Cecelski, 2000, Clancy, Skutsch & Batchelor, 2003

⁶ Global Gender Gap Report 2009

⁷ Clancy, Skutsch & Batchelor, 2003

reproductive activities. Women usually work more hours than men because their roles are triple: the reproductive role in the household, paid work on other farms besides unpaid labour in the family.¹ Women often have restricted access to resources and decision-making in the household.² Traditionally, men are the main providers of the family which further reinforces their power in the household.³ Regarding food and health care, the antifemale bias can bring distributional inequalities; nutrition intake can vary greatly between men and women in the same household.⁴ But when women's financial incomes improves, the situation seem to even out more.⁵ Gender inequality means a limitation of freedoms in everyday life. *"Women do two-thirds of the world's work, receive 10 percent of the world's income and own 1 percent of the means of production"*⁶.

Gender and energy

Rural women are usually both the main users and the main suppliers of energy into the household. At household level, variations can be analysed through three divisions; decision-making, labour division and perceptions of benefits of energy services. Despite local variations, women are more responsible for the household's energy needs.⁷ Usually men enter the household energy supply when money becomes involved; if a household needs a cooking stove, the husband usually decides whether to buy one or not. Men often perceive access to electricity as a means for leisure or education for their children while women portray it as beneficial to health, household economy and reduced workload.⁸ Due to an increased shortage of biomass household work becomes more time intensive. Electricity implementation in developing countries has so far often been centralized, thus ignoring the household needs.⁹ There is also more focus on the electricity supply instead of demand, which may further neglect different household requirements. Much of women's contributions to economic development is unrecognized, thus also their need of technology and energy - electricity implementation often ignore gender differences.¹⁰ But, overall women are becoming more involved in the energy sector, due to an increased access to education and new opportunities. Hence, a gender perspective in energy implementation is necessary in order to understand the different energy needs between men and women. Gender perspectives in development measures often fails to notice the importance of energy matters.¹¹

¹ Momsen, 2004

² Clancy, Skutsch & Batchelor, 2003

³ Sen, 1999

⁴ Momsen, 2004

⁵ Sen, 1999

⁶ Robbins, 1999

⁷ Dutta, 2005

⁸ Dutta, 2005

⁹ Clancy, Skutsch & Batchelor, 2003

¹⁰ Cecelski, 2000

¹¹ Clancy, Skutsch & Batchelor, 2003

Empowerment and development

Empowering poor rural women in developing countries gives tremendous benefits; not only does it improve women's life situation and freedoms, but it also benefits all people in a society and helps poverty reduction. Gender equality leads to education and higher household incomes, better health, an increased participation in decision-making both in society and in the household. Empowered women are often key driving force towards development, away from poverty. Access to land increases as well as business activities and cash income.¹ Furthermore, an increased gender equality improves agricultural productivity.² It also benefits the children who becomes more well-educated and healthier, and child mortality drops. Fertility rates usually lowers as women becomes more empowered, thus providing with the freedom of not constantly bearing a child. Women's entitlement and their changing agency is central to many features of development.³ Gender equality is a *fundamental human right*.⁴

Solar Power

Energy and technology

Solar power generates electricity from sunlight. It is possible to harness sunlight directly or indirectly. Photovoltaic technique was discovered already in the 19th century, thus humans have harnessed solar power since ancient times.⁵ Solar power is highly flexible in energy performance requirements, and can power anything from a small calculator to large power stations like the Solar Energy Generating Systems (SEGS) situated in California's Mojave Desert, which have 354 MMW capacity installed. The sun produces enormous amounts of energy.

In one year the Earth's atmosphere including all land masses and oceans, absorbs about 3,850,000 exajoules. To put this in perspective, all energy globally produced and consumed in one year is less than the sun produces in one hour.⁶ Since rural areas in developing countries rarely are connected to the grid, an off-grid electrical distribution is preferred. This means that no connection to a conventional grid is necessary. A simple off-grid solar home system consists of one module, a charge controller, wires, a battery and a power outlet.

A watt is a unit of electrical power and indicates the rate of electricity produced or consumed. A watt-hour indicates the rate of electricity consumed during a certain time-span.⁷ A solar home system produces Direct Current power, but larger appliances such as a refrigerator requires Alternating Current. An inverter changes the current from DC to AC, but it adds to the solar system

¹ Sen, 1999

² Gender Mainstreaming – An Overview, 2002

³ Sen, 1999

⁴ UNDP

⁵ SEI, 2004

⁶ SEI, 2004

⁷ An exemple: if a 100-watt light bulb is used for 10 hours, 1000 watt-hours are consumed.

cost. Solar power is *not* always the ultimate solution for electricity implementation - there is a variety of both conventional and RE alternatives and it's important to consider variables like geography, economics, specific needs etc. But, solar power is promising enough to analyse as one of many energy solutions in developing countries.¹

Geography and Environment

Geographically, solar power is widely applicable in most areas of the world. The current largest PV implementation actually takes place in Germany, a country relatively far north.² The number of peak sun hours (PSH) per day and levels of solar radiation determines the rate of electricity production, and most developing countries cover enough peak sun hours. Solar radiation is measured in kWh/m². Environmentally, solar power is characterized as a sustainable alternative, hence its production requires energy inputs. The energy payback or life cycle analysis is used for calculating the amount of time until the appliance has produced as much energy as it did consume during production. Currently it takes about 1 to 3,5 years before the solar home system has completed the energy payback time.³ When installation is complete and the energy payback time is reached, a solar power system provides environmental friendly electricity without any emissions of greenhouse gases - and free electricity for decades. That's one of the foremost advantages of this particular technique. A proper system can produce 90 percent of peak power 20 years after installation, and still function well after 50 years of usage.⁴

