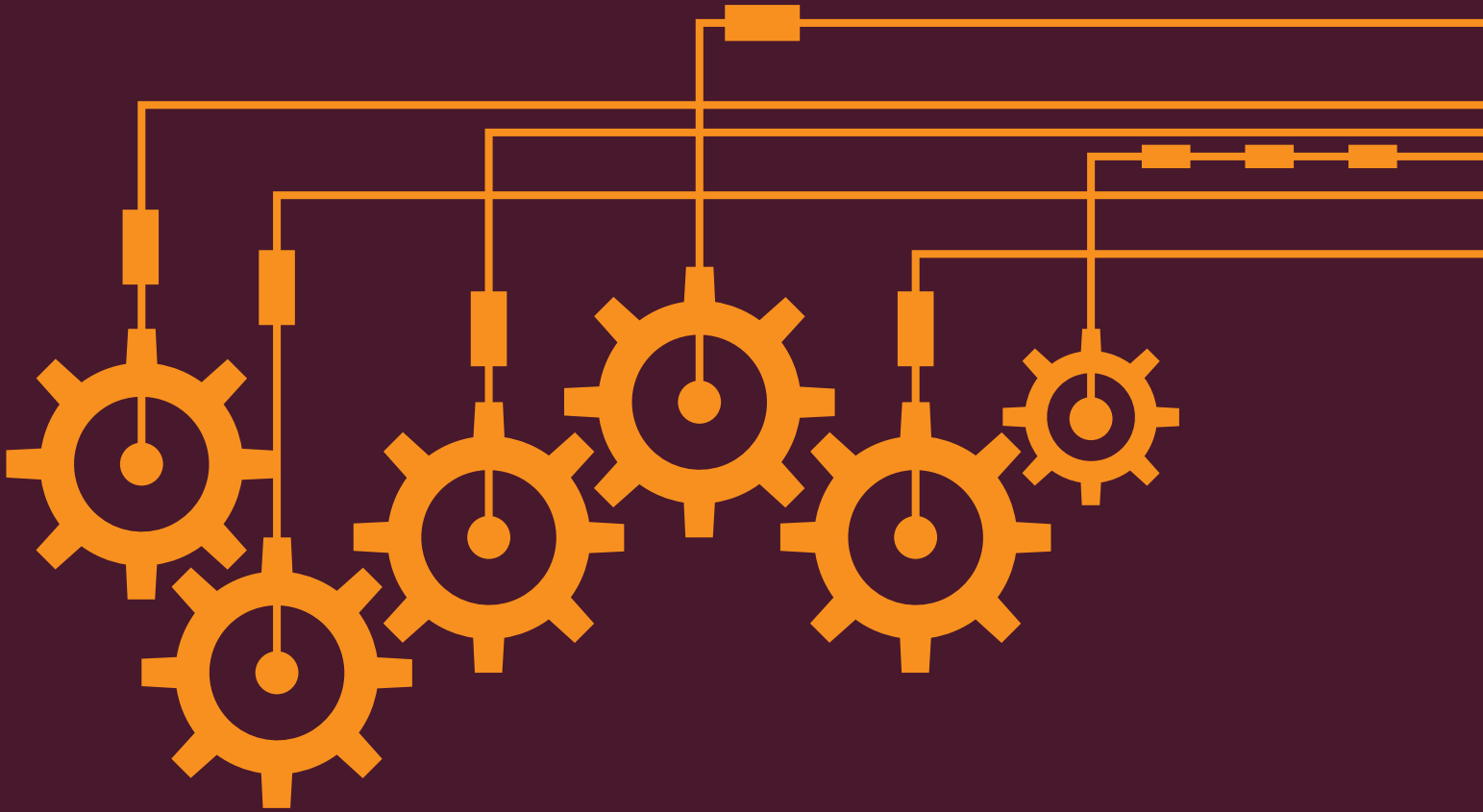


Guidelines on Renewable Energy Technologies for Women in Rural and Informal Urban Areas

Ana Victoria Rojas, Florian Marc Schmitt and Lorena Aguilar





ENERGIA



Contents

FOREWORD	6
ACKNOWLEDGEMENTS	7
INTRODUCTION	8
How to use these Guidelines	9
If you are using these Guidelines for training purposes	9
1. Before you start	9
2. Designing your training programme	10
3. Choosing your training method	10
4. Learning from experience	11
Module 1: How are Gender and Energy Related?	14
1.1. Gender in energy matters	14
1.2. What is gender?	15
1.3. Gender roles and gender norms	16
1.4. Gender analysis	16
1.5. Further resources	18
1.6. Possible exercises	18
Module 2: Gender, Energy and Development	21
2.1. Energy and development	21
2.2. Energy poverty	23
2.3. Energy, gender and the MDGs	24
2.4. Further resources	27
2.5. Possible exercises	27
Module 3: Energy Concepts	29
3.1. What is energy?	29
3.2. Energy conversion and storage	31
3.3. The energy chain	31
3.4. The energy ladder	33
3.5. Neglected sources of energy	33
3.6. Metabolic & biomass energy in national energy planning	34
3.7. What are energy services?	35
3.8. Further resources	35
3.9. Possible exercises	36

Module 4: Renewable Energy Technologies	38
4.1. What are renewable energy sources and technologies?	38
4.2. Matching renewable energy technologies (RETs) and energy services	39
4.3. Environmental impacts	40
4.4. Further resources	42
4.5. Possible exercises.....	42
Module 5: Choosing the Most Appropriate Technology	44
5.1. What is appropriate technology?	44
5.2. The need to involve women and men as beneficiaries in choosing appropriate technologies	44
5.3. Using the energy service approach to choose the most appropriate technology for women	45
5.4. Further resources	47
5.5. Possible exercises	48
Module 6: Matching Energy Services And Renewable Energy Technologies for Women	50
6.1. Cooking and water heating or purification.....	51
6.1.1. Cooking and water sterilisation technologies.....	51
6.1.1.1. Improved cooking stoves.....	52
6.1.1.2. Biofuel stoves.....	56
6.1.1.3. Biogas stoves.....	57
6.1.1.4. Solar cookers.....	58
6.1.2. Water-heating solar collectors	63
6.1.3. Solar water disinfection (SODIS).....	65
6.2. Lighting.....	66
6.2.1. Electricity generation.....	67
6.2.1.1. Wind power	67
6.2.1.2. Hydropower	70
6.2.1.3. Photovoltaic technology (PV)	73
6.2.1.4. Biofuels.....	75
6.2.2. Biogas lamps.....	77
6.2.3. Efficient lighting systems using fluorescent lamps or LED lamps	78
6.3. Domestic heating.....	80
6.3.1. Solar collector for heating	81
6.3.2. Power and heat coupled systems for heating.....	82
6.3.3. Improved stoves for traditional biomass fuels	83
6.4. Cooling	84
6.4.1. Solar powered refrigerator	85
6.4.2. Efficient electrical appliances – electric ventilation and refrigerators	86

6.5. Earning a living	86
6.5.1. Creation of new earning opportunities	88
6.5.1.1. Women as energy providers	88
Solar battery chargers	88
Multifunctional platforms	88
6.5.1.2. Women as engineers -building solar technologies.....	89
6.5.2. Improvement of existing activities	91
6.5.2.1. Increasing agricultural yields by improving irrigation using RETs	91
PV water pumping	91
Wind mechanical water pumping	91
6.5.2.2. Improving the quality of products using RETs	91
Dryers	91
Solar dryers	92
Solar collector	93
Biomass fuelled cabinet dryers	93
6.5.3. Reduction of opportunity costs	94
6.5.3.1. Electrical and other household devices.....	94
6.5.3.2. [Informal] food enterprises	94
6.6. Further resources.....	94
6.7. Possible exercises	96

Abbreviations	97
Bibliography	99
Documents.....	99
Web-based resources	107
Interviews	109
Videos	

FOREWORD

Renewable energy technologies are increasingly been seen as a solution to energy-related problems worldwide, including mitigation of climate change through the reduction of greenhouse gas emissions, the search for energy security at national levels, and efforts to achieve locally appropriate and sustainable development among disadvantaged communities. These Guidelines represent a collaborative effort to support women's understanding of the different technologies available to them and provide hands-on guidance for assessing available renewable energy technologies to help them make informed decisions when choosing the most appropriate technologies for their own situations.

The research, compilation and preparation of these Guidelines were jointly organized and managed by ENERGIA, the International Network on Gender and Sustainable Energy, and the International Union for the Conservation of Nature (IUCN). ENERGIA is an international network on gender and sustainable energy with a direct presence in 22 countries in Africa and Asia. ENERGIA has been working in the energy sector since 1996 and focuses on ways in which increased access to energy can improve the lives and livelihoods of women and men in developing countries, with a special emphasis on rural energy access. ENERGIA applies gender analysis to projects, programmes and policies to ensure that women's energy needs, roles, responsibilities and interests are not overlooked.

IUCN's mission is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. The aim of IUCN's Energy, Ecosystems and Livelihoods Initiative is to accelerate transitions to energy systems which are ecologically sustainable, socially equitable and economically viable. Since 1998 IUCN has had a gender equity and equality policy in place through which it recognizes that gender is an essential component of the sustainable use, management and conservation of natural resources. IUCN is committed to mainstreaming gender in its work, and in particular recognizes the importance of gender equity issues associated with its energy programme. In 2008, IUCN entered into a collaborative agreement with ENERGIA to address the complex linkages between energy, gender and environmental issues.

It is our hope that these Guidelines will provide useful information for women's groups, governments and energy planners to assist them to implement in a gender responsive manner renewable energy initiatives that are appropriate to local contexts and address the energy needs of women and men in rural and informal urban areas.

ACKNOWLEDGEMENTS

IUCN and ENERGIA are grateful to the participants in the Workshop on Sustainable Use of Renewable Energy Technologies by Women in Urban and Informal Urban Areas, held in San José Costa Rica, from 3–5 August 2011: Alicia Hayman, Loreto Duffy-Mayers, Hazel Brown, Orfa Dalila Condega Pérez, Alejandra Bonilla Leiva, Martha Ardila, María Antonia Gutiérrez, Maite Rodríguez Blandón, Arely Jiménez Beltrán, Evelyn Acosta, Yolanda Terán, Hortencia Hidalgo, Jenny Vaca, Blanca Villafranca Marchand. Their contributions and comments during and after the workshop have served to enrich these Guidelines and the experiences shared in these pages.

IUCN and ENERGIA would like to thank Ana Victoria Rojas and Florian Marc Schmitt for their work in designing, compiling and editing these Guidelines; and Celia Steel for her constant support during the production process. Special thanks also go to Christina Aristante from Yayasan Dian Desa for her contributions and peer-review of these Guidelines.

This publication owes much to the vision of Lorena Aguilar Revelo, IUCN's Global Senior Gender Adviser, and the encouragement of Raquel Chacón, Programme Officer, Central American Regional Office, HIVOS (Humanist Institute for Co-operation with Developing Countries), whose financial support have made these Guidelines possible.

Our deepest gratitude goes to those who have enriched this publication by permitting us to use their documentation materials, interviews and photographs: Holger Postel, Karin Beisiegel, Kerstin Schnatz, Michael Altenhenne, Juergen Schneider – Deutsche Welle / DW-TV (2011), Germany; Carlos Oreamuno, Consenergy (2010), Costa Rica; Christoph Mueller, ECOANDINA Foundation (2011), Argentina; José Chiroque, Soluciones Prácticas (2011), Perú; Raúl Botero and Luis Carazo, EARTH University (2010), Costa Rica; Harry Stokes and Brady Luceno, Project Gaia-the Domestic Clean Cook Stove, USA; Martha Ardila, Asociación para el Desarrollo de los Pueblos, ADP, Nicaragua; Christopher Hughes, HEDON Household Energy Network, UK, as well as Wiwik Widyastuti and Afra Sucit, Hivos Regional Office Southeast Asia and the Indonesia Domestic Biogas Programme (BIRU), a four-year program managed and implemented by Hivos with Technical Assistance from SNV (Netherlands Development Organization), responsible for effective knowledge exchange and transfer during the implementation of the program.

Finally, thanks to Kate Mann for editing the English version of these Guidelines; Diana Ávila for translating the first version of these Guidelines into Spanish and Isabel Blanco for her translation and editing of the final version to Spanish.

INTRODUCTION

The absence of modern and renewable energy technologies (RETs) in rural and informal urban areas around the world affects women and men differently. Women and men use energy in different ways during the course of their daily activities. Most women in rural and informal urban areas spend the majority of their day performing basic tasks without the benefits offered by green renewable energy technologies. Rather, they still rely on traditional biomass to meet their energy needs. Under this scenario, the future prosperity of women and girls is likely limited. Much of their time is spent searching for and using less efficient forms of energy. This in turn limits access by girl children to schools and by association to improved literacy; restricts opportunities to engage in politics or other social activities; and prevents them from acquiring new skills or engaging in income-generating activities.

Yet, renewable energy technologies are increasingly been promoted as a solution to a number of energy-related problems worldwide, including mitigation of climate change through the reduction of greenhouse gas emissions, the search for energy security at national levels, and efforts to achieve locally appropriate and sustainable development among disadvantaged communities. If these goals are to be achieved, it will be necessary to challenge the traditional view of energy planning as the simple provision of energy sources and appropriate conversion of technologies, to include the social and economic circumstances of the groups for whom energy is being provided – the target groups.

To achieve a clear understanding of the needs of the target groups, it is essential to integrate gender considerations in the design, planning and implementation of energy projects and policies, including renewable energy policies and projects. This is because women and men have different roles as users and managers of energy systems. It follows therefore that they may have differentiated energy needs in terms of, for example, appropriate technology for their situation, capacity building or training needs, access to available technologies and funding, among others. A gender-sensitive energy project or policy, therefore, would benefit women and men equally by recognizing their differentiated energy needs.

Unfortunately, practice has demonstrated that fully integrating women as key stakeholders in the design, use, distribution and maintenance of renewable energy technologies remains a challenge for energy planners. As a result, women are often a disadvantaged group whose energy needs are not adequately addressed. For this reason, these Guidelines focus primarily on renewable energy technologies (RETs) for women.

The first step towards ensuring women's participation in renewable energy projects and policies is to empower them by providing them with knowledge about available technologies and the potential benefits or constraints they may bring to their lives. **The Guidelines on renewable energy technologies for women in rural and informal urban areas**, seek to inform women as key actors about the different potential uses of renewable energies in many areas of their daily lives. Along with hands-on guidance on how to assess available renewable energy technologies, these Guidelines are intended to support women in their efforts to choose renewable energy technologies appropriate to their particular situations.

How to use these Guidelines

These Guidelines are a compilation of previous materials and are intended as a tool to help women understand different energy technology concepts, the variety of technologies available to them, and how choice of technology can be affected by social or gender relations, among others. They offer information to assist women to make informed decisions about technology choices. These Guidelines are not intended as a manual to train women in the use of these technologies.

These Guidelines are divided into modules covering different topics. Each module is sub-divided into units where these topics are further explored.

Module 1: How are gender and energy related?

Module 2: Gender, energy and development

Module 3: Energy concepts

Module 4: Renewable energy technologies

Module 5: Choosing the most appropriate technology

Module 6: Matching energy services and renewable energy technologies for women

Each module includes short case studies, information boxes and tables. At the end of each module are examples of exercises that could be undertaken by individuals or by trainers in a group setting to test the knowledge acquired.

These Guidelines have been written for professionals and technicians working with or for women's groups and seeking information about renewable energy technologies with a view to making informed choices. Their contents have been presented to and tested among women and women's groups working in rural and informal urban areas in Latin America.

If you are using these Guidelines for training purposes¹

1. Before you start

Keep in mind your specific **target group or audience**. Defining your target group is essential, as it will determine the type of information to be shared as well as the method of delivery. For example, if you are working closely with women with low levels of literacy or scant exposure to energy technologies, it may be necessary to set aside time to explain what these terms mean. Visual support may be very effective in such situations. However, if the target audience includes a group of engineers tasked with developing energy solutions for a particular community, it may be important to start by highlighting the social and gender-related aspects of technology design and deployment as part of efforts to sensitize them prior to their work with women's groups.