Economy

Solar power has so far been expensive due to production and material. Solar manufacturers haven't produced appliances complementing the growing demand - leading to higher prices. Silicon is the main component in solar cells, and was earlier faced with a shortage. Thus, solar power prices has dropped and is predicted to further price lowering.⁵ Silicon is now more abundant, and solar technology development constantly explores innovative alternatives and cheaper materials. Maintenance expenses are low but sometimes required.⁶ Batteries are usually the most expensive appliance, which is problematic. Without batteries, the system cannot distribute electricity when the demand is probably the highest - during evening and night. The average price for a SHS is currently about 4 USD/ watt, but the price is highly variable depending on manufacturer,

¹ SEI, 2004

² SEI, 2004

³ Alsema, E.A.; Wild - Scholten, M.J. de; Fthenakis, V.M.-200

⁴ SEI, 2004

⁵ Duke, R. D. and Kammen, D. M., 2003

⁶ SEI, 2004

government subsidies, production, export/import, type of solar technology, tax incentives etc.¹ An Indian simple SHS can range the double price from an African, and the price per watt in Sri Lanka is only a third compared to Kenya.² The lowest current price per wattage is 0,98 USD/watt.³ Currently, solar prices are falling, and in 2012 it's predicted that many manufacturers will offer solar power at 1 USD/watt or less. This is cheaper than many existing grid connections.⁴ Manufacturers are rushing to reach the lowest production costs, and some of them aim for 60-70 cent per watt in 2012.⁵

¹ Foley, 1995

² Foley, 1995

³ Sun Electronics International Inc.

⁴ LaMonica, 2009

⁵ Kanter, 2009

6. RESULTS AND ANALYSIS

What are the typical electrification needs for poor rural women in developing countries?

6.1 Energy needs of rural women in developing countries

UNDP has together with ENERGIA and with financial support from SIDA developed a Toolkit and Resource Guide for the department Gender and Energy for a Sustainable Development. This toolkit is designed to be a support on both at a policy and project level mainly for energy planners, organizations, companies and community groups, development practitioners and projects and gender experts¹ The toolkit emerges the links between energy and gender with a base in sustainable development. Womens´energy needs are flexible and differ a lot depending on poverty level, infrastructure, culture, traditons, economic possibilities, household responsibilities and geographical prequeresites etc.² Though UNDP and ENERGIA manages to collaborate and summarize common energy needs for poor, rural women, which provides an important gender perspective. The common needs are divided in three parts; Electricity, Improved Biomass and Mechanical. My focus on the *electricity* needs, and if solar power can provide for any of them.

Table 1. Poor rural womens´energy needs, a summarize by UNDP, ENERGIA and SIDA³

Energy Form	Practical Needs	Productive Needs	Strategic Issues
Electricity	<ul style="list-style-type: none"> *Pumping water supplies – reducing need to haul and carry *mills for grinding *lighting improves working conditions at home 	<ul style="list-style-type: none"> *increase possibility of activities during evening hours *provide refrigeration for food production and sale *power for specialised enterprises such as hairdressing and Internet cafes 	<ul style="list-style-type: none"> *make streets safer allowing participation in other activities (e.g., evening classes and women´s group meetings) *opening horizons through radio, TV, and Internet

¹ UNDP & ENERGIA Toolkit Guide

² UNDP & ENERGIA Toolkit Guide

³ UNDP & ENERGIA Toolkit Guide

6.2 Explanations of rural women's electricity needs

6.2.1 Waterpumps

Fetching for water is not an easy task for women in rural areas, where drought and pollution easily affect availability and quality of water. Globally water scarcity is becoming a huge problem – industrial production, increasing consumption, climate change and insufficient technique are big contributors to the problems.¹ Millions of rural women search water for hours everyday, which is often an extensively energy craving task. In Kenya, water fetching alone can burn up to 85 percent of women's daily calory intake.² When the water searching is impossible to do for the women alone, often the daughters are forced to stay home from school in order to assist the mothers. This negatively affects girls' quality of education and prolongs the vicious circle of poverty. Water scarcity also decreases family sanitation, limits agricultural activities and negatively affects preparation of cooked food.³ By installing waterpumps in waterscarce rural areas, women's workload is often reduced by several hours every day, providing free time which can be used for education, economical activity, child care, or a break from the extensive household work. When children do not need to assist in the search for water, they receive greater opportunities to finish their education which is a long-term benefit.⁴ In rural Zanzibar an installed waterpump reduced water fetching time with up to 25 hours per week, which gave women more spare time for productive activities and their daughters attended school at a higher rate.⁵

6.2.2 Grinding mills

Agriculture and crop residue is an important and common activity for rural women in developing countries. It's both a productive and reproductive activity; aimed for both markets and household demand. Besides managing the fields without proper means, the environmental degradation increases and with that the hardship of agricultural work. Working hours on the field increases, and women need to grow larger areas in order to earn what they previously did⁶. Agriculture and crop residue is becoming increasingly time consuming. When women process the farmed crops like manioc or grain into flour, they usually grind the crops by hand. This is stated as one of the *most* hardship and time consuming activities by many rural women.⁷ If provided with an electric mill for grinding, numerous hours of work are saved since the mill can do the same work in just a few minutes.

¹ UNDP & ENERGIA Toolkit Guide

² UNDP

³ UNDP & ENERGIA Toolkit Guide

⁴ Foley, 1995

⁵ Winter, 2008

⁶ UNDP & ENERGIA Toolkit Guide

⁷ Women's Grinding Mills – INGABO - Rwanda

A more effective grain production for market sell may benefit women's social, health and financial situation. Their bodies are less worn out, and they can become more competitive on the market. ¹

6.2.3 Indoor lighting

When in several developing countries only a fraction of the rural population attain access to electricity, many households have to rely on other lighting sources. Candles, kerosene and oil are the most common alternatives, and about 1,6 billion people rely on kerosene as their primary source for lighting.² Kerosene, which is a combustible hydrocarbon liquid, has several disadvantages; it is expensive, unsafe, impose health risks and do not give a satisfying illumination. It is often bought in black markets, and the price varies greatly. Kerosene is usually one of the poor households' largest expenses. An average household uses about 4-7 litres of kerosene a month for lighting, and an common price for kerosene is 1-2 USD/litre. When 1,4 billion people earn less than 37,5 USD/month, it's clear that kerosene costs strains poor households' economy. The price for useful light energy from kerosene is actually 1625 times higher than lighting from compact fluorescent light bulbs!³ Kerosene is not safe to use, it is highly flammable and proper safety measures are not always afforded. Only in India, 2,5 million people – mostly women, annually suffers from burning injuries from kerosene accidents.⁴ Kerosene burning also imposes several health risks, about 780 million women and children inhale dangerous particles enough to be compared with 2 packs of cigarettes a day. Poor ventilation increases the damage risks. This poses problems with eye and respiratory problems, and explains why two thirds of female lung-cancer victims in developing countries are non-smokers⁵. It is not a proper source of illumination, and kerosene lamps are highly inefficient. The burning of kerosene also contributes with emission of greenhouse gases, and stands for 58 percent of residential household lighting CO₂ emissions. An electrification of indoor lighting can eliminate the health risks and improve rural womens' and childrens health and safety tremendously. It can also save time for women since they no longer have to travel away to buy kerosene.⁶ Besides this, it can improve the quality of indoor illumination, making it easier to work, relax or read when the sun goes down.

¹ Clancy, Skutsch and Batchelor, 2003

² Lights For Life™

³ Energistic Systems, LLC

⁴ Lights For Life™

⁵ UNDP & ENERGIA Toolkit

⁶ Dutta, 2005

6.2.4 Refrigeration

Rural areas in developing countries rarely have access to refrigeration possibilities. This hampers women's economical development and hardens household work. Milk and similar groceries cannot be stored which affects both nutritional intake and food preparation. Access to refrigeration can simplify and vary household cooking, making it easier to store and consume a more varied diet, thus improving nutritional health.¹ Further, it can improve women's financial situation. Women sometimes sell cold beverages for some extra income, but the frequent investments in ice-blocks can easily become expensive. A reliable refrigeration appliance may be an important improvement.²

6.2.5 Specialised enterprises

Two thirds of poor rural women are not involved in the formal work sector. This lowers the financial income and power for women, and they become more dependent on the husband's income.³ Millions of women manage to survive through subsistence farming, which is often irregular, thus making it hard to escape poverty. A more reliable income source may improve rural women's situations. Besides, rural women's enterprises are often energy intensive; a common activity is food-processing or different home based industries⁴. Further, the informal sector is not very safe for women. But a small enterprise can bring several positive effects; it empowers women, increases the financial incomes to the household and thereby often the quality of life. Power for an internetcafé, phone lending or such might provide a substantial improvement.⁵

6.2.6 Street lighting

When the sun goes down in rural areas without any outside lighting utilities, it becomes completely dark. This increases the risk of violence and rape of women, dampens the villages and lowers the possibilities of business and leisure during the evenings.⁶ Street lighting provides several benefits; it reduces road accidents and crime, stimulates night-time trade and provides a feeling of amenity. It also increases opportunities of participation in other activities like evening classes and different women's group meetings. This can contribute with several advantages and opportunities for the participating women.⁷

¹ UNDP & ENERGIA Toolkit

² Clancy, Skutsch & Batchelor, 2003

³ Clancy, Skutsch & Batchelor, 2003

⁴ Cecelski, 2000

⁵ UNDP & ENERGIA Toolkit

⁶ Clancy Skutsch & Batchelor, 2003

⁷ UNDP and ENERGIA Toolkit

6.2.7 TV:s, radio and internet

Women in developing countries, especially in rural areas, often need to maintain multiple roles for survival and economic income. Women are family care takers, entrepreneurs, farmers, fuel and water providers, food makers and educators¹. And just like electricity, communication possibilities provides several benefits for these multi-tasked women. The unequal communication opportunities refers to the term *digital divide*. Rural women are especially disadvantaged due to both location and gender.² Access to communication technology makes it easier to communicate without travelling, which is a huge benefit in many areas where travel on the roads can be both dangerous and time consuming. In northern Ghana for example, women working on the markets save 4 days of travelling with just a phone call.³ It also benefits economic activities. Technical communication in rural areas has proven to be time saving, it increases communication with family, friends and business contacts, traders and farmers becomes more updated on market and price changes, and emergency and health situations improves.⁴ It also amends the notice on job opportunities, improves education resources and provides an important link to the outside world. (and makes it more difficult for governments to ignore human rights and violations towards their citizens which benefits the whole population.)⁵ Women often experience many new insights and acquaintances, local and global. Radios are cheap and render as an easy and effective way of providing education and female empowerment in remote areas.⁶ Though access to internet services are more complex than radios and phones; computers can be expensive and many rural women are still illiterate. But it's an important source of information. Access to television has proven to be surprisingly empowering; in rural Indian villages attitudes rapidly shifted from conservative and patriarchal to more positivity towards female empowerment when introduced to cable television. Thanks to the TV, rural women can experience urbanised women, with more power and access to money, and who are less subordinant towards men and have fewer children, which is empowering.⁷⁸

¹ Clancy, Skutsch & Batchelor, 2003

² Shore, 2006

³ Shore, 2006

⁴ Atkin

⁵ Atkin

⁶ Fr. Francis B. Lucas 1999

⁷ Waldfogel Joel, 2007

⁸ S. Hiremath & A.S. Balasubramanya, 2008

6.3 Designing the needs and issues into technical solutions

Poor rural women's energy needs summarized by UNDP and ENERGIA can be translated into four electricity supply solutions by revolving the practical electricity needs into technical definitions; *Water pumps, Mills for grinding, Indoor and street lighting and Power to cover computers, refrigerators, TVs, radios, enterprises* etc. The following step is to investigate if there exist technical solutions driven by solar power, and to highlight the geographical and economical prerequisites.