¹This section and the steps referred to are based on IUCN, UNDP and GGCA (2009); and Clancy, J. et al. (2005a).

Once the target group has been defined, it may be necessary to conduct a **training needs assessment** among participants. This will enable a better understanding of participants and their needs, offer insights into their existing knowledge, and reveal knowledge gaps within the group. This information can be used to shape the design of the training programme; it will also be valuable for managing expectations of the audience and highlighting potential challenges you may face in your capacity as a trainer.

2. Designing your training programme

Using the training needs assessment as a starting point, identify the **main objectives** you hope to achieve through the implementation of your training programme. For example, if you are interested in creating awareness of the existence of different solar technologies, you may wish to focus primarily on the sections of these Guidelines that focus on this technology. Alternatively, if lack of appropriate lighting has been identified as a key constraint in the target community you are working with and you want to make an informed decision about the type of energy intervention required, you may want to concentrate on exploring the different lighting options available and use these Guidelines to work with the community to assess which option may be best suited to its particular situation.

During the design phase it is important to consider the **timing and length** of the training programme. To ensure optimum participation in the programme it will be necessary to identify the best time to conduct the training. This may mean choosing a time of day when all participants are able to attend (morning, afternoon, evening); alternatively it might mean identifying a time of year when training will not conflict with religious or local festivities, the harvest, or with other activities which may limit attendance.

Similarly, the duration of the training programme will be determined by the number and complexity of topics to be covered. Remember to allow sufficient time for interaction and question and answer sessions with participants throughout the programme. Remember also to schedule breaks during the training to give participants the opportunity to reflect on and absorb the information that has been presented. A tired participant is not a focused participant!

It is important to give your training programme a **coherent structure** and to ensure that only **topics of relevance** to your audience are presented. This will ensure that participants have acquired all the information necessary to understanding a topic before a new or more complicated topic is introduced. Furthermore, this will help to keep the audience engaged; after all, the audience has come because it wants to learn about these topics. You know this because you have conducted a training assessment!

3. Choosing your training method

There are a variety of training methods available. You will have to choose the best method to deliver your message and keep the audience engaged. For example, lectures and reading materials can be an effective way to impart knowledge. However, engaging the audience through group exercises or discussions may be a more effective way for participants to interpret the knowledge learned and integrate it into their own lives. This will also help to create a sense of ownership. Such exercises can also facilitate information sharing among participants and have a positive influence on group dynamics by helping to connect participants at a personal level.

If possible, alternate between training methods to avoid repetition, audience fatigue (if there are too many lecture presentations) or dilution of the message (if only interactive methods are used with no time set aside to assess if the message or objective of the exercise have been understood). **Possible training methods** to consider include:

- Lectures by trainer(s) (these can be supported by PowerPoint presentations, overhead projectors, flip charts, or any other visual aids appropriate to the setting and circumstances)
- Background reading material
- Group discussions
- Presentations by participants
- Case studies
- Role playing
- Field visits
- Experts or high profile guest speakers
- Videos

If you opt for **video** presentations, remember to ensure that the necessary equipment is available for screening and that there are no problems of compatibility between the format of the video and the delivery system. It is also advisable to watch the video in advance of sharing it with the audience to ensure that its contents will not cause offense (some language, references or points of view may not be appropriate for your audience). It is important not to alienate the audience thereby adding an extra layer of challenge to the training programme.

These Guidelines offer **examples of different exercises**, quizzes, case studies and even video references that could be useful for your training programme. These are intended as suggestions; you should feel free to modify and adapt them or come up with your own exercises! When doing so, always keep in mind the question: which is the best way to reach my target audience?

Another device to consider as part of the training programme is **field visits**. Field visits allow participants to experience and see in action many of the things they have learned during the workshop. Field visits could involve visiting a nearby rural community or informal urban area and testing some of the questions included in these Guidelines as part of efforts to support the choice by women of renewable energy technologies, or to identify potential barriers to a particular choice of technology. Field visits also offer opportunities for participants to see firsthand how a particular renewable energy technology is produced, installed and/or used. Experiences like this can be worth a thousand words!

4. Learning from experience

It is important to assess if your training workshop has achieved its main objectives and whether it has properly addressed the needs of participants. This can help you to make improvements to your training programme and/or to replicate it among other groups or communities. It is therefore important to include an **evaluation component** at the end of your training programme.



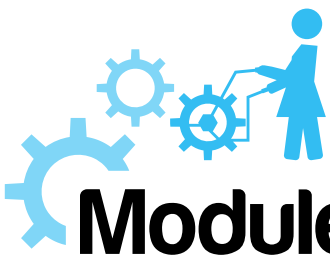
There are several options for carrying out evaluations; the choice of method will depend on the target audience and your own information needs. For example, if the purpose is to have a record of each participant's evaluation, it may be useful to use an anonymous questionnaire. If the training programme was short and you are seeking a quick evaluation, it might be useful to ask each participant to write on a colour card one item they found useful and to write on another something they did not like or something where they felt there was room for improvement. Ask participants to post their cards in the wall, keeping all the 'likes/usefuls' together on one side and the 'room for improvement' cards on the other. Read all the comments to the attentive audience and ask for additional feedback. This is an effective way to stimulate discussion.

These guidelines are intended as a dynamic living document. We plan to up-date it regularly. To this end, we would appreciate your feedback. Any comments about your experience of using these Guidelines, the usefulness of the different modules, exercises and information, or any suggestions for items for inclusion should be sent to energia@etcnl.nl and lorena.aguilar@iucn.org

Module



HOW ARE GENDER AND ENERGY RELATED?



Module 1: How are Gender and Energy Related?²

Access to affordable energy services is essential to achieve economic growth and poverty reduction. Energy is a critical input in the daily lives of women, who need enormous volumes of energy to carry out their daily chores including cooking and domestic heating; for agricultural uses, including post-harvest processing; and for rural industry uses such as milling and heat processing. In developing countries, women play a vital role as energy producers and managers of household energy security. Yet relative to men, women's access to productive assets such as land and technology and to services such as finance and extension is more limited.

1.1. Gender in energy matters

Energy carries a gender dimension. Within households women tend to bear a greater burden of responsibility for energy-related activities, especially those centred around the kitchen.

This has negative impacts on women's health and has the effect of making them time poor. Women are often helped in their fuel wood gathering activities by girls and sometimes boys, who are kept out of school thereby damaging their own future livelihood choices. Men's involvement in fuel wood collection tends to be at the industrial level, where large volumes of wood are transported over long distances.

Energy provision is not gender neutral:

- Energy determines the efficiency and effectiveness of activities and the quality of life of users (women and men)
- Energy has different uses and addresses different needs
- Energy provision has different impacts on men and women
- Energy might be a factor in helping women become more productive, independent and empowered
- A gender approach can help reduce poverty and support livelihoods – for women and men and children.

Women are an important target group in energy projects because:

- Women's interests in energy are often ignored
- Well-intentioned energy projects may unwittingly increase the burden on women if their situation is not taken into account
- Very few women are involved in energy planning or able to speak up for women's needs

²This Module is based on ENERGIA (2008c).

The disproportionate number of women living in energy poverty implies that energy policies should take account of the unique situation of women. However, in practice, energy policies tend to be gender-blind. They often fail to meet women's needs and do not change gender relations. Energy policy makers assume that a good energy policy, programme or project will benefit both men and women equally. Energy policies are considered gender-neutral.

As part of efforts to try to redress these inadvertent biases against women in energy policies and the role of women in providing energy in low-income households, there needs to be a greater focus on women in energy policy formulation and implementation. That is not to say, however, that men should be excluded. Men are an important part of energy solutions (including decision making, implementation, distribution of benefits and correlated duties, etc.) and men in low-income households also experience energy poverty.

In summary, **gender in energy matters because:**

- Women and men have different roles in the energy system: women bear the main burden for providing and using biomass energy for cooking. A situation made worse by fuel scarcity and negative health and safety impacts.
- Women bear the invisible burden of the human energy crisis – women's time and effort in water pumping, agricultural processing, and transport. They need modern and more efficient energy sources to improve their work and quality of life both within and outside the home.
- Women have less access than men to the credit, extension, land and training necessary to improve energy access to support their livelihoods and income generation from micro-enterprises.
- Women and men have different kinds of knowledge and experience of energy, either through their traditional roles, their new non-traditional roles (especially in female-headed households), or increasingly as professionals in the energy sector.
- Since women experience poverty differently to men they may need different energy policies to help them escape energy poverty: new energy technologies can even have unintended negative consequences for women, as demonstrated in the past by other new technologies e.g. during the Green Revolution.

1.2. What is gender?³

Gender is not the same as **sex** since the former is not determined by biological differences, but rather is socially determined and based on social, cultural, political and economic expectations. Since 'gender' is shaped by society, it will take on different forms in different societies. There are different ways to describe what it means to be a woman or a man. Biologists use physical characteristics which they call sexual differences. While social scientists use social characteristics, which they call gender. These characteristics include the tasks, roles, obligations and privileges in public and private life of women and men as well as the relationships between them.

³This section is based on ENERGIA (2008a).

1.3. Gender roles and gender norms

Gender roles are roles assigned to men and women by society. Gender roles shape our identity, determining how we are perceived, how we are expected to think and act as women and men. The manner in which women and men behave within their gender roles is shaped by gender norms, the accepted standards of behaviour shared by a particular society.

Closely related to this is the fact that men and women are able to some extent to negotiate their rights, benefits and obligations in relation to certain duties or tasks both in the household and the community. These negotiations are also about the use of resources, such as land, labour and cash. These negotiations are not always harmonious since there can be disagreements and competition for resources. It is important to remember that these negotiations do not usually take place between equals. In most societies, men have more power than women to make decisions about and exercise control over their own lives and resources, as well as those of other family members. This balance of power between men and women defines the relationship between the genders. The effects of differences in power operate at all levels of society: household, community, organizational, national and international.

1.4. Gender analysis

To understand fully the gender element of energy, it is important to realize that gender contracts do exist, and that the underlying reasons for energy-related gender differences may be found in the underlying gender relations that characterize the society in question. Gender experts use a number of different strategies to analyse gender roles and relations. **Gender analysis** asks questions, in relation to men and women, about who is doing what, who owns what, who makes decisions about what and how, who gains and loses by a planned intervention, etc. Gender analysis examines what is happening within the household and makes linkages with the different levels of the wider society.

Gender analysis is not about looking at women alone, nor is it about complaining that women suffer more than men, rather gender analysis is about reaching a better understanding of how communities work from the perspective of relationships between men and women.

Gender analytical tools are used to organize information in a systematic way (known as a framework) which helps to understand the existing gender situation in a given community, or to assess the likely impact of an intervention, such as an energy project, on men and on women. Gender analytical tools can be used in a number of ways. For example, to draw attention to gender inequalities in a given community or as an early warning system to identify potential gender problems that may arise if an energy initiative is initiated within that community.

The triple role

One of the earliest attempts at gender analysis was based on the gender division of labour. It divided tasks for men and women into three main socio-economic areas: reproductive, productive and community. This framework is known as the triple role.

1. Reproductive

This refers to all tasks undertaken to reproduce the labour force (bringing up the next generation).

2. Productive

This covers work done for payment in cash or in kind.

3. Community tasks

Those tasks done not for individual family gain but for the well-being of the community or society. Women's community tasks are often seen as an extension of their reproductive roles.

Practical needs, productive needs and strategic interests

Another analytical approach considers that gender roles have different assigned tasks in which different needs, including energy needs, have to be met. These needs are usually divided into practical and strategic; they always depend on local circumstances and are influenced by variables such as a person's age and civil status. In the context of energy, however, it is more helpful to consider three sets of needs or interests: practical needs, productive needs and strategic interests. These are described below.

Practical needs

Practical needs are interventions needed to make women's lives easier and more pleasant, but which do not challenge the customary tasks and role of women in the household or in society, or their gender relations. That is to say, they do not upset the traditional balance of power and authority between men and women. They are needs primarily related to the reproductive functions of women, activities that keep the household running and ensure the family's daily survival.

Productive needs

Productive needs are those that if resolved, allow women to produce more and better products (usually for income gain). Cleaner energy forms and new technologies, for example, might make work easier and reduce drudgery. However, does meeting productive needs change gender relations within the household and community? Some researchers do claim that a woman's status within the household improves when she contributes to the household income. There is no universal answer.

Strategic interests

Strategic interests are those which relate to women changing their position in society and which help them gain more equality with men, and help to empower them.

Practical needs, productive needs and strategic interests (continued)

Women's strategic interests are generally to do with addressing issues related to laws and gender contracts which tend to be biased against women. For example, in many societies certain groups of women (widows, divorcees, and abandoned wives) suffer economic deprivation as a result of their civil status, based on traditional or modern legal codes: their property can be taken away from them by male relatives.

Other strategic interests for women may include laws on inheritance so that daughters have equal rights with sons, for example, and prohibiting violence against women. In most countries there are such laws but they are not always enforced.

1.5. Further resources

More information about the topics covered by this module can be found in the following resources:

- Clancy, J. et al. (2005a). The Gender Face of Energy: A Training Manual. Module 1.
- Clancy, J. et al. (2005b). The Gender Face of Energy: Gender Tools for Energy Projects. Module 2.
- ENERGIA (2011). Mainstreaming Gender in Energy Projects: A Practical Handbook. Prepared by Elizabeth Cecelski and Soma Dutta for ENERGIA. Forthcoming.
- GNESD (2007). Reaching the Millennium Development Goals and beyond. Access to modern forms of energy as a prerequisite.
- IUCN, UNDP and GGCA (2009). Training Manual on Gender and Climate Change.
- UNDP and ENERGIA (2004). Gender and Energy for Sustainable Development: a toolkit and resource guide.
- UNDP (2007). Gender Mainstreaming: a key driver of development in environment and development. Training Manual.
- UNDP (2001). Generating Opportunities: Case studies on energy and Women.

1.6. Possible exercises

The following exercises could be used to test and strengthen knowledge among training workshop participants.

Exercise 1. Discussing gender perceptions⁴

Share the following statements with workshop participants; ask them if they agree or disagree with them. This exercise offers an opportunity to discuss gender roles and how they are internalized:

“Men are more logical and rational, women are more emotional.”

“Women have more difficulty working with numbers than men.”

“A family really consists of a man who is head of the household, a woman, and their children.”

“Men are much less sensitive than women: they don't notice how people are feeling.”

“Women are more responsible than men.”

⁴Based on ENERGIA (2008a).

Exercise 2. Becoming aware of your own gender perceptions⁵

Put the following questions to the group. This will give each participant a chance to think about gender roles and how these shape his/her perception of the world. Ask workshop participants to share their examples and comment on their own reflections.

1. According to you, what is gender? Is gender and sex the same thing? Why?
2. List two things you like to do which are considered typical for your gender in your culture
3. List two things you do not like doing but which are considered normal for your gender in your culture.
4. List two things you really wish you could do but which would be frowned upon by society if you did them because they are 'for the other gender'.

A variant of this exercise is to ask participants to draw individually on a piece of paper "what gender is" according to them. Afterwards you can pick a number of interesting pictures and ask the artist to explain his/her picture. This is a more interactive exercise.

Exercise 3. Gender and energy

Test the group's understanding of gender roles by listing a series of [energy] technologies and asking participants if these technologies contribute to or support practical, productive or strategic needs. For example, show the group photos of a light bulb, a radio, a stove, a street light, a phone, a refrigerator and a mobile phone. Then ask the group to comment on whether a light bulb contributes to a practical, productive or strategic need **and why**.