6.3.1 Solar Waterpumping

Solar water pumping is a common way to increase water supply in areas where water scarcity is a problem, and applied in numerous development projects. Thus, they are increasingly popular worldwide. The technical design is simple; is it an ordinary waterpump driven by solar energy. Solar waterpumps can be used for a different reasons; irrigation, livestock watering, industrial activity and of course community and household water supply.¹ Since it is solar driven, it's important to consider that they must work during dark conditions without overheating or stalling which requires a certain design and technique. Solar water pumps use direct current (DC) so there is no need for an inverter, since solar panels generate DC electricity. If an all-around availability is needed, batteries or storage tanks are necessary. Storage tanks are a more affordable option, since batteries usually are one of the largest expenses in solar power systems. There are various models of water pumps on the market to satisfy different needs, thus submersible pumps are the most commonly used in developing countries.²

- **Circulating pumps** - suitable for fluid in space heating, landscaping applications, solar hot water and pool heating systems. Are usually small, and designed to run on both DC and AC power.

- **Submersible pump** – suitable for wells and drill holes, and preferable when the water supply reaches more than 20 feet from surface. Can satisfy a large water demand. Solar power are rarely used for larger designs - it becomes too cost intensive, but smaller pumps are cost effective.

- **Delivery pumps** - when water supply already exists, but needs to be moved. There are both low and high pressure delivery pumps available.

¹ Foley, 1995

² SELF, 2008

- **Surface pumps** - for shallow surface levels. Functions with a suctioning approach, and reaches their maximum prestanda when water is less than 20 feet from the surface.

Solar water pumps are flexible in size and specific requirements, and many household pumps requires less than a kilowatt of hydraulic output.¹ Another advantage is that water scarce areas are often rich in radiation from the sun, which provides a more reliable and effective electricity supply to the water pump. They work just as good off grid. Solar water pumps are both environmental friendly and cheaper to use than traditional AC pumps. There is no need for further installations or disruptions in the environment, and no power pole lines or ditches are necessary.² Solar waterpumps requires low maintenance, operates unattended, are easy to install and when properly used they have a long lifespan. They can be designed for portability if necessary. Thus, if reparations are required it usually requires skilled technicians, which can be difficult to find in remote areas, and require large expences. Initial capital costs are usually high.³ To lower the cost it's preferable for a small village or a group of families to share the investments for a larger pump, than for each family to invest one of their own. For calculating the costs, the first step is to investigate the amounts of water needed. The second step is to calculate the Unit Water Cost (UWC) for comparison to other alternatives. Very large waterpumps are cheaper to power by diesel.⁴ The economical expenses to consider can be divided into four subcosts; *initial, replacement, maintenance* and *operational costs*. For small and medium-scale solar waterpumps it can be up to four or five times cheaper than a dieselpump, which is the currently most common alternative. During a twenty year time span- including all expences and a daily pumping volume of 10 000 litres, a solar water pump may only cost about 17 percent of what a diesel pump would at current prices.⁵

6.3.2 Solar grinding mills

Larger grinding mills are usually powered with conventional fuel; a diesel engine and a generator.⁶ The smallest are handdriven, but for larger production demands, an mechanical mill grinder is preferable for an increased efficiency. Capacity requirements reaches from about 1kW to 10 kW or more. With the current average solar price per watt of 4 USD/watt, expences for the solar power alone is at least 4 000 USD. Large appliances are usually not recommendable for solar power.⁷

Electrical grinding mills are usually required to perform during a limited time span during the day

¹ By calculating energy requirements, a formel is used; $E = HV$. E = daily energy requirement in watt hours, H= hydraulic head in meters, V= daily volume of water in cubic meters (one cubic meter = 1 000 litres)

² SELF; 2008

³ SELF, 2008, Foley, 1995

⁴ Ministry of Mines and Energy, The custodian of Namibia's rich endowment on mineral and energy resources,

⁵ SELF, 2008

⁶ Africa Renewal, 2006

⁷ Foley, 1995

or week – when grain needs to be milled. The grinder requires a high wattage peak – which requires a large solar power system. It is possible to power a grinder with solar power, thus it’s not a viable economical solution when comparing the limited performance requirements versus the high financial cost.¹

6.3.3 Indoor and street lighting

Indoor lighting

Using photovoltaic energy for indoor lighting has become a relatively common feature in rural lighting development. Usually it consist of a simple Solar Home System (SHS), with enough performance to power a few lamps, small appliances like a radio, a phone, and a black and white television.² The size of the SHS vary depending on household requirements, which are determined by a load analysis. A load analysis is important because it improves the performance, maximize the efficiency and by that lower the economic expences. When installing the SHS it’s important to consider possible shading from trees, houses or mountains to reach a maximum performance. A common recommendation is no shading between 9.am-15.pm.³ A regular SHS consists of a module, a charge controller, wires, a power outlet and batteries. For larger appliances that requires an AC outlet, an inverter is needed. An ordinary SHS in rural areas provides about 25-50 Wp capacity. A solar home system performing 30 Wp can power three 12 V DC fluorescent lights, a 14 inch black and white television during three hours a day, and it also covers power for a radio or for charging a cellphone.⁴ A 50 Wp system produces about 180 daily watt-hours. Regarding light bulbs there’s a difference between fluorescent and indescendent; fluorescent lightbulbs lasts longer, are more efficient and environmental friendly than indescendent, thus they are more expensive than indescendent. Table three below shows average typical performances on common, smaller solar home systems. A 10Wp cannot power more than a few lights, whereas a 60 Wp solar home system can power lights and a television.

Table 2. SHS typical representative energy service levels .⁵

SHS typical representative energy service levels
10 Wp 3 Ah/day: 2½ hours per day for three 5W lights
30 Wp 9 Ah/day: 3 hours per day for three 8W lights and a 12W TV
60 Wp 18 Ah/day: 4 hours per day for five 8W lights and a 12W TV

¹ Foley, 1995

² SEI, 2004

³ SEI, 2004

⁴ SEI 2004, Foley, 1995

⁵ Sri Lanka: Renewable Energy For Rural Economic Development Project, Solar Home System Specifications – 27 January 2004, SEI, 2004

A more affordable alternative for indoor lighting is a solar powered lantern. They function independently and are easy to move and carry if needed, thus they may not function as long as a SHS. There are numerous models of solar powered lanterns available, with a broad price range. If a household chooses to invest in a few cheap solar lanterns, the SHS performance requirements are reduced, following the SHS financial investments as well. The cheapest available solar lantern today costs 10 USD.¹ An ordinary smaller solar home system ranges from 200-500 USD, sometimes more, depending on the manufacturer etc.²

Street lighting

Solar power street lighting appliances are becoming increasingly popular in both developed and developing countries. No grid connection is necessary and the installment is fast which increases the popularity. They have proven to be reliable and usually have a long warranty.³ The design is simple; the solar panel and the lightbulb is mounted on top of a pole, which is then mounted into the ground. If technical problems occur, a professional technician is often required, which can be expensive and hard to find in remote areas.⁴ Considering performance and environmental benefits, there's a difference between regular conventional lights and newer LED-lights. Regular solar street lights contains mercury which is a toxic liquid heavy metal. They are less efficient than LED-lights; they consume more power. A regular lightbulbs lifespan is shorter and there is a greater risk for black or brown outs. LED-lights are more efficient - their life span range from 50 000 hours and up. And, they are mercury free and safer since they run on low voltage DC 12 power. The disadvantage is that LED-lights are more expensive. When installing it's important to carefully analyse the environmental variations; weather conditions, insolation and number of cloudy days.⁵ A further issue is how stabile they are in order to withstand theft, which can be an issue. For smaller rural villages where the road infrastructure is limited and traffic is rare, a solar spotlight is a simple and affordable alternative. A solar spotlight do not require wiring, installment or maintenance.

Spotlights can be mounted both on the ground or on walls or such, and are easy to move if necessary. Hence, this is also one of the disadvantages; they are easier to steal than a proper street lighting. A solar LED spotlight costs from about 18 USD.⁶

¹ The cheapest solar lantern currently available is manufactured by the international company D-light and is called "the kerosene killer" with the proper name "the Kiran". When fully charged it lasts for about 4-8 hours, and provides a light appropriate for reading. It has an integrated solar panel.

² ENERGIA

³ Foley, 1995

⁴ Solar Street Lighting

⁵ Solar Street Lighting

⁶ Sundance Solar™

Solar powered street lights are usually more affordable than conventional utility connected lighting, partly because of the difference in installation costs.¹ Regarding solar street lights that are suitable for traffic and similar preferences, prices range from less than 300 USD up to 6 000 USD/ lighting pole, depending on design, materiel, efficiency and performance.^{2 3}

6.3.4 Refrigeration, internet, radio, TV , enterprices

Powering household appliances such as computers and refrigerators with solar power is possible, but requires a significantly larger electricity load than regular indoor lighting. Further, large appliances usually runs on AC which requires an inverter connected to the SHS, since the photovoltaic system produces DC power. As mentioned in chapter 6.3.3 Indoor Lighting, a load analysis is necessary when designing a proper Solar Home System, following a site analysis for maximum performance and cost efficiency.

Table 3. Common appliances and average typical wattage requirements.⁴

Appliances	Typical wattage requirements
Larger refrigerator	540
Smaller refrigerator	60
Radio	10
Cellular phone	24
Computer (desktop)	80-150
Computer (laptop)	20-50
TV (12-inch B&W)	15
TV (25-inch colour)	130
Blow dryer	1 000
Ceiling fan	10-50
Sewing machine	100
VCR	40
Mixer	120

¹ Sol. Inc,

² Solar manufacturer Alibaba

⁴ SEI, 2004

Conventional and larger refrigerators are not usually recommended to be powered by solar photovoltaic since it is too cost intensive because of the high wattage requirements.

A refrigerator usually have to run all around, unlike a computer or a TV, which further increase the SHS expences.¹ But there are new, smaller and more efficient refrigerators which requires less power. A small refrigerator has a significantly lower wattage requirement. And, for less sensitive grocerices like vegetables and fruits, a refrigerator might not always be necessary. If a household wishes to only store the most sensitive groceries in a refrigerator, a “Zeer”² can be a well-functioning and affordable complement. Hence, a refrigerator is necessary in order to store certain groceries.

When powering a radio, the wattage requirements are usually low.(Table 4.). It’s possible to either supply the radio with a small independent solar panel which charges the radio directly, or to charge it through a larger solar home system. Independent solar power radios are more expensive than regular radios.³ But it is not cost effective to install a SHS if the only electricity need is covering a radio and a few lights. In that case it’s cheaper to invest in solar lanterns and a solar powered radio. Charging a cellphone require more wattage than a radio. But a proper cellphone doesn’t need to be charged more than a few times a week, which still makes a well-working option with solar power. It is also possible to charge a cellphone with a small solar system designed for phone charging. Laptops requires less wattage than a cellphone, and just like a cellphone, a proper laptop do not need a constant charging. Computers have been very expensive, but currently one of the most affordable laptops costs 10-20 USD, and runs on 2 watt.⁴ Still the purchase of a laptop can be straining for a poor household living below the poverty line.