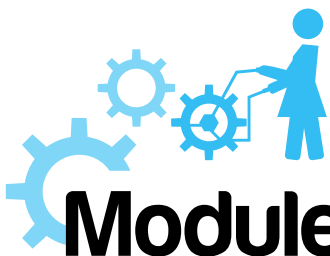
If necessary, divide a large group into smaller working groups and provide them with a list of the same technologies. Then compare the results among and between the groups; depending on group assumptions conclusions may be very different.

⁵Based on ENERGIA (2008a).

Module

2

**GENDER, ENERGY AND
DEVELOPMENT**



Module 2: Gender, Energy and Development

Access to affordable energy services is essential to achieve economic growth and poverty reduction. Women and men have different energy needs and use energy differently depending on their traditional cultural roles. This in turn implies that they may require different energy solutions (technologies, training and knowledge, funding opportunities) if they are to be lifted out of poverty.

In practice, energy policies in most developing countries assume that energy is gender neutral and therefore fail to conceptualize women as key stakeholders in the design, usage, distribution and maintenance of renewable energy technologies. The result is to make women a disadvantaged group whose energy needs may not be adequately addressed. For this reason, most of the discussion in these Guidelines focuses on renewable energy technologies for women. These Guidelines are intended to highlight the differentiated needs and opportunities that renewable energy technologies may offer women.

2.1. Energy and development⁶

Energy is an essential component of our daily life. We require energy for all our activities, from moving, to cooking, to manufacturing. The volume of energy consumed is strongly correlated to economic growth, especially in the industrial age. There is strong correlation between per capita energy consumption and the human development indicators including life expectancy, literacy and school enrolment used in the Human Development Index (HDI).

Pasternak's analysis (2000) revealed that annual electricity consumption of 4,000 kWh per capita is required to achieve an HDI value of 0.9 or greater. Consumption above 4,000 kWh per capita was found not to have any significant impact on HDI value. In the 31 low-human development countries, electricity consumption per capita is less than 1,000 kWh.

Source: Gaye, A. (2007).

Gender issues in the energy sector are a subset of gender issues in development. Compared to men, women have reduced access to productive assets such as land and technology, and to services such as finance and extension. These inequalities continue despite efforts to address them. For instance, millions of women still:

⁶Section based on ENERGIA/DfID Collaborative Research Group on Gender and Energy (CRGGE) (2006).



Table 1 - Gender and Development

Earn less than men for their work	Women's nominal wages are 20 per cent lower than men's; women perform 70 per cent of the world's agricultural labour and produce 90 per cent of the food, but earn 10 per cent of the income and own 1 per cent of the property. ⁷
Work hard for their family's subsistence	In sub-Saharan Africa, women spend 40 billion hours a year collecting water – the equivalent of a year's worth of labour by the entire workforce in France. ⁸
Have less control over income and assets	Women are less likely to own land than men, and female landowners tend to own less land than male landowners. ⁹ In most regions of the world, women manage 20 per cent of farms. ¹⁰
Have less access to education and health services	Ten million more girls than boys are out of primary school; maternal mortality rates in sub-Saharan Africa have barely changed over two decades. ¹¹ Women account for two-thirds of the world's 774 million illiterate adults – a proportion that has remained unchanged over the past two decades. ¹²
Are poorly represented in policy and decision making	Globally, only 17 percent of seats in national parliaments are occupied by women. ¹³
Have a subordinate social position and are subject to violence and intimidation	In a 10-country study of different regions, between 15 and 71 per cent of women reported experiencing violence from a partner over the course of their lifetime, and up to nearly a third had reported violence in the past. ¹⁴

⁷UNICEF (2006).

⁸UNDP (2006).

⁹Doss, C. et al (2008).

¹⁰UNDP (2010).

¹¹UNIFEM, (n.d.b)

¹²United Nations (2010).

¹³Idem.

¹⁴UNIFEM (n.d.a)

The disproportionate percentage of women among the world's poor is referred to as the feminization of poverty.¹⁵

2.2. Energy poverty

Energy availability varies both within and between countries. Energy scarcity affects women as well as men. However, the actual impact of energy scarcity depends on the different uses of energy by men and women in their everyday lives. **Energy poverty** can be defined as the “inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset”.¹⁶

There are large numbers of both women and men suffering from energy poverty,¹⁷ in the world:

- 2.5 billion people, mostly in developing countries, still rely on traditional biomass fuels for cooking
- 1.6 billion people are without access to electricity because of lack of availability and affordability.

Energy poverty has an important gender dimension: an estimated 70 per cent of the approximately 1.3 billion people living in poverty are women, many of whom live in female-headed households in rural areas. Given that women generally have less access to resources and decision-making than their male counterparts, many poor female-headed households live in extreme energy poverty. This not only has an impact on energy supply, but in addition affects other household services such as provision of clean water, for example. Lack of access to resources makes these households particularly vulnerable to events beyond their control such as drought, for example.

The burden of energy poverty resulting from heavy reliance on biomass fuels falls disproportionately on women. Traditionally, women are responsible for gathering fuelwood and cooking. The real rural energy crisis is a crisis of rural women's time: women work longer days than men providing human energy for survival activities including gathering fuel and fetching and carrying water, cooking, food processing, transport, agriculture and small enterprises. All these are non-monetized activities which are largely invisible in national energy accounts and labour force statistics.¹⁸

As a result of energy poverty, women

- Spend a huge amount of time and effort collecting traditional fuels, a physically draining task that can take from 2 to 20 or more hours per week.¹⁹
- Along with their children, face exposure to smoke from inefficient stoves in poorly ventilated homes, which kills 1.45 million people each year. With a death every 20 seconds, indoor air pollution is the fourth biggest killer in the developing world.²⁰

¹⁵Chant, S. (2006).

¹⁶UNDP (2006).

¹⁷Modi, V., et al. (2005).

¹⁸ENERGIA/DfID Collaborative Research Group on Gender and Energy (CRGGE) (2006).

¹⁹UNDP (2007).

²⁰WHO (2011).

As a result of energy poverty, women (continued)

- Face, on a daily basis, hazards related to fuelwood collection: fractures, repetitive strain injuries, back disorders and miscarriages; exposure to burns, smoke and skin diseases from fuel-use; and physical violence, including rapes perpetrated while gathering fuelwood or other resources.
- Find it difficult to take advantage of opportunities as energy entrepreneurs. Many income-generating activities of women in the informal sector – often critical to family survival– are fuel intensive, and their viability is affected by energy prices and availability. With more limited access to productive assets such as land and technology, and to services such as finance and extension, women’s participation in markets as operators of energy businesses is more limited.
- Are able to benefit only partially from energy interventions as they are constrained by other ‘overriding’ factors such as lower levels of education, mobility and access to information. Furthermore, they are poorly represented in decision-making and organizations at all levels of the energy sector, and lack a voice to make their needs known and choose energy options.

2.3. Energy, gender and the MDGs²¹

The Millennium Development Goals (MDGs) were adopted in 2000 at a United Nations Assembly Summit as a set of time-bound, measurable goals and targets to be achieved by 2015. In September 2005, they were re-endorsed at a World Summit to review progress. Although there is no MDG on energy, the independent UN Millennium Project report has identified energy, including electricity and safe cooking fuels, as an essential infrastructure service and part of the “means to a productive life”.

The World Energy Outlook 2010 reports that the UN Millennium Development Goal of eradicating extreme poverty by 2015 will not be achieved unless substantial progress is made in improving energy access, given the billions of people worldwide who still rely on traditional biomass fuels for cooking and the billions who still do not have access to electricity.²²

²¹This section is based on Dutta, S. et al (2005).

²²International Energy Agency (IEA) (2010).



Table 2 - Energy, gender and the MDGs

Millennium Development Goals (MDGs)	Importance of energy to achieving the MDG (can be indicators to assess energy access)
<p>Goal 1. Eradicating extreme poverty and hunger</p>	<ul style="list-style-type: none"> • Saving time and effort spent in cooking and fuel collection and in food processing may reduce calorie consumption and free up time for additional, less straining activities. • Saving time spent being ill or taking care of sick children will cut health care expenses and increase earning capacities. • Where fuels are purchased, increasing fuel efficiency and thus cutting down on the quantity of fuel needed will ease constraints on already tight household budgets. • Improved household energy technologies and practices will open up opportunities for income generation (direct application in agriculture, home industry, longer working hours thanks to increased lighting, energy entrepreneurs). • Access to electricity will provide a source of light for economic activities in the evening and a source of energy for operating sewing machines or refrigerators, for example.
<p>Goal 2. Achieve universal primary education of boys and girls</p>	<ul style="list-style-type: none"> • With less time spent collecting fuel or due to ill health, boys and girls will have more time available for school attendance and homework. • Better lighting will allow boys and girls to study outside of daylight hours and without putting their eyesight at risk.
<p>Goal 3. Promote gender equality and empower women</p>	<ul style="list-style-type: none"> • Alleviating the burden of fuel collection and reducing cooking time will free up women's time for other productive endeavours, education and child care. • Reducing the time and distance that women need to travel to collect fuel will free up time for other productive uses. • Involving women in household energy decisions will promote gender equality, raise women's prestige and change gender relations. • Access to information through media and telecommunications. • Education through ICTs (for decision making). • Control over and access to modern energy services. • Voice and participation of women in the energy sector. • Employment of women in the energy sector.



Table 2 - Energy, gender and the MDGs (continued)

Millennium Development Goals (MDGs)	Importance of energy to achieving the MDG (can be indicators to assess energy access)
Goal 4. Reduce child mortality	<ul style="list-style-type: none"> • Indoor air pollution contributes to respiratory infections that account for up to 20 per cent of the 11 million child deaths each year (WHO, 2002). • Low birth weight due to indoor air pollution. • Gathering of wood fuel by women and children exposes them to health risks and reduces time spent on education. • Provision of nutritious cooked food, domestic heating, and boiled water contribute to better health. • Electricity enables pumped clean water and purification. • Reliance on cleaner energy technologies may reduce other health risks, such as burns and kerosene poisoning.
Goal 5. Improved maternal health	<ul style="list-style-type: none"> • Energy services for maternal care and medicine refrigeration, etc. • Excessive workload and heavy manual labour (e.g. fuel, wood and water collection) affect a pregnant woman's general health and well-being.
Goal 6. Combat HIV/AIDS, malaria, others	<ul style="list-style-type: none"> • Improved energy may support recommended health behaviour (e.g. cooking food) for persons living with HIV/AIDS (PLWHA). • May reduce women's burden and drudgery related to caring for PLWHA. • Improve quality of health care by making vaccines available and for sterilization of equipment to take place in clinics. • May reduce the risk of infection from sexual violence against women and girls while collecting fuel, wood or water.
Goal 7. Ensure environmental sustainability including safe drinking water and improvement in lives of slum dwellers	<ul style="list-style-type: none"> • Deforestation rates may be reduced as a result of reduced need for fuel wood. • Allowing forested lands to remain or expand will result in positive contributions to ecosystem protection and a reduction in greenhouse gases (GHG) emissions. • Energy technologies with reduced impacts on the environment may allow for more and cleaner water to be available. • Improved access to cooking energy and electricity by slum dwellers (women and men).

Source: Based on WHO (2006) and CRGGE (2006).

Links between energy, gender and the MDGs range from time savings and reduced household expenditures, to increased school attendance by girls, empowerment as a result of greater choice in organizing work and through access to TV and media, improvements in rates of acute respiratory illness, improved maternal health and reduced infant mortality, reduced rates of deforestation and greenhouse gas emissions.

2.4. Further resources

More information about the topics covered by this module can be found in the following resources:

- Energy, Poverty and Gender Initiative (EnPoGen). Special issue of ENERGIA News 2002, vol. 5 issue 3.
- IEA et al. (2010) Energy Poverty. How to make modern energy access universal?
- IUCN, UNDP and GGCA (2009). Training Manual on Gender and Climate Change.
- Mohdam, V. (2005) The Feminization of Poverty and Women's Human Rights. SHS Papers in Women Studies / Gender Research. No. 2. For UNESCO.
- UN, Millennium Development Goals, at: <http://www.un.org/millenniumgoals/>
- UNDP and ENERGIA (2004). Gender and Energy for Sustainable Development: a toolkit and resource guide.
- UNDP (2001). Generating Opportunities: Case studies on energy and Women.
- UNDP (2007). Will tomorrow be brighter than today? Addressing gender concerns in energy for poverty reduction in the Asia-Pacific Region.
- UNIFEM, Facts and Figures, available at: UNIFEM.org/gender_issues/women_poverty_economics/facts_figures.php
- WHO (2006). Fuel for Life: Household energy and health.

2.5. Possible exercises

The following exercises could be used to test and strengthen knowledge among training workshop participants.

Exercise 1. Energy poverty

Start this module by asking participants what they understand by “energy poverty”. This will help to engage them in an early discussion and assess their understanding of the concept.

Stimulate further discussion by making the following statement and asking the following questions. Make sure you set aside ample time for discussion:

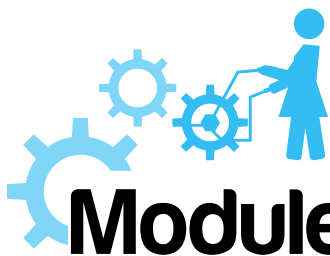
Statement: “Energy poverty has been defined by UNDP as the inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset.”

Questions: Do you agree with this statement? Can you provide other examples of energy poverty you have experienced or seen?

Module

3

ENERGY CONCEPTS



Module 3: Energy Concepts

3.1. What is energy?²³

Everything we do involves energy, from breathing or eating (metabolic energy) to producing goods. Some forms of energy make life easier and more efficient. For example, a flour mill may be run on electricity, which may be derived from fossil fuels. This saves the tedious and tiring work of pounding maize or hulling rice by hand. Kerosene (paraffin) lights are brighter than candles; electric light is even better for seeing at night. LPG gas, which is a fossil fuel, provides faster heating, while the flame is easier to adjust and cleaner and healthier than wood.²⁴

Energy is a concept that physical scientists use to explain certain processes that have a number of common features. We cannot see or feel energy but we can see or feel the consequences of energy (for example, heat, light, sound, motion). Energy enables us to do such diverse things as: cooking a meal, lighting a room, operating a grain mill. The energy forms used for these activities are: heat to cook the food, electricity for lighting, and the motion of a diesel engine to turn the shaft of the mill. So the first important feature to note about **energy** is that it **takes different forms**.

What is energy?

Energy is the ability to do work. It is measured in joules (J).

Energy can take different forms, such as: heat (thermal); light (radiant); motion (kinetic); electrical; chemical; nuclear; and gravitational energy. All energy can be classified into two categories:

- **Stored energy – includes potential and the energy of position**
- **Kinetic energy – means there is motion**

For example, wood stores energy (potential); this energy is stored until the wood is consumed (kinetic) by fire for cooking or heating.

Different types of energy are measured in different physical units:

- Barrels or gallons for petroleum
- Cubic feet for natural gas
- Tons for coal
- Kilowatt hours for electricity

To compare different fuels, we need to convert the measurements to the same units. Some popular units for comparing energy include British Thermal Units (Btu), barrels of oil equivalent, metric tons of oil equivalent, metric tons of coal equivalent, and terajoules.

²³This module is based on ENERGIA (2008b).

²⁴Clancy, J. et al. (2005a).

The second important point to note is that **energy can be converted from one form to another**. Electricity can be made by burning natural gas in a power station (chemical energy converted into electrical energy). Electricity can be converted into light (electromagnetic radiation). These conversions all require the use of a piece of equipment or a device, for example, a stove, a light bulb or a diesel engine.



Table 3: Energy classifications

Potential energy

Potential energy is stored energy and the energy of position — gravitational energy. There are several forms of potential energy.

Chemical energy is energy stored in the bonds of atoms and molecules. Batteries, biomass, petroleum, natural gas, and coal are examples of stored chemical energy. Chemical energy is converted to thermal energy when we burn wood in a fireplace or burn gasoline in a car's engine.

Mechanical energy is energy stored in objects by tension. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Nuclear energy is energy stored in the nucleus of an atom — the energy that holds the nucleus together. Very large amounts of energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms in a process called **fusion**.