There’s a large wattage requirement difference regarding size and black and white/coloured televisions, following a larger solar power system and thus the price. Regarding rural women’s enterprising possibilities electricity can tribute with a lot.⁵ Since current laptops requires low wattage power and are very affordable compared to earlier prices, internet cafés are highly possible to run on solar power. Investments can rather quickly be returned.⁶ Smaller appliances like radios, fans, mixers, VCRs and smaller refrigerators are also relatively affordable for both home and business activities, but for intensive appliances like a hair dryers or similar that requires 1kW or

¹ SEI, 2004

² A zeer consists of two earthenware pots in different sizes. One is put inside the other and the gap between is filled with wet sand, which cools down the contents when moist and covered with a damp cloth. It works through the laws of thermodynamics – the evaporation process cools down the inner container and thereby preservs the food. It is very cheap and can lower the necessary expences for poor households struggling with limited finances and credit. Webpage; <http://ruralindia.blogspot.com/2008/05/almost-free-refrigeration-using.html>

³ SEI, 2004

⁴ Tnerd 2009

⁵ Clancy, Skutsch & Batchelor, 2003

⁶ Clancy, Skutsch & Batchelor, 2003

more, it will become too cost intensive.¹ An increasingly popular tool in agriculture production is a solar powered fruit dryer. There are both small low cost solar dryers for household needs and larger for market production needs. The smaller dryers can be produced locally, and are much more effective than drying crops in a traditional (open air) way.²

6.3.5 Financial Expenses: Kerosene and Diesel VS Solar Power

Solar power has high investment costs, but kerosene is actually currently one of the largest expenses for numerous rural households. Earlier, fossil fuels have been a cheap and efficient energy source. But the supply and affordability of oil and similar fuels have changed – current fossil fuel prices fluctuate a lot leading to an unstable supply, and during a limited time in 2008, oil prices went up to over 140 USD/barrel.³ The dependence on fossil fuels increases the financial vulnerability on developing countries, which also spend large amounts of money on subsidies in order to lower the price for the poorest.⁴ Currently, poor people pay more for their energy both in relative and absolute terms.⁵ Furthermore, women often lower their food intake due to increasing fuel prices which negatively affects their health.⁶ The transport of oil to remote, rural areas is sometimes difficult due to poor infrastructure.⁷

It's calculated that poor people in developing countries together spend up to astonishing \$38 billion a year on kerosene for lighting.⁸ If assuming that solar power costs 1 USD/watt which it might in a few years, 38 billion USD is equivalent to 38 billion Watts. If every household would invest in a 100 W SHS for the total amount of money that's annually spent on kerosene, 380 million households would benefit from solar power instead of kerosene or other improper energy options. The households would also be able to power a smaller television, a radio or similar appliances. Thus, current average solar price per watt is 3-4 USD. That would still provide a 100 W SHS to over a 100 million rural households in developing countries.

¹ Foley, 1995

² Commercialisation of the solar dryer, AREED

³ ASPO International

⁴ Foley, 1995

⁵ Clancy, Skutsch & Batchelor, 2003

⁶ Lallement, 2008

⁷ ASPO International

⁸ <http://www.riazhaq.com/2009/05/shakti-solar-model-for-pakistan.html>

How can poor, rural women in developing countries access the solar power technique?

“Providing electricity is a government responsibility, but it’s a gigantic task and the government alone cannot do it”¹

6.4 Barriers and possibilities

Women in developing countries are overrepresented in the informal sector which gives them less financial security, and makes it harder to be entitled to bank loans for technical investments or other life-improving measures. It is difficult to find work in the formal sector when the household work consumes much time and energy. Men are usually more active in the productive formal sector that implies cash income activities - which often is their prime activity.² Since women often have less responsibility and power over the households’ economic resources, it can be difficult to invest in a solar system if the husband do not agree. And, men are sometimes reluctant to invest in household expenses since they rarely are much involved themselves.³ Antifemale cultural and social barriers may further affect women’s regular bank credit.⁴ Because of that, it is more viable to offer rural women outside economical preferences. There are several alternatives that can provide economical solutions, such as microfinance, government subsidies, tax regulations and international aid.

6.4.1 Microfinance

An increasingly common method for applying economic support to the poor is the extension of *microfinance* alternatives - the most known one is the Grameen Bank, originated from Bangladesh. Overall it has been a rather successful tool in providing new possibilities to entrepreneurship and investments for those who cannot get access to regular credit loans, and currently there are over 400 active microcredit movements active in numerous countries.^{5,6} Microcredit for solar power investments are increasingly common. Thus, microfinance can be complex if its organisation is not properly adapted to its borrowers.

¹ Shirish Garud, coordinator of the Renewable Energy and Energy Efficiency Partnership (REEEP) in South Asia.

² Cecelski, 2000

³ UNDP and ENERGIA Toolkit Guide

⁴ Sen, 1999

⁵ Smith, 2000

⁶ Lallement, 2008

It's sometimes criticized for focusing more on the lender's perspective, and the often very high repayment rate can be problematic.¹ Besides, there's an overall risk of governments lowering the focus on social and health expenses, which can also occur regarding rural electricity implementation.² *Solitary lending or Self Help Groups* (SHG) is another approach to offer microloans - with lower payback rates. Recipients consists of smaller groups of about 5 persons instead of individuals, which can reduce the need of a collateral and lowers the banks' administrative expenses. The lending prerequisites focus on social capital instead of properties and material capital, which makes it suitable for landless people in rural areas.³ Solidarity lending is more succesful in womens' groups than those of men, and also are the foremost recipients to this method. Responsibility and collectivity can be varied. The solidariy loan activities usually aims towards poorer countries than the regular microfinances. Thus, problems may occur; individual mistakes sometimes receive collective sanctions. Loan conditions are sometimes demanding and time consuming, with reoccurring meetings and activities.⁴ Assessing microfinance for electricity distribution is different than an ordinary loan for a small enterprise or such. Investing in technology requires larger loans and a longer payback rate. Further, it presupposes a spread of solar power knowledge, help and preferably support in order to generate incomes from the installation.⁵ *Grameen Shakti*, originated from Grameen Bank, works with energy poverty and sustainable option. For the poorest, a micro-utility model is applied, whereas the installer sells some of the electricity produced to neighbours, thus helping to pay the revenues. Further, soft credit is applied, information is shared and free monthly post-installation checkups are included. Local women and youth are trained as technicians which may increas cash incomes. Since Grameen Shakti is succesful and one of the fastest growing RE companies in the world based in rural areas, followers are likely to join the market.⁶ Evolving separate microfinance institutions for energy and technology can be a more succesful option since it's financial advantages are almost impossible to measure in advance.⁷

¹ Writers comment: From a gender perspective, microfinance involves some issues to attend, even though it originally started in order to support poor women; Sometimes women play the role of loan collection agents for the male family members, while not having any power over the loans themselves, thus still responsible for the credit risks. Besides an already existing poverty, this pushes women into the informal economy, and many loan recipients are pushed deeply into the cycle of dept. ¹ Sometimes an increased income to the household only makes the husband invest less money on the household and more on himself. Women's workload may significantly increase, and the household gender relations may even worsen. So far gender empowerment has been superficial and systematically neglected because the main focus is on economic successes.¹ The implementation of microfinance needs gender mainstreaming just as much as electricity projects.

² Armendáriz de Aghion & Morduch, 2005

³ Armendáriz de Aghion & Morduch, 2005

⁴ Armendáriz de Aghion & Morduch, 2005

⁵ Clancy, Skutsch & Batchelor, 2003

⁶ Grameen Shakti

⁷ Grameen Shakti

6.4.2 Government subsidies and tax regulations

It can be argued if the poorest in this world should carry the whole burden for the total expenses of electrification, since many households in developed countries receive large subsidies and tax reliefs for home installation of solar power.¹ Many developing countries pay large subsidies for fossil fuels in order to make kerosene, diesel etc more affordable to the poor. The Indian government provides its rural population with solar power subsidies and soft loans². Thus, in order to make kerosene more affordable the Indian government also annually subsidies about 100 million USD for kerosene.³ Because of the weak banks and economical risks, Uganda has established a Credit Support Facility with support from the World Bank, with the aim of improving rural electrification possibilities.⁴ Such initiatives can provide as an important support for rural electrification.⁵ Government energy policys can attent promotional campains and adapt to a more decentralized energy scheme.⁶ Furthermore, they need to work together with donor agencies and the private sector.⁷ Tariffs may provide as a support since they lower the upfront expenses.⁸ Tax regulations can further affect the price of a solar home system. Subsidies can be helpful, thus there´s a risk of undermining the commercial and local market if not carefully implemented.⁹ However, democratization and participatory approaches in the energy sector are also fundamental.¹⁰ Governments need to take responsibility for their citizens and prioritize development.¹¹

6.4.3 International Aid

Many developing countries face difficulties in providing enough resources to their population. There are numerous large international aid fundings and smaller NGOs working for rural energy development. Energy poverty can be more highlighted, thus focusing more on its positive implementation possibilities and thereby increasing the fundings.¹² The importance of modern energy already engages many development organizations. The UN, World Bank and FAO are now recognising the importance of energy implementation through various reports and projects. NGOs and various help-organizations have implemented thousands of households with solar power. Some organizations take it a step further and besides the electricity implementation, they also educate local people – often women, as solar power engineers.

¹ Foley, 1995

² Ministry of New and Renewble Energy, Government of India

³ Chandran, 2009

⁴ Ministry of Energy and Mineral Development, Uganda 2007

⁵ Ljung, 2007

⁶ Energy and gender in rural sustainable devleopment, FAO 2006

⁷ Lallement, 2008

⁸ Cecelski, 2002

⁹ Foley, 1995

¹⁰ ENERGIA

¹¹ Sen, 1999

¹² FAO, 2006

Women learn how to manufacture and install different solar appliances and systems, and then how to train others. The Barefoot College has successfully installed solar power and has educated rural women in both Africa, India and Afghanistan. The educated women pass on the knowledge to more women, creating a cumulative positive effect.¹

6.4.4 Development as Freedom – Empowerment as a prerequisite

One of the current measures against gender inequality is the implementation of gender mainstreaming in projects and policies. The idea of gender mainstreaming is to highlight the fact that situations like poverty have different effects on men and women, and hence different measures need to be considered when implementing policies and projects. Gender mainstreaming is used as a tool in order to reach gender equality, not as a goal itself.² So far, gender mainstreaming has been rather neglected in projects planning, which have led to a skepticism and critique of its rates of success and importance.³ Though there often have been higher rates of success in projects implementing gender mainstreaming.⁴ There are a variety of measures to implement this approach into development and energy projects. As a premier objective, women need to be empowered in order to make energy choices of their own. Energy needs to be considered more as a service than a technology, and energy manufacturers and project developers need to be responsive towards women. As the main producers and users of energy, women's involvement can give significant benefits in rural energy programs.⁵ An implementation of gendered data in energy project planning provides new dimensions and insights.⁶ Women's time in domestic chores needs to be recognized. It's easier to measure efforts in money, but women's energy spent in time is not easy to measure, thus often forgotten. Women's efforts and inputs are not counted when reckoning national energy accounts, which underestimates women's work.⁷

Furthermore, there are some key questions to highlight; what do women want, and what do they want to pay for the particular service? Who makes the decisions in the household? Who benefits from the energy implementation? How do the current energy policies affect rural women, and how should they change? As active agents, how do women cope with energy scarcity?⁸ Whole societies are affected negatively from the lack of freedoms and active agency that millions of women currently experience.

¹ The Barefoot College

² The concept gender mainstreaming was first stated in the Third World Conference on Women in Nairobi in 1985, and approved as a major global strategy in the Platform for Action in the Fourth United Nations World Conference on Women in Beijing in 1995.