Gravitational energy is energy stored in an object's height. The higher and heavier the object, the more gravitational energy is stored. When you ride a bicycle down a steep hill and pick up speed, the gravitational energy is being converted to motion energy. Hydropower is another example of gravitational energy, where the dam 'piles' up water from a river into a reservoir.

Kinetic energy

Kinetic energy is motion — of waves, electrons, atoms, molecules, substances, and objects.

Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Sunshine is radiant energy which provides the fuel and warmth that make life on Earth possible.

Thermal energy, or heat, is the vibration and movement of the atoms and molecules within substances. As an object is heated up, its atoms and molecules move and collide faster. Geothermal energy is the thermal energy in the Earth.

Motion energy is energy stored in the movement of objects. The faster they move, the more energy is stored. It takes energy to get an object moving, and energy is released when an object slows down. Wind is an example of motion energy. A dramatic example of motion is a car crash, when the car comes to a total stop and releases all its motion energy at once in an uncontrolled instant.

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate — the energy is transferred through the substance in a wave. Typically, the energy in sound is far less than other forms of energy.

Electrical energy is delivered by tiny charged particles called electrons, typically moving through a wire. Lightning is an example of electrical energy in nature, so powerful that it is not confined to a wire.

Source: US-EIA

3.2. Energy conversion and storage

When **energy is converted** from one form to another not all of the energy ends up where we would like it: **a portion always ends up as heat**. Scientists and engineers strive to make a piece of equipment as efficient as possible. This makes good economic sense as well as being better for the environment. The efficiency of conversion equipment varies. An LPG stove converts around 60 to 70 per cent of the chemical energy stored in the LPG into heat energy while a wood stove converts around 12 to 30 per cent of the chemical energy stored in the wood into heat energy. However, this assumes that the equipment is well maintained. Poor maintenance can lead to lower efficiency as well as reducing the lifetime of the equipment.

What is energy efficiency?²⁵

Energy efficiency is the amount of useful energy you get from any type of system. A perfectly energy-efficient machine would convert all the energy put into it into useful work. In reality, converting from one form of energy to another always involves a loss of useable energy.

Savings in energy costs and energy efficiency could effectively increase household income and food consumption. There is good evidence to suggest that more efficient and lower cost cooking stoves and lighting fuels can yield savings in energy expenditure of 20-50 per cent.²⁶

Some of the equipment used to convert energy uses fuel (such as wood, LPG, diesel, coal). **Fuels store chemical energy which is released when the fuels are burnt**. These fuels differ from one another in a number of ways: their physical form (gas, solid and liquid) and the amount of energy they store. For example, a 1 cm³ piece of wood contains less energy than a 1 cm³ piece of coal. There are other ways to store energy: for example in batteries (chemical energy) and water in dams.

What is calorific value?²⁷

Calorific value is the heat per unit of mass produced by the complete combustion of a given substance. Calorific values are used to express the energy value of fuels (measured in megajoules per kilogramme). They are also used to measure the energy content of foodstuff (measured in kilojoules per gram)

3.3. The energy chain²⁸

All energy has its origin in the natural environment. Energy analysts classify the natural sources of energy as **primary energy**. Some of the natural sources of energy, like biomass, can be used directly.

²⁵US-EIA (n.d.)

²⁶Dutta, S. et al (2005).

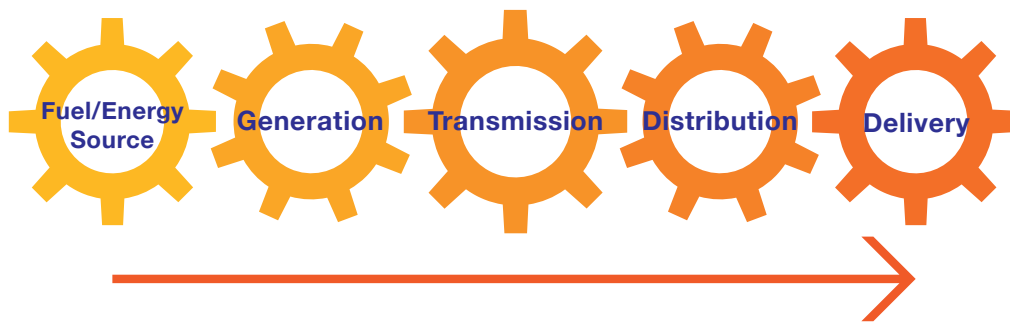
²⁷Energy for Sustainable Development Online Course (2009).

²⁸This section is based on ENERGIA (2008c).

Often though, primary energy will have to undergo a number of conversions so that it can be delivered to the consumer. It can be transformed into **secondary energy** for transport or transmission, to end up as **final energy or energy carrier** with the consumer. The consumer then uses the energy carrier in an appliance to produce useful energy. This process from primary to useful energy is called the **energy chain**. Energy analysts use energy chains to analyse energy losses.



Figure 1: Graphic example of the energy chain²⁹



There are other ways of classifying energy sources:

Energy can be classified in terms of sustainability of the resource.

Most of the primary sources of energy are renewable: in other words, they will not be depleted unlike fossil fuels (non-renewable) which will at some stage in the future be expended.

Renewable energy sources include biomass (if not managed properly it can become non-renewable), solar, water and wind.

Energy can be classified in terms of familiarity of use.

We consider energy sources that have long been in use as ‘traditional’ or ‘conventional’ as opposed to new sources (non-traditional or non-conventional). Sometimes, it is the conversion technology rather than the resource itself which determines the classification. Animal dung can be regarded as a traditional energy resource if burnt directly; but if it is used to produce biogas in a digester it then become a ‘non-traditional’ energy source. The terminology is rather ambiguous since it depends very much on the context.

Energy can be classified in terms of whether or not it is purchased.

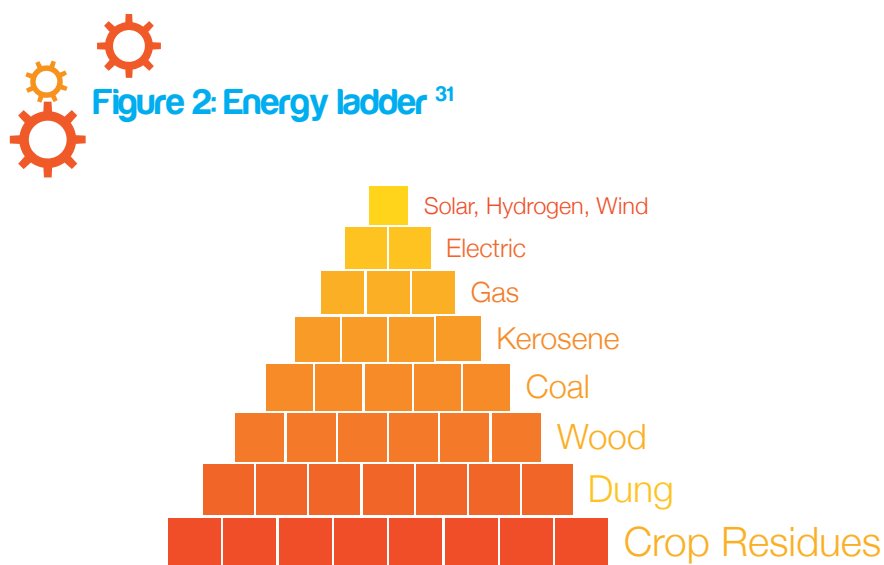
Commercial energy always includes fossil fuels and some new and renewable sources. Biomass is usually classified as non-commercial – however again this depends on where you are in the world. In many urban areas and some rural areas biomass is a commercial energy source.

²⁹ENERGIA (2008c).

3.4. The energy ladder³⁰

Some forms of energy or fuels are less attractive while others are much more attractive depending on the task for which they are intended. Energy analysts sometimes display these fuels in the form of a ladder. The least attractive fuels are at the bottom of the ladder, while the most attractive fuels are at the top. The rungs of the ladder represent other, intermediate, fuels. Energy interventions are sometimes intended to help users move up the energy ladder. The problem with the transition up the ladder is, of course, that the more attractive energy forms tend to be more expensive as is the equipment required to use the energy.

Cost influences the type of energy people use. Poor people are at the bottom of the ladder, using wood for cooking and even for lighting at night. But the same can hold true further up the ladder, with well-off people using LPG instead of electricity for cooking, as the former can be cheaper and more flexible.



The energy ladder is a simplified form of reality. Often people use more than one form of energy carrier for a particular task, depending on a number of factors such as availability and convenience. There does not appear to be a smooth progression as incomes increase of switching from biomass fuels to kerosene, to LPG, to electricity. Even wealthy households are known to keep kerosene lamps in case of power cuts. Low-income households may be prepared to pay for electricity for lighting but will continue to cook using biomass or kerosene. Energy choice is not a simple matter of income.

3.5. Neglected sources of energy³²

Most of the fuel used in developing countries is derived from the traditional forms of biomass: from trees, agricultural wastes and dung. A large part of this is used in its original form, which is generally inconvenient and not attractive. However, for most rural people it is 'free' in the sense that they do not pay cash for it. Also, often they have no alternative.

³⁰This section is based on ENERGIA (2008c).

³¹ENERGIA (2008c).

³²This section is based on ENERGIA (2008c).

Two billion people in the world do not have access to 'modern' energy carriers (electricity, petroleum-derived fuels or gas). This is largely because:

1. These energy carriers are not available in rural areas.
2. These are commercial fuels and the income levels of the poor are insufficient to access them.

Traditional biomass and metabolic energy (see 3.1.5) are the main energy sources for poor people in both rural and urban areas.

3.6. Metabolic & biomass energy in national energy planning³³

Metabolic energy is rarely measured; few energy departments concern themselves with trying to include metabolic energy in official statistics. Nevertheless, metabolic energy is a very important part of the energy balance in people's lives. Many of the tasks that use metabolic energy are physically demanding and can be repetitive, boring and time consuming (burden).

What is metabolic energy?

Metabolic energy is the energy produced by our bodies and is derived from the food we eat.³⁴ Metabolic energy is measured in calories.

Similarly, a typical report on the national energy situation in most developing countries will devote most of its attention to commercial energy use and supply, only a few pages to biomass, and nothing at all to metabolic energy. It is usually recognized, however, that much of the biomass energy is gathered by women and both the burden represented by this task and the presumed environmental consequences are often mentioned. Where solutions are sought, these normally involve tree-planting or energy-saving stoves. However, national energy policies only usually devote a small percentage of their budgets to biomass-related projects.

What is biomass?

Biomass is organic material that originates from a biological, spontaneous or engineered process, and used as an energy source.³⁵ Biomass is one of the oldest sources of energy and includes residues and wastes, crops and trees.

³³This section is based on ENERGIA (2008c).

³⁴Clancy, J. et al. (2005).

³⁵Real Academia Española (2001).

3.7. What are energy services?³⁶

Energy service is the application of useful energy to tasks demanded by the consumer at the end-use point in order to produce benefits for human well-being, such as transportation, lighting, cooking and food refrigeration. Energy services can be provided by different energy carriers; for example, cooking can be done using fuels – firewood, charcoal, gas – or electricity. From the point of view of the user, what matters is the energy service not the source used to produce it.

What are energy services?³⁷

Energy services are the benefits that energy carriers produce for human well-being.

Examples of energy services include:

- Cooking and water purification
- Lighting
- Domestic heating
- Cooling
- Supporting income-generation activities

Under the energy services approach, not only is the technology used to generate the energy important to the user, but also other non-technical items such as affordability, reliability and accessibility. This is a particularly important consideration for women who usually have fewer assets than men. Innovative mechanisms are needed to facilitate access by women to the energy services they require.

Above all, the energy services approach to energy provision and access means not using technology as a starting point, but rather starting with an analysis of people's needs and priorities. This analysis needs to be conducted from the perspective of the people themselves, and not solely by policy makers or energy providers. Dozens of energy projects have failed because well-meaning planners have arrived in a community with a ready-made plan: for example, to provide a windmill with a pump for the water supply. This is supply-side planning: “we have the technology; we want you to have it”. Far better and more successful is the demand driven approach: “what do people actually want?” This allows energy initiatives to address the needs of the target group in a more comprehensive manner.

3.8. Further resources

More information about the topics covered by this module can be found in the following resources:

- Clancy, J. et al. (2005a). The Gender Face of Energy: A Training Manual. Module 1.
- Clancy, J et al. (2005b). The Gender Face of Energy: Gender Tools for Energy Projects. Module 2.
- IUCN, UNDP and GGCA (2009). Training Manual on Gender and Climate Change.
- UNDP and ENERGIA (2004). Gender and Energy for Sustainable Development: a toolkit and resource guide.

³⁶This section is based on ENERGIA (2008c).

³⁷Modi, V. et al (2005).

- UNDP (2007). Gender Mainstreaming: a key driver of development in environment and development. Training Manual.
- UNDP (2007). Will tomorrow be brighter than today? Addressing gender concerns in energy for poverty reduction in the Asia-Pacific Region.

3.9. Possible exercises

The following exercises could be used to test and strengthen knowledge among training workshop participants.

Exercise 1. Short quiz

Develop a simple quiz to encourage participants to test their understanding of the main concepts they have just learned about. One way to achieve this could be to match specific terms with their definitions. For example: on a board or piece of paper, draw two columns. In one column include terms such as 'energy', 'carriers', 'source', 'fuel', 'energy service'. In the second column include the definitions of these terms. Then ask participants to match the terms to the definitions.

Participants can do this exercise individually or in groups, to stimulate discussion.

Exercise 2. Sellers and buyers

Use a dynamic exercise

On separate colour cards, write each of the terms 'energy', 'carriers', 'source', etc. Then write each definition on a separate colour card. Divide participants into two groups, 'terms' and 'definitions'; each group should have the same number of members as the number of cards available. Then invite the 'terms' to be the buyers and the 'definitions' to be the sellers. Invite each group member to 'buy' and 'sell' as a way of matching up the cards. Each time a pair buys and sells, ask them to clap hands. When each 'buyer' and 'seller' has found his/her match, ask all participants to share their terms and definitions with the group to stimulate further discussion.

Exercise 3. Day-to-day examples

Test participants' knowledge of energy services by asking them to share examples of how benefit from using energy and energy technologies in their daily lives.

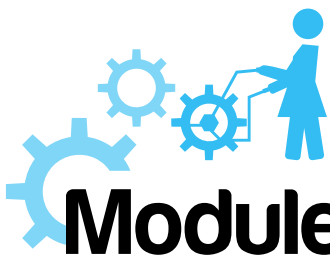
A variant of this group exercise can be conducted using the 'Buyer' and 'Seller' scenario described above. Ask the 'Buyers' to write needs on separate cards, for example, cooking, lighting, domestic heating, etc. Ask the 'sellers' to write energy and technology types on separate cards. Next, ask the buyers to 'shop' for the different technology types. Include as many technology choices as possible to demonstrate that a single need may be met with several different types of technology.

Module



4

**RENEWABLE ENERGY
TECHNOLOGIES**



Module 4: Renewable Energy Technologies

4.1. What are renewable energy sources and technologies?

Renewable energy sources are those that are not depleted through use. These are known as indigenous resources (meaning they are found at the point of use) and have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases.

Renewable energy sources include:

- **Biomass energy** – organic material which can be used as an energy source, it includes wood and wood waste, agricultural waste, municipal solid waste, landfill gas, biogas, ethanol and biodiesel.
- **Hydropower** – utilizes the movement of water to generate energy.
- **Wind energy** – relies on the movement of masses of air to produce energy.
- **Geothermal energy** –utilizes heat stored in rocks by the natural heat flow of the Earth which is converted into energy.
- **Solar energy** – uses the heat produced by radiation from the sun.

Renewable energy sources need to be converted in order to produce useful energy. **Renewable energy technologies (RETs)** are those technologies used to harness and convert renewable energy sources into useful energy.