³ Gender Mainstreaming – An Overview, UNDP 2002

⁴ Cecelski, 2000

⁵ Cecelski, 2000

⁶ Clancy, Skutsch & Batchelor, 2003

⁷ Cecelski, 2000, Sen 1999

⁸ Clancy, Skutsch & Batchelor, 2003

Individual freedom must be prioritized and obtained as a social obligation of the governments. Women's economic activity outside the home, education and literacy, property rights etc. all contribute to women's empowerment through a stronger voice of independence.¹ Electricity do not automatically empower women, but modern energy greatly reduces the time invested in household drudgery work, providing possibilities for women's entitlement and equity – a human right.²

“Renewable energy manufacturers that do not pay attention to women's needs will be missing a huge potential market. Energy policymakers who ignore women's needs will be failing to make use of a powerful force for renewable energy development. Energy researchers who leave women out of energy research and analysis will be failing to understand a large part of energy consumption and production. Donors who do not support gender-sensitive energy assistance will be overlooking one of their primary target groups.”³

¹ Sen, 1999

² Sen, 1999

³ Cecelski, 2000

7. DISCUSSION

When exploring poor rural women's electrification needs in developing countries, it emerges how important a gender analysis is in all development measures. It is interesting that even in gender mainstreaming projects, women are sometimes portrayed as a means for development, not the goal. Providing sustainable electrification for women's needs in rural areas is not completely impossible. Quite opposite, it's at least theoretically doable, both technologically, geographically and economically. The foremost obstacles lies in other questions; *how* it shall be implemented, *who* should pay for it, *which* technology to use and *how* to make it beneficial towards gender equality and development? Thus, I cannot but conclude that there are more reasons why it should be implemented, than why it should not. Poverty alleviations I firmly believe is just as complex as poverty itself and the reasons for why people are still poor. But the possible effects of a sustainable access to electricity *can be* tremendous. In order to reduce the drudgery household work in poor in rural areas, new technique and modern energy is nothing but necessary, even if it's not enough for poverty alleviation measures. Solar panels are the current most popular renewable energy source, as well as the most reliable. Comparing solar power expenses with the enormous kerosene costs in developing countries, it is obvious that electricity implementation among the poorest *is* possible. It does require that governments and institutions put their will and power together in order to reach a successful electricity implementation. The annual billion dollar expenses on kerosene obviously give a large profit to oil companies. Several developing countries are dependent on oil extraction and export. One might assume that there are financial interests and conflicts that might further complicate commitments to rural electrification, just as dictatorship, corruption and bad governance can restrain important government development measures.

Amartya Sen highlights the importance of democracy and good governance; people have more freedoms in a democracy, thus provided with a higher quality of life. Democracy implementation, good governance, economic growth, increasing social expenditures, changes of antifemale bias and patriarchal societies are extremely important, but all long-term changes; it can take generations to come before the desired societal prerequisites exists. I take the stand to believe that most poor rural women would agree with me when I say that there is no time waiting for all that to happen. Millions of poor rural women suffer from their unequal hardship situation *today*. And they need and in my opinion *-deserve* help today. Change is needed now. And *that's* why I firmly believe in an increased focus on electricity implementation in rural areas in developing countries. As a quick start to a longterm process which seeks to provide all humans with the freedoms we all want, need and deserve.

Regarding financial alternatives, microfinances can be a very important option. Thus, so far the

pressure and interest of making it profitable might lower results and exclude those who need it the most. I think it is very important to separate microloans for enterprises and other investments with electricity and technology investments. Indirectly it can provide numerous benefits, but it might not directly lead to an increased financial income for the household. Thus it will probably improve quality of life. Then another question arises; shall rural women bear the total loan burden of investing in a technology that theoretically benefits the whole household? Access to electricity reduces the time for household work, and provides new freedoms and opportunities for other activities. In turn, women's empowerment benefits all - the whole society and development, not solely the women. A similar issue arises regarding community benefits like smaller enterprises, water pumps and street lighting. Providing solar powered pumps in waterscarce areas benefits the whole community, not only the women. Is it not an unfair burden to put the whole financial responsibility on the poorest and most vulnerable to pay it themselves?

It's also apparent how important it is to provide information on options and different types of technique to choose from. Currently, solar power development is very quick, and manufacturers and producers all seem to be racing towards the cheapest price with the highest efficiency. Solar lanterns are a perfect example; a few years ago a solar lantern would cost close to 100 USD, while today the cheapest only cost 10 USD. For a household who only requires lights, there's a big difference to invest lighting for 30 USD or 200 USD. And of course, solar power is as mentioned earlier not always a good choice, the preferable energy source for a certain area can vary greatly and it's important to be aware of the different prerequisites.

Within a couple of years, it's theoretically possible to eliminate the current number of households living without any access to electricity.

8. CONCLUSIONS

- * Solar power is a highly flexible and interesting electricity option for rural areas, and its popularity annually grows. Photovoltaic implementation in rural areas can be successful and increase quality of life for hard working women. It can supply the electricity needs for numerous rural women. Hence, it is not completely unproblematic; investing in solar power means high investment costs, and large appliances are sometimes simply too cost intensive to power with photovoltaics

- * Solar powered water pumps is a overall succesful and well-functioning alternative. They are easy to install, function reliable and they are much more affordable than conventional diesel pumps in a long-term perspective

- * Smaller grinding mills can be solar powered, but large mills are very cost intensive

- * Solar power is a proper, healthy and affordable choice for both indoor and street lighting

- *Smaller and energy efficient appliances like refrigerators, computers and televisions can preferably be powered by solar power, but larger enterprises that requires a continous or temporary higher wattage are very cost intensive

- * Microfinance is an important oppportunity for rural women receiving access to credit loans for solar power investments. But government subsidies, tax incentives, international aid and a discussion on how many of these investments that poor rural women actually should pay for is absolutely necessary

- * Access to electricity do not automatically alleviate poverty, nor does it always empower rural women with more freedoms. Thus, access to electricity does provide tremendous opportunities for women in poor, rural areas to obtain more freedoms and gain more empowerment. Rural electricity saves numerous hours of drudgery household work. Thus it is women´ s empowerment and a focus on gender equality that can turn all those extra hours into new possibilites and freedoms

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