Renewable energy sources have the potential to meet the present world energy demand many times over, while enhancing the diversity of energy supply markets, securing long-term sustainable energy supplies and reducing greenhouse gas emissions. They can also provide commercially attractive options to meet specific needs for energy services, create new employment opportunities and offer possibilities for local manufacturing of equipment.³⁸

Scenarios investigating the potential of renewable energy sources reveal that these could contribute between 20 and 50 per cent of energy supplies during the second half of the 21st century. A transition to renewable-based energy systems would have to rely on:³⁹

- The successful development and diffusion of renewable energy technologies that have become more competitive thanks to cost reductions from technological and organizational developments.
- The political will to acknowledge the real cost of producing, distributing and using fossil fuels (by internalizing environmental costs and other externalities, eliminating subsidies, etc); price increase of fossil fuels will then render RETs more competitive.

³⁸UNDP and IIEE at Lund University (2009).

³⁹Idem.

- The need to address social requirements, including the identification of women as energy managers, capable of engaging in development, usage, maintenance and diffusion of renewable energy technologies.

4.2. Matching renewable energy technologies (RETs) and energy services

The previous module showed how energy technologies can provide different services or benefits to their users. The table below provides a summary of renewable energy sources, the renewable energy technologies utilized in their transformation, and the energy services provided as a result of this transformation.




Table 4. RETs and Energy Services

Energy Source	RET's	Energy Services
Biomass • Fuel wood and vegetation residues • Biogas • Biofuels (ethanol and biodiesel)	Improved cooking stoves (p.52)	Cooking and water disinfection Domestic heating
	Biodigesters (p.58)	Cooking and water disinfection Domestic heating Lighting
	Biofuel stoves (p.56)	Cooking and water disinfection
	Biofuel-powered generators (p.75)	Domestic heating Lighting Income-generation activities (milling, water pumping, electrical appliances)
Solar energy	Solar cookers (p.58)	Cooking and water disinfection
	Water heating solar collector (p.63)	Water heating
	SODIS (p.65)	Water disinfection



Table 4. RETs and Energy Services (continued)

Energy Source	RET's	Energy Services
Solar energy	Solar collector for heating (p.81)	Domestic heating
	Solar photovoltaic panels (SPV) (p.73)	Lighting Refrigeration Income-generation activities (water pumping, electrical appliances)
Hydropower	Hydro systems (p.70)	Cooling Lighting Income-generation activities (milling, electrical appliances)
Wind energy	Wind generators (p.67)	Cooling Lighting Income-generation activities (water pumping, electrical appliances)

For more information about the specific technologies described in this table, please refer to the page numbers in column two.

4.3. Environmental impacts

Renewable energy technologies are generally thought to be harmless as they do not burn fossil fuels or rely on nuclear power. However, RETs do have environmental impacts. These could be due to the utilization of large areas of land, their impacts on ecosystems (watersheds, fisheries, birds and their migration paths, among others), or simply aesthetic impacts.⁴⁰

Although there may be a correlation between the impact of RETs and the scale of their use (i.e. small-scale RETs may have significantly less impact than large-scale installations), small-scale RETs may still have important impacts to their surroundings. When implementing RET initiatives, therefore, it is important to carry out an environmental and social impact assessment in consultation with local women and men in order to ensure that environmental impacts are kept to a minimum and that local resources and needs of women and men are preserved.

The matrix below includes some of the best known examples of potential environmental impacts of RETs. For further information on potential environmental impacts of specific RETs, please refer to Module 6.

⁴⁰de Wachter, B. (2006).



Table 5. RETs and Environmental Impacts

RET or Energy Source	Environmental Impact
Biofuels	<p>Large scale biofuel plantations are linked to: deforestation, displacement of small farmers and indigenous people from their lands, and increased production of GHGs due to loss of forested areas and use of fossil fuels for planting, fertilizing, harvesting and processing biofuels.⁴¹</p> <p>However, when produced on a small scale and using native species, biofuel production could have positive environmental impacts, such as land restoration/regeneration and forest conservation.⁴²</p>
Hydropower	<p>Hydropower often entails changes to the natural variation of water flows. Hydro plants without water storage reservoirs cause relatively small changes to the water flow and nearby ecosystems. In the case of high-pressure power plants with regulation reservoirs, the impact on biodiversity depends on the height of the reservoir walls.</p> <p>Damming has a negative effect on the environment as large areas are flooded; with decaying vegetation trapped underwater decomposes and produce methane. Additionally, dams may impact: reservoirs on terrestrial ecosystems and biodiversity; natural flood cycles on downstream floodplains, and fisheries. Damming may also cause displacement of local or indigenous people living in rural areas.⁴³</p>
PV systems	<p>The main concern with (small) PV systems relates to the use and disposal of their batteries. During the battery charging process, hydrogen is released into the environment. This is not a problem if the battery is located in a well-ventilated room; otherwise there may be a risk of explosion due to high concentrations of gas. Additionally, it is necessary to have an efficient programme to dispose of and recycle these batteries to avoid environmental pollution from the batteries.⁴⁴</p>
Wind turbines	<p>Environmental impacts of wind turbines and wind parks are local and relatively easy to mitigate. Some of the main concerns related to this technology include:⁴⁵</p> <ul style="list-style-type: none"> • Noise produced by the rotating turbine: a large turbine will sound like a standard refrigerator at a distance of 250m • Area of land utilized for wind parks: wind turbines may be installed on large areas of land, however they may require only between 1-5 per cent of the area for their installation and access roads; the rest of the land can be utilized for traditional activities (crops, animal rearing). • Displacement of fauna: large mammals and local birds tend not to return to the area of the wind parks once the turbines have been installed; migratory birds are at a high risk due of collision with turbines and the electric lines.

⁴¹Karlsson, G. and Banda, K. (2009).

⁴²Idem.

⁴³World Commission on Dams (2000).

⁴⁴BUN-CA (2002d). Manuales sobre energía renovable: Solar Fotovoltaica.

⁴⁵BUN-CA (2002b). Manuales sobre energía renovable: Eólica.

4.4. Further resources

More information about the topics covered by this module can be found in the following resources:

- BUN-CA (2002a). Manuales sobre energía renovable: Biomasa.
- BUN-CA (2002b). Manuales sobre energía renovable: Eólica.
- BUN-CA (2002c). Manuales sobre energía renovable: Hidráulica a pequeña escala.
- BUN-CA (2002d). Manuales sobre energía renovable: Solar Fotovoltaica.
- BUN-CA (2002e). Manuales sobre energía renovable: Solar Térmica.
- ENERGIA (2009). Biofuels for Sustainable Rural Development and Empowerment of Women. Case studies from Africa and Asia.
- ENERGIA (2011). Mainstreaming Gender in Energy Projects: A Practical Handbook. Prepared by Elizabeth Cecelski and Soma Dutta for ENERGIA. Forthcoming.
- Hivos and ENERGIA (2010). A Guide on Gender Mainstreaming in the Africa Biogas Partnership Programme. Prepared by ENERGIA.
- Leonardo Energy, Photovoltaic Systems, at: <http://www.leonardo-energy.org/fxchange/webcast/photovoltaic-systems/player.html>
- Practical Action, Regional Programme (2011). Gender Mainstreaming in Energy. Training Manual for Pico Hydro Installations.

4.5. Possible exercises

The following exercises could be used to test and strengthen knowledge among training workshop participants.

Exercise 1. Identifying renewable energy resources

Prior to introducing this topic, ask participants to identify renewable resources (what comes to mind when they hear the concept?). Do they know how these can be transformed into energy?

Exercise 2. Mapping renewable energy resources

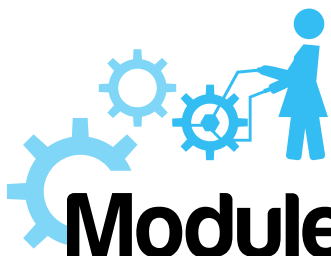
Ask participants to describe their own community (or a community they know well) and identify potential renewable energy sources. Encourage participants to think about and discuss the following questions:

1. Which RET's could be implemented in this community?
2. Which environmental impacts do they foresee or expect from the installation of these RET's?
3. Could the environmental impacts be mitigated or corrected after installation of the RETs?
4. Would the trade-off between environmental impacts and energy services be sufficient for women and men in this community to accept a particular RET?

Module



**CHOOSING THE MOST
APPROPRIATE
TECHNOLOGY**



Module 5: Choosing the Most Appropriate Technology

5.1. What is appropriate technology?

The term **appropriate technology** is generally recognized as referring to an inclusive technological choice and application that is small scale, labour intensive, energy efficient, environmentally sound and locally controlled.⁴⁶ Appropriate technology does not necessarily mean simple technology, but technology which is specifically designed for the conditions in which it is to be deployed and takes into account the skills and technologies available at local level.

Some of the main characteristics of these technologies include:⁴⁷

1. System design – the design of a renewable energy technology should cater to the conditions where it will be placed and the needs of the users
2. Costs – should be affordable to local communities
3. Maintenance needs – maintenance and repair skills and spare parts should be available in the vicinity.

5.2. The need to involve women and men as beneficiaries in choosing appropriate technologies

Choosing the most appropriate technology for a particular situation is not as simple as may at first be believed. In many cases renewable energy technologies have been rejected following their introduction in a community.

It is easy to attribute this rejection to the lack of interest or cultural barriers among the target communities.⁴⁸ However, renewable energy technologies may fail for a variety of reasons, including the failure to recognize women's roles as energy managers. Women should be involved in the assessment, choice and adaptation of renewable energy technologies because.

- Failure to involve women in the initial testing of new technologies can result in reduced effectiveness and use of the same. This was the case, for example, of improved cooking stoves which cooking panes were too small to cook traditional meals.
- Failure to involve women in the use, maintenance and/or repair of renewable energy technologies may in the long run bring the use of these technologies to a halt, particularly if women are the primary users.

⁴⁶Hazeltine, B. and Bull, C. (1999).

⁴⁷ILO INSTRAW (n.d.).

⁴⁸Idem.

Recognition of women and men living in communities where RET initiatives are to be implemented is therefore key to ensuring that these technologies address not only the energy needs of the beneficiaries, but are also culturally sensitive. In this vein, the Network of Indigenous Women in Biodiversity⁴⁹ recommends that RET initiatives implemented in Indigenous People's Territories:⁵⁰

1. Be subject to a consultation process, held in the native tongue of the indigenous groups and in accordance with their own protocols.
2. Recognize that Indigenous People (IP) have a right to free, previous and informed consent as well as the right to veto the implementation of projects or activities which do not address their needs or are detrimental to IPs.
3. Include an assessment of the impacts these projects may have on the lives and culture of IPs.
4. Be developed in a sustainable and culturally appropriate manner, taking into account knowledge transfer, capacity building for maintenance, and others to avoid technical and economic dependency.
5. Ensure the full and effective participation of indigenous women in the design, planning, implementation and evaluation of RET projects.
6. Ensure that RETs and energy sources utilized are appropriate to the context in which they will be utilized. Questions to be addressed may include: how will RET's will affect the health, environment, interpersonal relationships, local economy, capacity to maintain the RET systems running, payment capacity for energy services received?

5.3. Using the energy service approach to choose the most appropriate technology for women

The energy services approach considers that not only is the technology important but also other non-technical aspects such as affordability, reliability and accessibility for the user. The starting point for an energy service approach to choice of technology starts by asking the question:

“Which are the energy services or energy needs that can be addressed?”

These might include:

- Cooking and water purification
- Lighting
- Domestic heating
- Cooling
- Supporting income-generation activities

⁴⁹Free translation from Spanish: Red de Mujeres Indígenas en Biodiversidad

⁵⁰Based on written comments and recommendations provided by the Red de Mujeres Indígenas en Biodiversidad, during the August 2011 workshop on “Sustainable Use of Renewable Energy Technologies for women in rural and periurban areas”, IUCN, ENERGIA, Hivos, San José, Costa Rica.

Once the energy service has been defined, the following questions can be used to guide choice of technology:⁵¹

1. Which renewable energy technologies are available in my region/country which provide this particular energy service?
2. What do these technologies do for the lives of women? Do they all have the same implications?
3. What changes in women's work patterns will be required to use it?
4. Does it use local initiatives or allow for local development? (i.e. produce additional income generation activities for women and/or men)
5. Is the design appropriate to women? Is it easy to maintain? Does it encourage self-reliance? If so, how?
6. Is this technology the most affordable option? Can women afford the costs? What are the benefits for women and the community?
7. Can women be trained [or are they willing to be trained] as technicians to maintain the energy technologies?

NOTE TO READER: The above questions can be reframed to identify the implications, roles and opportunities for women **and** men.

The following table lists a variety of renewable energy systems and the advantages they present for women.




Table 6. RETs and possible advantages for women.

Renewable green energy systems	Advantages for women, girls and the family
Decentralized and small-scale electricity generation from renewable energy sources (photovoltaic, bio-digester gas, biofuels, micro hydro and wind power)	<ul style="list-style-type: none"> • Facilitate time consuming manual house chores (transporting, harvesting, grinding and processing food) • Improve household and garden productivity well as activities in small-scale businesses. • Gained time can be spent in education, income-generating activities, more efficient household management and domestic responsibilities, as well as social and political involvement. • Enable introduction and access to modern information and communication technologies. This is an important empowerment tool for women and girls as it promotes education, as well as participation in markets in addition to social and political issues and improves economic efficiency.

⁵¹Adapted from ILO INSTRAW (n.d.)



Table 6. RETs and possible advantages for women (continued)

Renewable green energy systems	Advantages for women, girls and the family
<p>Mechanized wells and water pumping for running water systems in households as well as for irrigation, using energy from biofuels or electricity generated from renewable energy sources (photovoltaic, biogas, biofuels, micro hydro and wind power)</p>	<ul style="list-style-type: none">• Removes need for physical, demanding and potentially health damaging work involved in hauling water over long distances.• Improvement of the infrastructure thanks to implementation of a running water system.• More efficient food supply with better irrigation methods in fields and gardens, relatively independent of the seasons.• Gained time can be spent in education, income-generating activities, more efficient household management and domestic responsibilities, as well as devoted to social and political issues.
<p>Biogas and biofuels used for indoor cooking and heating</p>	<ul style="list-style-type: none">• Less time-consuming process for cooking and heating in comparison to traditional biomass fuels systems (i.e. drudgery reduction)• Reduction in indoor air pollution by toxic and harmful compounds of fumes.• Corresponding reduction of associated sicknesses and health dangers.• Gained time can be spent in education, income-generating activities, more efficient household management and domestic responsibilities as well as devoted to social and political issues.

5.4. Further resources

More information about the topics covered by this module can be found in the following resources:

- UNDP and ENERGIA (2004). Gender and Energy for Sustainable Development: a toolkit and resource guide.
- UNDP (2007). Gender Mainstreaming: a key driver of development in environment and development. Training Manual.
- ILO INSTRAW (n.d.). Women: New and Renewable Sources of Energy.

5.5. Possible exercises

The following exercises can be used to test and reinforce knowledge among training workshop participants.

Exercise 1. Selecting an energy technology

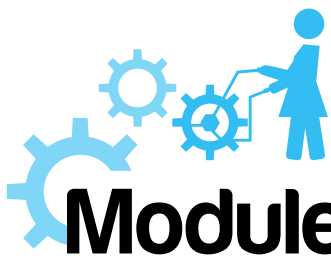
Ask participants to choose a community they know. Then ask them to answer the following questions:

1. Which energy service is the weakest in the community?
2. Which technology would be the best choice for providing this service for this particular community? Taking into account:
 - a. Availability of the technologies
 - b. Affordability of the technologies
 - c. Benefits for women
 - d. Changes in work patterns of women necessary to use this technology
 - e. Is the design appropriate for women
 - f. Usage of local initiatives or production of opportunities for local development.

Module

6

**MATCHING ENERGY
SERVICES AND
RENEWABLE ENERGY
TECHNOLOGIES FOR
WOMEN**



Module 6: Matching Energy Services and Renewable Energy Technologies for Women

Women and men have different energy needs due to their different roles. As a consequence, energy poverty in rural and informal urban areas affects women and men differently. In order to identify effective strategies to combat energy poverty this chapter will focus on the provision of basic energy services and the identification of different renewable energy technologies which could provide these services. Concentrating on the provision of an energy service makes it easier to assess the non-technological barriers and opportunities to providing an affordable, reliable and accessible service. These elements may vary between families, communities, cities and even continents, as they are interlinked with issues such as: income, closeness or remoteness to settlements, availability of renewable energy sources in the region, among others.

This module is intended therefore to provide concise information about different renewable energy technologies available and their potential contribution to one or more energy services. It is not intended as an exhaustive list, but rather to highlight key existing and proven technologies.

When considering the provision of energy services it is particularly important to understand the different gender dynamics within households and communities. A gender analysis of energy services requires addressing a series of questions including:

- What is the main service to be provided?
- Who chooses the energy carrier or renewable energy technology to be used?
- Does the existing energy technology address the needs of the user?
- What is the cost of the technology?
- Is the fuel necessary to power this renewable energy technology available all year round? Are there substitutions for this fuel in case of shortages?
- How is this technology used?
- Who knows about the use and maintenance of the renewable energy technology?

NOTE TO READER: This module concentrates on RET systems intended to provide services at household or community levels for rural and informal urban women. As a result, the technologies described tend to be small-scale technologies, with little or no mention of larger applications or systems.

6.1. Cooking and water heating or purification

Cooking is essential to our existence, as close to 80 per cent of the foods we eat need to be cooked; however, only 2 per cent of energy strategies in the least developed countries address cooking.⁵² Nearly three billion people use biomass (such as wood and agri-residues) and coal for cooking and nearly three-quarters of people still cook on stone fires and rudimentary stoves.⁵³ This energy poverty means women, in particular, spend many hours in drudgery, gathering fuel, cooking over inefficient stoves and cleaning soot-laden pots, clothes, walls and ceilings.⁵⁴

In contrast, child mortality and maternal health are clearly improved by modern cooking fuels; evidence also suggests reduced incidence of acute respiratory infections (ARI) and reduced drudgery affecting neonatal survival (though the latter has not been specifically imputed to energy). There is some evidence too to suggest a positive correlation with birth weights.⁵⁵

Additional energy services⁵⁶

Energy is also necessary for sterilizing and heating water for washing and personal hygiene. Additionally, stoves may be used for cooking animal feed. These uses may extend the time a stove or fire must be lit, with the associated impacts on fuel use and smoke generated. Moreover, stoves are used by many women for home-based enterprises such as cooking and selling street foods or brewing beer and spirits, which may constitute their main source of income. Hence, the importance in the selection of technologies and fuels.

6.1.1. Cooking and water sterilisation technologies

All stoves or cookers need to be efficiency optimized to burn as little fuel as possible with a maximum output in heat. Stoves should be designed in a manner that ensures that heat is stored thanks to good insulation or directed efficiently towards the cooking elements (hot plates, pots, etc.) Affordable aluminium cooking pots with well-fitting lids that conduct heat efficiently are ideal. An integrated windshield application on the stove can also help save energy so that heat is not lost.

Gender considerations

Do available stoves cater to the cooking needs of the family? (For example, are the cooking spaces [burners for stoves or baking chambers for cookers/ovens] wide enough for the pots regularly used or for the hot plates usually prepared? Can traditional meals be prepared on these stoves? Is the stove the preferred height for women? Does it work with the preferred fuel type?)

Can the stove be used with other kitchen improvements?

Where is the marketing information distributed?

Who makes the decision to buy the stoves?

Who produces and distributes the stoves?

⁵²Havet et al. (2009).

⁵³Practical Action (2010).

⁵⁴Idem.

⁵⁵Dutta, S. et al (2005).

⁵⁶Practical Action (2010).

6.1.1.1. Improved cooking stoves

Traditionally, cooking is carried out in many areas on a three-stone cooking stove. This stove is cheap to produce as it requires only three stones of equal height on which a cooking pot can be balanced over a fire. The three stone cooking fire is powered by biomass (including firewood, agricultural waste, and/or dung). This traditional cooking method is inefficient, consumes large amounts of fuel and produces large quantities of smoke, which may cause severe health problems.

In contrast, Improved Cooking Stoves (ICS) aim to save time (as they are designed to increase conversion efficiency), as well create a smokeless environment in the kitchen and/or reduce the volume of smoke emissions. There are several different designs of **improved cooking stoves**, classified according to their **use** (one or multiple uses), **construction material** (clay, metal, ceramic, brick, etc.), **portability** (fixed, portable), and **fuel type** (fuel wood, rice husk, charcoal, etc.).

The main characteristics of an improved cooking stove include:⁵⁷

1. A well proportioned combustion chamber
2. High thermal efficiency
3. High fuel efficiency
4. May use processed fuels
5. High heat transfer ratio
6. High combustion efficiency
7. Low emissions of smoke and other pollutants
8. May or may not have chimney to remove emissions from the kitchen
9. May have provision for primary and secondary air inlets for combustion
10. May have provision for forced draft of air
11. Stove body made of durable material such as well-baked clay, ceramic or metal



Materials are an extremely important part of any stove. The high temperature environment to which the combustion chamber is exposed is highly corrosive and hence can severely affect the life of the combustion chamber lining. Desirable features of materials use in improved cooking stoves include:

- Durability in high temperature environment
- Low cost
- Local availability
- Easy manufacturability

⁵⁷HEDON (n.d.)



Table 7: Types of improved cooking stoves

	Name	Function	Construction materials	Portability	Fuel type
	Improved three stone or mud-stove	Mono-function	Clay, straw, dung, cement, stone	Fixed	Wood
	Multi-fuel	Mono-function	Metal	Portable	Wood, charcoal, dung, agriculture residues
	Multi-cooker	Mono-function	Metal	Portable	Wood
	Mono-cooker	Mono-function	Metal	Portable	Charcoal
	Mono-cooker	Mono-function	Metal and ceramic	Portable	Charcoal

Source: HEDON, at: <http://www.hedon.info/Improvedcookstove>

Advantages: ICSs are relatively cheap and easy to build using local materials. ICSs use traditional fuels and therefore may be met with less resistance by users – technology change is sometimes met with resistance – (the fuel base remains the same and use of the stove may not differ much from traditional usages). Some well insulated ICS models are safer (less hot side walls) and easier to handle in the kitchen (mobile not stable), prepare food faster and could prevent domestic accidents among the family.⁵⁸

Disadvantages: ICSs principally have a high combustion efficiency⁵⁹ but solid fuel combustion is however much more complex than liquid fuel combustion⁶⁰ (the efficiency of alcohol stoves⁶¹ fuelled by liquid ethanol, can be up to 60%). Some designs still allow for open flames and if they do not include a chimney then indoor air pollution may remain a problem.⁶²

Environmental impacts: The use of ICSs and the required biomass fuel/fuel wood should be always seen in the context of their impact on the environment.⁶³ In the need of sufficient biomass fuels, such as fuel wood, animal manure or rice husks, firewood is, most often, the preferred choice. Yet, demand for firewood may exceed the supply of sustainably grown fuel wood around villages or cities. Overexploitation and uncontrolled harvest of unsustainably grown fuel wood (including roots, young trees and shrubs) in already damaged or threatened ecosystems around human settlements can result in massive deforestation, followed by land degradation, erosion and in the worst case, total loss of the ecosystem. A better approach would be to encourage the controlled use and distribution of fuel wood harvested in a sustainably maintained forest ecosystem with a management plan based on a multi-stakeholder engagement.

There is evidence to suggest that improved stoves save thousands of tons of fuel wood. Therefore, in urban areas or locally deforested rural areas, where large quantities of wood are used, controlled use could be significant in helping to reduce deforestation. More importantly, women in their role as forest managers and tree planters contribute to reforestation.⁶⁴ The use of more efficient household cooking fuels is believed to contribute to reductions in greenhouse gas emissions; however, when compared to the global volume of emissions, these reductions are not significant.

Depending on the material used in the manufacturing process, different cooking stoves have different impacts on the environment. The use of metal in the manufacture of cooking stoves means that their production is energy intensive with associated high levels of GHG emissions. However, metal is fairly durable in comparison to cheaper materials like clay, for example. Materials like clay, straw, dung and stone are easier to obtain and have a smaller impact on the environment if they are gathered sustainably in their natural surroundings.

Gender considerations: By relying on a smaller volumes of fuel improved cooking stoves may reduce the burden associated with firewood gathering, a task for which women and girls are largely responsible; they may also reduce exposure to harmful gases and have a positive effect on the health of women and

⁵⁸Barnes, D.F., et al. (1994)

⁵⁹HEDON (n.d.)

⁶⁰Barnes, D.F., et al. (1994)

⁶¹Project Gaia, Domestic CleanCook (2010)

⁶²CRT/Nepal, (2011)

⁶³Staton, D. and Harding, M. (n.d.)

⁶⁴Dutta, S., et al. (2005).

children (boys and girls) who tend to be involved in cooking. If fuels are purchased (like charcoal, for example) the use of smaller volumes of fuel may have a positive effect on the household economy. Time saved by women and girls as a result of not having to gather fuel wood can free them up to engage in other activities, including attending school or income-generating activities.

CASE STUDY: LORENA stoves, a successful example from Nicaragua⁶⁵

The residents of three communities from Chinandega in Nicaragua have decided to take the future of their cooking stoves, quite literally, into their own hands. These families took the decision to improve upon their traditional cooking methods through the innovative hands-on construction of LORENA improved cooking stoves. These stoves are built by hand, mainly out of clay and sand, hence the name LORENA: *LO* from *lodo* (=clay) and *RENA* from *arena* (=sand). These innovative cooking stoves were introduced to the inhabitants of the villages of Becerro, Pajuil and Canyonipe in the municipality of Villa Nueva in the department of Chinandega by the Asociación para el Desarrollo de los Pueblos (ADP), a Nicaraguan organization. The area was considered ripe for their introduction because most households prepared food, beverages and products for sale using a simple three stone cooking fire in the kitchen. These indoor fires, which burn wood as an energy source, are the cause of tremendous health problems including chronic lung infections and eye irritations; they even weaken the immune system of the children and women who are regularly exposed to toxic fumes in the kitchen area. Apart from health issues, these stoves are associated with even bigger environmental problems resulting from the long-term felling of trees and shrubs, digging up of roots, and cutting of young trees in the areas surrounding the communities to harvest this traditional source of energy. The resulting deforestation leaves large areas exposed to the elements and vulnerable to the impacts of the heavy rains or prolonged dry periods increasingly associated with climate change in the region. Soil, valuable for local agriculture, is washed away while erosion renders the degraded landscape unsuitable for settlement. To prevent the development of such a hostile environment, local expert Marta Ardila from ADP and her team convinced women and men as well as adolescents from schools in the Chinandega area to join them and participate in a capacity-building process intended to improve their livelihoods. A series of training workshops were organized to introduce the stoves and demonstrate how residents could use the innovative technology offered by the LORENA stove to improve their lives in a more sustainable manner, especially in a climate change context. Members of the local community who have received training are now dispensing training themselves and showing how other communities can use the LORENA stoves to help themselves. The stoves are relatively simple to build and can be assembled in one or two days with the help of trained instructors from the district and a few members of the community.

“We use recycled material such as shredded glass bottles to reinforce the wall within the stove and retain the heat for longer”, explained Marta of the advantages of the LORENA stove. A pipe attached to the stove guides the toxic fumes directly out of the house and therefore improves the health and hygiene conditions of every member of the 213 participating families right away. Up to 60 per cent of fire wood can be saved by preparing three daily meals with this technology. An average family in the Chinandega area needs some four to six bundles of sustainably cut wood for their LORENA stoves, compared to 12 bundles before. The project has shown the communities how to protect and restore their surrounding forests using tree nurseries and reforestation projects. Around 4,000 new trees of local species have been planted in the Chinandega area as part of effort for the long-term mitigation of climate change impacts.

⁶⁵Ardila, M. (2011). Case study produced using material provided by M. Ardila, with her express authorization.



Source and photo: Traditional stove, M. Ardila



Source and photo: Improved LORENA stove, M. Ardila

6.1.1.2. Biofuel stoves

These solid metal stoves come in two versions: a one or two-burner model.⁶⁶ Both models include a spill-proof fuel canister that holds enough fuel to meet the daily needs of an average family. These stoves have an efficiency of 65 per cent; they burn as hot as a LPG stove and produce no soot. A durable model of this stove can be manufactured locally; it has a life expectancy of more than 10 years. These stoves use renewable biofuels: combustible bio-alcohol (Ethanol) produced locally from the fermentation of plant mass (for example, sugarcane). Bio-alcohol is a safer and less polluting fuel produced at less than half the cost of kerosene.⁶⁷



Source and photo: The two-burner model, A2 CleanCook domestic stove, Project Gaia



Source and photo: A2 CleanCook domestic stove: boiling water for tea, Kebribeyah refugee camp, Ethiopia, Gaia Project

⁶⁶Project Gaia (n.d. b)

⁶⁷Project Gaia (n.d. a)

Advantages: Biofuels are relatively cheap and more efficient than biomass fuel⁶⁸ (efficiency with ethanol: more than 60 per cent⁶⁹). Tests of the CleanCook in laboratory settings and in a small household survey have shown an average CO/CO₂ ratio of 4 per cent at high power and 5 per cent at low power. Particle (particulate) emissions were negligible in all tests. Methane emissions have been highly variable (methane/CO₂ ratio from 0.02 per cent to 0.35 per cent).⁷⁰

Disadvantages: Biofuel stoves have an open flame, which may be hazardous; however it can be extinguished with water.

Environmental impacts: Bio-alcohol is produced from a variety of carbohydrate-rich crops including sugar cane and sugar beet. Growing and processing these plants or plant parts to make substantial volumes of bio-alcohol necessitates considerable resources including large areas of agricultural land, water and fertilizer. In an ideal scenario, these processes should be carried out in a controlled and environmentally friendly manner to ensure minimal consumption of resources and minimized outputs of emissions. Similarly, the metal used in the manufacture of the stove itself can have a negative impact on the environment when the production process – from mining of the metal to the manufacturing process – is taken into account. During this process, land is degraded to extract the raw material; additionally, the production process is energy and water intensive with associated high levels of GHG emissions.

Following distillation, the bio-alcohol has to be transported to the consumer resulting in additional consumption of resources. For this reason, it is important to select the most energy-efficient mode of transport. Similarly, the metal used in the manufacture of the stove itself can have a negative impact on the environment when the production process – from mining of the metal to the manufacturing process – is taken into account. During this process land is degraded to harvest the raw material, while large volumes of energy and water are consumed and large volumes of emissions produced. In light of this, stoves should be assembled locally in small workshops to minimize impacts. Where appropriate, recycled materials should be used in the place of new ones. Negative impacts have to be weighed up against the benefits represented by the durability and lifespan of the product, to determine their sustainable viability.⁷¹

Gender considerations: Reducing the burden of firewood collection, a task for which women and girls are widely responsible worldwide; reduced exposure to harmful gases resulting in positive effects on the health of women and children (boys and girls) who are involved in cooking. In some cases, time saved by women and girls as a result of not having to gather fuel wood can free them up to engage in other activities, including attending school or engaging in income-generating activities.

6.1.1.3. Biogas stoves⁷²

Biogas stoves work in a similar manner to LPG stoves; the main difference is that the gas used to power these stoves comes directly from a nearby biodigester. The biodigester produces biogas (mostly methane) which is transported through pipes to the actual stove. As this system uses the pressure from the fermentation chamber to force the gas from its reservoir at the biodigester to the kitchen stove, no gas cylinder is needed.

⁶⁸Barnes, D.F., et al. (1994)

⁶⁹Project Gaia, Dometic CleanCook (2010)

⁷⁰MacCarty, N. (2009)

⁷¹Project Gaia, Dometic CleanCook (2010)

⁷²Botero, R. (2011) and Botero, R. & Carazo, L. (2010)

What is biogas?

Biogas is a clean, non-polluting and low-cost fuel. It contains about 55 to 75 per cent methane, which is inflammable. Biogas can be produced from cattle dung, human waste and other organic matter by a process of anaerobic digestion in a biogas plant. Biogas is typically used for cooking and lighting.

What is a biodigester?

Biodigesters convert organic wastes into a nutrient rich liquid fertilizer and biogas. There are at least two well-known types of biodigesters:

The **dome type** consists of an inlet, outlet, dome, digester, turret, water drain pit, compost pit, pipe fittings and biogas appliances such as stove, lamp, etc. It can be built using concrete and is durable, lasting up to 20 years. The digested material, which comes out of the plant, is enriched manure which can be used as organic fertilizer.

The **“Taiwan”⁷³** or **“salchicha” type** is built from PE (polyethylene) plastic foil and is used for fermenting waste water (gray and black water). The pressure within the PE chamber is sufficient to push the gas through a steel wool filter directly through a tube system into a gas stove or to a gas light.

The **cleaned waste water** should be passed through a sand filter where bacterial activity breaks down the rest of nutrients and residues. Another alternative would be a small lagoon where the waste water gets cleared by aquatic plants like water lilies and the nutrients enrich the plant growth.⁷⁴



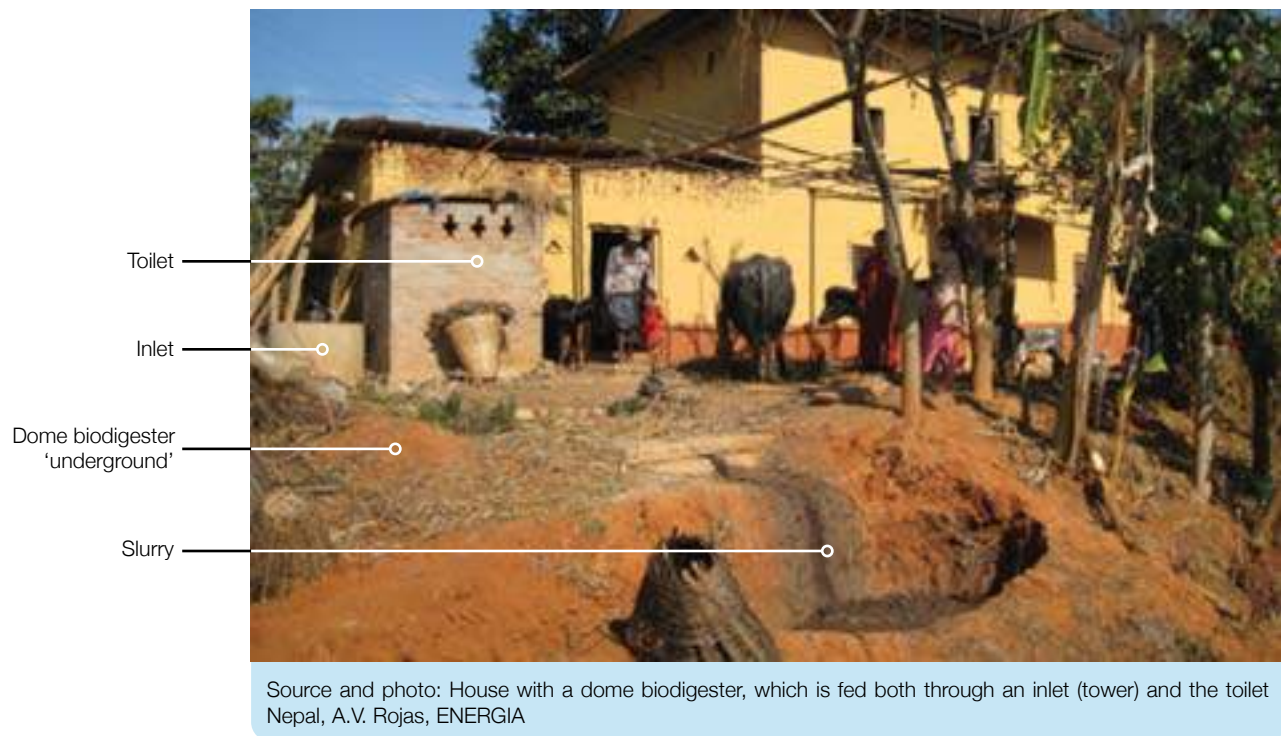
Source and photo: Biodigester “Taiwan” model, Earth University’s Community Development Programme, F. Schmitt



Source and photo: Diagram of a dome biodigester, as exemplified in a user’s manual produced by the Biogas Support Programme (B.S.P.), Nepal, A.V. Rojas, ENERGIA

⁷³Rodriguez, L. and Preston, T.R. (2004).

⁷⁴Botero, R. (2011)



Advantages: Biogas is relatively cheap and more effective than biomass fuel. No LPG cylinder is required and raw materials for production of biogas are readily available (most likely at no additional cost). The *salchicha model* is relatively low cost (around US\$300), and given the relative simplicity of its parts can be produced locally. If well maintained, the biodigester does not produce any bad odours. The system produces a very effective fertilizer at the end of the process.

Disadvantages: Biogas production is dependent on the availability of enough organic material and water year-round with an ideal proportion of one part solid to four liquid parts. The system requires constant maintenance and monitoring. If sufficient water is not readily available for feeding the biodigester, time and effort needed for fetching water may increase as a result. Biodigesters function poorly in colder climates unless an external heat source is applied.⁷⁵ For example, the *salchicha model* requires an ideal working temperature of 28 to 35 degrees Celsius (but the chamber can be insulated to guarantee optimum temperatures in order to function properly in colder climates).

Environmental impacts: This system converts the greenhouse gas methane into less harmful carbon dioxide and water during the burning process. Furthermore, biogas generation yields a by-product (slurry), which is a very effective fertilizer for crops. Nevertheless, it requires large volumes of water to dilute the manure mixture. This means that water has to be available year-round in sufficient volumes to feed the biodigester daily. Too great water consumption could harm nearby fragile ecosystems if the resource is limited during certain seasons (dry season).

⁷⁵AIDG (2011).

⁷⁶Botero, R. & Carazo, L. (2010)

⁷⁷Botero, R. & Carazo, L. (2010). Case study produced using material provided by R. Botero and L. Carazo, with their express authorization.

The nutrient-rich liquid fertilizer has to be handled carefully to avoid it spilling uncontrolled and directly into nearby water ecosystems. These ecosystems could be damaged as a result of nutrient overload which is a cause of algae-blooming and reduces the oxygen content to a level where other life forms (e.g. fish) in the river or pond cannot survive.⁷⁶

The lifespan of a biodigester varies depending on the type of construction and the materials used for the production of the burner (including PE plastic foil and PVC tubes); for example, the approximate lifespan for the 'Taiwan' model is less than 5 years; while dome types could last up to 20 years. A shorter lifespan could result in an increased consumption of the resources and energy needed to produce those same raw materials.

Gender considerations: Reduces in the burden associated with firewood collection; however, it has the potential to increase the burden associated with fetching water if this is not available in sufficient quantities to feed the biodigester. Reduced exposure to harmful gases resulting in positive impacts on the health and well-being of women and children (boys and girls) who spend most time in the cooking area. In some cases, time saved by women and girls as a result of not having to gather fuel wood can free them up to engage in other activities, including attending school or income-generating activities.

CASE STUDY: Biodigestors, an opportunity to develop rural communities in Costa Rica⁷⁷

While the price of carbon-based fuel rises from month to month, Doña Marjorie from the small-holder project in nearby Guacimo, in the Caribbean lowlands of Costa Rica, no longer needs to worry about how she can afford the US\$20 or so that she needs every few months for a new LPG-cylinder to cook her family's daily food. She and her husband Don Mario are proud owners of a small-scale biodigester. Thanks to a small investment they are now able to produce their own biogas from the waste of their livestock.

Their modified two-flame gas burning kitchen stove with an integrated oven is directly connected to the new alternative fuel source via a 15-metre long pipe system. The manure from their few cows and pigs is transformed in the digester by bacteria into mainly methane, a combustible gas, which serves as an ideal alternative to cooking fuel. "The only important step is to feed the biodigester every day with the farm animal waste," says Doña Marjorie, who fills it with a 15-gallon mixture of manure and water in order to produce enough gas in accordance with the minimum functioning and required energy needs. The biodigester, which is built from a 3m long and 1.5m wide half buried PE plastic foil tube, also offers a sustainable solution for the management of the animal waste.

Doña Marjorie appreciates the useful and rich fertilizer that the system produces when the processed liquid leaves the digester some 30 days afterwards. Her new intensive vegetable garden benefits from the nutrients and keeps the food costs low in the long term, while providing the household with a healthy diet.

⁷⁶Botero, R. & Carazo, L. (2010)

⁷⁷Botero, R. & Carazo, L. (2010). Case study produced using material provided by R. Botero and L. Carazo, with their express authorization.

CASE STUDY: Biodigestors, an opportunity to develop rural communities in Costa Rica (continued)

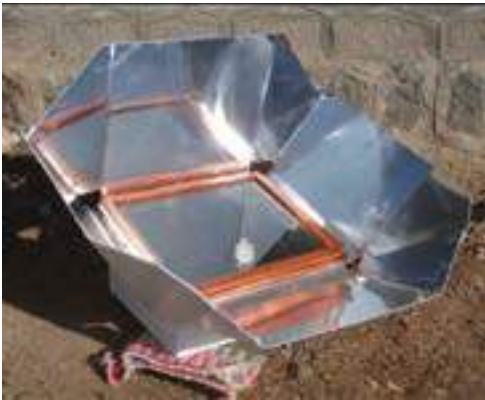
This sustainable subsistence farm project powered using affordable (less than US\$300) and low maintenance technology was the idea of agronomists from the EARTH University in nearby Guacimo. Experts Raúl Botero and Luis Carazo designed concepts intended to offer reasonably-priced solutions to local communities and small-holder farms. Within their University's PEP and Community Development Programme both agronomists supply these women and men with the much needed technical knowledge and guidance necessary to use the biodigester. This project also involves housewives as an important stakeholder group in an environmentally-friendly approach.

Now two of Doña Marjorie's female neighbours have also decided to invest in this technology and together with Raúl and Luis build their own independent small-scale biodigestors to generate a sustainable source of fuel.

6.1.1.4. Solar cookers

A **solar cooker**, or **solar oven**, is a device which concentrates sunlight for use as a heat source.⁷⁸ Solar cookers are used for outdoor cooking and are often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high.⁷⁹ This method is most practical for women and men living in a climate which is generally dry and sunny for periods of up to at least six months. Latitudes ranging from the equator to 40 degrees are ideal; nevertheless it is possible to use the solar cooker in higher latitudes.⁸⁰

Three models of solar cooker currently exist.



Source and photo: Sun scoop box oven, T. Sponheim

The **box cooker** or **box oven** is an insulated box with reflective foil and a mirror system that directs the heat of the sun directly to various pots inside. The top of the box cooker can usually be removed to allow dark pots containing food to be placed inside. One or more reflectors of shiny metal or foil-lined material may be positioned to bounce extra light into the interior of the oven chamber. The box should have insulated sides.⁸¹

⁷⁸Solar Cookers International (2004)

⁷⁹Solar Cookers International (2010c)

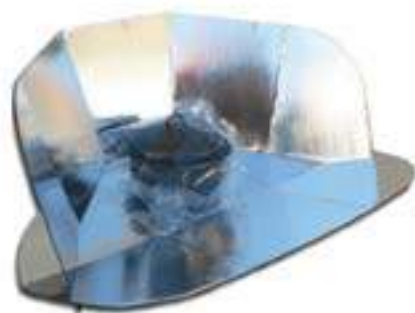
⁸⁰Solar Cookers International (2010b)

⁸¹Solar Cookers International (2010a)



Source and photo: Parabolic Solar Cooker, C. Mueller, Fundacion EcoAndina

The **parabolic solar cooker** uses curved and round mirror elements to concentrate the heat of the sun directly at its centre where a single cooking device can be installed. The reflector is mounted in such a way that it can be easily adjusted to face the sun. The adjustment should be made after every 20-30 minutes. At the bottom of the metal frame four roller wheels can be fitted to make it easy to move around. The parabolic solar cooker seems to be highly efficient; for example, on a sunny day (atmospheric temperature 24°C) two litres of water take about 15 minutes to boil. Almost every type of cooking including boiling, frying, baking can be done in this cooker.⁸²



Source and photo: CookIt Solar panel cooker, T. Sponheim

The **panel or combination cooker** combines features of both cookers described above to create a box-shaped cooker with curved elements inside that reflect maximum sunlight to heat a single cooking device in the middle of the panel. The cooking pot is covered with a heat resistant bag which traps the heat of the sun to improve the performance of the device.⁸³

Advantages: Solar cookers use no fuel, which means that their users do not need to fetch or pay for firewood, gas, electricity, or other fuels. Solar box cookers attain temperatures of up to about 165 deg. C and can be used to sterilize water or prepare most foods that can be made in a conventional oven or stove. Solar cookers do not produce any smoke.⁸⁴

Disadvantages: Solar cookers are less useful in cloudy weather and at high latitudes.⁸⁵ Also, solar cooking provides hot food during or shortly after the hottest part of the day, rather than in the evening when most people are likely to eat. Solar cookers take longer to cook food than a fuel-based oven; food preparation therefore has to start several hours before the meal.⁸⁶

Environmental impacts: Solar cookers do not rely on fuels and therefore, negative impacts on the environment such as deforestation or greenhouse gas emissions are null. Nevertheless, the lifespan of cookers could be relatively short, depending on the materials used in their manufacture (e.g. light wood or cardboard for panels, and plastic foil for the box cover). A shorter lifespan could result in an increased consumption of the resources and energy needed to produce those same raw materials. The use of durable materials could prolong the lifespan of the cooker and at the same time optimize consumption of resources.

⁸²CRT/Nepal (2011)

⁸³Solar Cookers International (2010a)

⁸⁴Knudson, B. (n.d.)

⁸⁵Solar Cookers International (2010b)

⁸⁶Solar Cookers International (2004)

Gender considerations: Reduced burden on women and girls associated with collection of firewood or other biofuels. Solar cookers have been well-received in refugee camps as they reduce the need to fetch wood; similarly, they reduce the exposure of women and girls to physical and sexual violence outside the refugee camps.

6.1.2. Water-heating solar collectors

A solar collector provides a household of four family members with enough hot water for day-long use. The solar collector is fixed to the roof and works best in regions with year-round sunshine for about 4.5 hours per day; it may also work in areas with less exposure to sunlight. The solar collector consists of a flat plate, metal tubing and an insulated water tank. The collector, which is mounted on the roof of the house for maximum exposure to sunshine, consists of a metal plate, made for example from copper, painted black to enhance absorption of solar radiation. The metal tubing which circulates water to a hot water storage tank is bonded to the collector plate and this assembly is sealed in an insulating box covered with glass to reduce heat loss while at the same time maximizing solar radiation transmission.⁸⁷



Source and photo: Solar collectors on the ground, C. Mueller, Termotanque X-Sol, Fundación EcoAndina

Depending on its construction, the solar collector can provide hot air for domestic heating. Solar collectors are becoming popular as a way to reduce electricity demand during peak times.⁸⁸

Advantages: Solar collectors are clean (they do not emit greenhouse gases) and absolutely silent. They are relatively cheap with prices ranging around the US\$300 mark. They can usually be produced locally and require little maintenance.⁸⁹

Disadvantages: Solar collectors require year-round sunshine, ideally 4.5 hours of sunlight per day.

Environmental impacts: Solar collector water heating technology using sunlight is environmentally friendly. No fuel is required for the heating process and no greenhouse gases are emitted.

Nonetheless, it is necessary to also consider all the different components used to assemble a solar collector. The different metal and glass components used for the collector itself have negative impacts on the environment when the chain of production is factored in – production of the metal or glass used in the manufacture of the collector. Extracting the raw materials produces land degradation; additionally, the production process of metal is energy and water intensive with associated high levels of GHG emissions. To maximize efficiency, the assembly and distribution of solar collectors should be carried out in local workshops.⁹⁰ Where possible, recycled materials should be used. However, these negative impacts need to be weighed up against the benefits brought by the durable and long lasting properties of the materials, to determine their sustainable viability.

⁸⁷Mueller, C. (2011a)

⁸⁸Mueller, C. (2011b)

⁸⁹Mueller, C. (2011a)

⁹⁰Mueller, C. (2011b)

Gender considerations: The burden on women and girls associated with firewood is reduced. Additionally, these systems may yield further positive impacts in terms of hygiene and health as they may allow for more regular and comfortable bathing.

Case study: Solar-powered communities in the Argentinean Andes⁹¹

Mrs. Antonia Caldera, the principal of the primary school in the local community of San Juan de Misa Rumi in the north-western Jujuy region of Argentina, is happy with the newly installed solar central heating system. “The environmental organization EcoAndina⁹² made it possible for the children to study and eat their meals at a comfortable 20 Degrees Celsius room temperature. Before, sometimes freezing temperatures distracted the students from their learning”, Mrs. Caldera explained while the kids around her enjoyed their warm surroundings.

Before the installation of the system the school wasted a lot of money on gas and firewood to fuel the heating and the kitchen. This practice, which was quite common in the community, resulted in a major environmental problem on the Puna plateau: drastic deforestation. This, coupled with a changing climate and reduced rainfall, served to profoundly damage the landscape.

In the past, the Quispe family needed 30 kg of fire wood just to bake one batch of bread in their oven. The wood, primarily a local shrub called *Toja*, burns so quickly that vast areas have been exploited. As a consequence, many families consider migration to periurban areas of the bigger cities as their only chance for survival, even if it means they live in even greater poverty.

The ten members of the Arias family decided to stay on their small farm where they keep a few lamas and continue to grow some crops. Several years ago Mr. Arias and his wife decided to install a solar water heater on their roof. At the same time, Mrs. Arias bought her own solar cooker to cook in the open patio of their farm house using solar power. “The investment of US\$420 was worth it as it has made all our lives easier and we have to pay less. The family now has the chance to use running hot water in the kitchen, wash clothes with warm water, and everybody can have a warm shower every day”, reported Mr. Arias. After selling a few of their lamas and prospecting for gold in the mountains, the Arias family now has enough money to buy a new solar water heating system for the roof and to share hot was with a neighbouring family. With the help of the solar energy expert Christoph Mueller from EcoAndina, a female neighbour has ordered and now owns a solar collector.

“The locally produced solar heaters and cookers support the small economy of the region. The company in San Salvador de Jujuy, for example, can employ 10 workers”, explains Christoph Mueller, “and the demand for this system is still high”. All members of the local communities can benefit from their installed solar systems. A meter device attached to each system measures the volume of greenhouse gas carbon dioxide that has been avoided. Carbon savings can be traded for certificates which provide all women and men in the community with an additional income. In the long run, the eight villages in the region with their 350 solar cookers, 81 warm water systems and 10 central heating systems for schools will benefit from reduced deforestation while the families will be able to stay on and maintain their land and enjoy a better quality of live.

⁹¹Schneider, J. (n.d.). Case study produced using material provided by J. Schneider (DW-TV), with his express authorization.

⁹²Fundación EcoAndina (n.d.)

6.1.3. Solar water disinfection (SODIS)

SODIS is a simple and low-cost technology for providing safe drinking water. SODIS stands for solar disinfection; it works through the synergy of UV-A radiation and the heat/temperature of the sun's rays to disinfect contaminated drinking water. The process takes about 6 hours when the water is placed in clean, unscratched transparent polyethylene plastic (PET) bottles at an angle to the sun. This exposure is sufficient provided there is less than 50 per cent cloud cover.⁹³ Ideally, the water should heat up to 50 Degrees Celsius, however, the method is also effective at lower water temperatures, as the UV-A rays kill and eliminate harmful germs like bacteria, viruses and parasites in the water in the bottle. The contaminated water must not be too turbid otherwise it must be filtered through a piece of clean cloth before being poured into the SODIS bottle. To evaluate whether the water is clear enough, the bottle should be placed on the headline of a newspaper. If the text can be read by looking straight from the neck into the bottom of the bottle, the water is clear enough to be treated in the SODIS.⁹⁴



Source and photo: SODIS examples from Bolivia (left) and Indonesia (right), SODIS Eawag

Advantages: SODIS is a cheap and easy to use technology, which helps to disinfect drinking water in very simple manner using sun light (UV-A rays) and without using any fuel to heat up the liquid. The process helps to prevent major diseases carried by untreated water.

Disadvantages: SODIS needs clean, unscratched and clear PE-bottles. The technology does not work properly under cloudy skies, or with turbid water (it needs to be filtered beforehand).

Environmental impacts: SODIS technology has no major impact on the environment, and can also make use of recycled PET bottles. However, the plastic from the bottles reveals negative environmental impacts when the production process of plastic resin (PE) derived from fossil fuels is factored in the assessment, along with the additional resources invested in transporting the bottles to the end consumer. More specifically, the raw materials for the production depend on the drilling of oil, and fossil fuel sourcing degrades the land. Furthermore, the processing is water and energy-intensive, with associated high levels of GHG emissions. Nevertheless, the assessment must weigh up the negative impacts against the benefits

⁹³SODIS (2002).

⁹⁴US AID Hygiene Improvement Project (2009)

these technologies yield, such as offering a second easy, durable and relatively long lifespan to the bottles, to determine their sustainable viability. To exercise these benefits and safeguard resources, the bottles must be integrated into a PE-plastic recycling programme after serving their ultimate use.

Gender considerations: The burden on women and girls associated with collection of firewood or other biofuels for heating water is reduced. Furthermore, this technology has positive impacts on health by providing cleaner drinking water.

6.2. Lighting

Lighting is essential to our lives. It is instrumental to our safety, allowing us to move freely within the household or outside of it. Access to proper lighting also means that evening and morning hours can be dedicated to productive and educational activities.⁹⁵

A national lighting survey of 6,000 people in rural Peru found that candles and kerosene lamps provided barely enough light to walk around the house.⁹⁶

Around 22 per cent of the global population does not have access to electricity.⁹⁷ Those without access to electricity must resort to lighting sources which are polluting, dangerous and provide low-quality light – and are more expensive than modern electric lighting. These mainly include using flaming brands, candles and kerosene wick lamps; which provide few units of luminescence, or brightness. Meanwhile, those with access to electricity can use high-efficiency light bulbs.⁹⁸

What is a lumen?

A lumen (lm) is a unit of measurement used to express how much illumination a source of light provides. A lumen equals the luminous intensity emitted by a point source located in the vertex of a solid angle and with the intensity of a candle.⁹⁹

Comparing different lighting sources¹⁰⁰

A kerosene wick lamp or candle provides 11 lm, compared to 1,300 lm from a 100W incandescent light bulb.

⁹⁵Practical Action (2010).

⁹⁶Barnes, (2010).

⁹⁷Legros et al., (2009).

⁹⁸Practical Action (2010).

⁹⁹Free translation based on Real Academia Española, (2001).

¹⁰⁰Practical Action (2010)

Gender considerations

Who makes the decision to buy the lighting technologies?
Who decides on the number of light points and the location of the lights?
Who benefits from the lighting during evening or early morning hours?
Is the workload of women and men increasing or decreasing as a result of having light in their homes?
Would it allow for additional activities? (productive/strategic)
Where is the marketing information distributed?
Who produces and distributes the lighting technologies and appliances?
Do women and girls feel safer if lighting is available? Are they able to move at night without fear of being attacked?

6.2.1. Electricity generation

Electricity is the flow of electrical power or charge. Electricity is a secondary energy source (energy carrier); that means that we can generate electricity from the conversion of other energy sources, such as wind power, water power, solar energy, biogas and biofuels.

6.2.1.1. Wind power

When air masses move, they create what we call wind, this is a powerful force of nature. Wind power can be 'harvested' or utilized to produce energy. A wind turbine is a device that converts the kinetic (moving) energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a **wind generator** or **wind charger**.¹⁰¹ If the mechanical energy is used to drive machinery, such as for grinding grain or pumping water, the device is called a windmill or a wind pump.



Source and photo: Wind turbine on pole, A.V. Rojas, ENERGIA.

Small-scale wind power is the name given to wind generation systems with the capacity to produce up to 100 kW of electrical power.¹⁰² Isolated communities, that may otherwise rely on diesel generators may use wind turbines to displace diesel fuel consumption.

A **small-scale wind turbine**¹⁰³ (0,3 KWh/d) fixed on a light tower or post can supply a household with enough electricity year round, provided that this is stored in a battery and there is enough wind. Under such conditions, a small-scale wind turbine could power some basic devices (i.e. 2-4 fluorescent lamps, a radio and a TV) for approximately 4 hours per day.

Advantages: By using a battery the system provides energy all day long. Wind technologies are relatively silent and can be fixed next to the house with short electric wires. These are robust and long-lasting systems which require relatively low maintenance.

¹⁰¹BUN-CA (2002b).

¹⁰²Idem.

¹⁰³Soluciones Prácticas (n.d.)

Disadvantages: Wind power is dependent on the availability of enough wind year round with a minimal velocity of 3 metres per second ($V= 3 \text{ m/s}$) and is relatively expensive (around US\$500 to 1,000).¹⁰⁴ The system depends on an expensive battery to store energy with a lifespan of only 3 years; the system quite often needs to be imported and may not be produced in the country.

Environmental impacts: A current publication points that most of the research on environmental impacts currently focuses on wind-parks of large dimensions rather than on a small-scale, individual use of wind turbines.¹⁰⁵ Latest results show that regardless of the scale, this technology is relatively harmless towards birds and bats.¹⁰⁶ Renowned environmental organizations suggest that environmental impacts are outweighed by clean and emission-free power generation¹⁰⁷ when the location of the system is determined in accordance with an environmental impact assessment.

However, the materials used to create the turbine, the wiring and the battery reveal their negative environmental impacts when the production chain is factored in the assessment, and associated to the mining, the production of plastic components derived from fossil fuels, the manufacturing of the turbine, wiring and battery, to the transportation and finally, to the end consumer. More specifically, land is degraded to source the raw materials; metals and fossil fuels. The processing is water and energy-intensive and, in addition, outputs high GHG emissions. Nevertheless, the assessment must weigh up the negative impacts against the benefits these technologies yield, such as easy power generation systems of a relatively-long lifespan, to determine their sustainable viability. The batteries for energy storage must be integrated into a recycling programme after serving their ultimate use, as they contain harmful materials (e.g. lead) for the environment.

Gender considerations: Better visibility during the evening or early morning hours may reduce the occurrence of accidents and make daily chores more manageable. In addition, the availability of light extends the number of productive hours, making it propitious for women to engage in additional income-generating activities and community tasks, as well as for girls and boys to study on these new available hours. Improved energy access could, however, make it necessary for family members to negotiate the use of certain appliances during particular times of day to ensure the interests and needs of all members to be served (for example, do not use the radio or TV during food preparation, when a grinder or mixer may be in use).

¹⁰⁴Oreamuno, C. (2010)

¹⁰⁵Wageningen University and Research Centre (2011)

¹⁰⁶BUN-CA (2002b)

¹⁰⁷The Royal Society for the Protection of Birds (2011)

¹⁰⁸Audubon Magazine (2006)

CASE STUDY: Bringing carbon-neutral electricity to remote villages in the Peruvian mountains¹⁰⁹

The small Andean village of El Alumbre is situated in one of the most northern regions of Peru at an altitude of 3,800m. The area is poor and the land is only suitable for potato and cattle farming; however, it holds high potential for wind energy generation. Around 65 per cent of the population of the Cajamarca Province, to which this village belongs, still depend on candles, kerosene or other fossil fuels for lighting.

Soluciones Prácticas, a Peruvian environmental aid organization, offered the women and men of the community an opportunity to produce all of their electricity on their own. Each of the 33 families was provided with a small wind generator. “So now El Alumbre is the first village in the country where the electricity is generated completely by wind turbines”, explains José Chiroque, from Soluciones Prácticas. Every house has its own individual wind turbine, which is sufficient to cover the daily consumption of 0.3 to 0.4 kWh.

Having a wind turbine has proven a great success for the Ramírez family as they have no need for their old petroleum lantern any more. Lighting is now provided by several energy-saving fluorescent light bulbs. Mrs. Ramírez benefits from the new technology and has more free time to make handcrafts, to knit or finish other household chores after sunset. A new cell phone and TV allows family members to communicate and receive information in a modern way. The cell phone transmitter was already available before, but the family was not able to charge its phone without a source of electricity.

“Life changed drastically in the community”, said Mr. Ramírez. The new electricity makes it possible for the nurses in the medical station to store vaccines in a refrigerator. Mrs. Ramírez is happy that there is now better and up-to-date education in the primary school as her children now have access to computers.

The López family had a gasoline generator to produce their energy for the household. But with a monthly income of around US\$55, it was very cost intensive to maintain. Every month they had to invest around US\$11 to 13 for gasoline, which was sufficient to generate 1 to 2 hours of electricity per day, more was not possible. Now they pay just US\$4 per month and the battery charged by the wind turbine supplies them with four hours of electricity per day. These examples show the advantages offered by the project to everybody in the community as part of efforts to overcome poverty and take important steps to mitigate climate change.

Soluciones Prácticas wanted to offer a sustainable solution in which they not only install technical appliances but also offer capacity building programmes. Young women and men from the area benefit from the training offered in a centre in the nearby the Provincial Capital of Cajamarca. “There they can learn all about the usage of wind turbines, micro-hydro power plants and solar panels. They also receive training in the maintenance of the equipment. These courses are very important for our participants. As soon as they return to their local communities every one of them can use their acquired knowledge and repair their own technical equipment”, explains the expert José Chiroque from Soluciones Prácticas. To date, more than 4,000 people in the province of Cajamarca have been supplied with green electricity produced by wind, water and solar energy.

¹⁰⁹Altenhenne, M. (n.d.). Case study produced using material provided by M. Altenhenne (DW-TV), with his express authorization.

6.2.1.2 Hydropower

Hydropower is the power of flowing water; this power can be converted into rotational mechanical power or electricity using a **hydropower energy system**. **Hydroelectric power systems** use the force of water to rotate wheels and turbines, which then power an electric generator. The size of hydroelectric power systems can vary from a few hundred watts to thousands of megawatts.¹¹⁰

The table below shows the different classifications according to the generation capacity (power output range) of hydropower energy systems.




Table 8. Hydropower classification.

Hydropower classification	Power Output Range
Pico-hydro	< 1kWe
Micro-hydro	1kWe-100 kWe
Mini-hydro	100 kWe-1MWe
Small hydro	1-10 MWe
Large hydro	> 10 MWe

Source: World Energy Assessment (2000)¹¹¹

The technology available for the functioning of pico-hydro and mini-hydro systems is **Pelton set technology**,¹¹² which can produce between 50 to 500 kW. This consists of a small vertical turbine with a generator attached to it. It generates electric power from a small quantity of water, falling from a great height; the electricity generated can be stored in a battery.

Pico hydro usually refers to smaller schemes of less than 1 kW. This technology can be imported or sometimes manufactured locally, depending on the availability and knowledge of skilled artisans.

A **micro-hydro plant** consists of civil and electro-mechanical components.¹¹³ The civil structure consists of intake, canal, de-silting basin, forebay tanks, support piers, anchor blocks and a powerhouse. Electrical components include a generator, control panel, ballast heater, transmission and distribution

¹¹⁰UNDP & IIIIEE at Lund University (2009).

¹¹¹UNDP (2000).

¹¹²Prado Ramos, G. (2006)

¹¹³CRT/Nepal (2011)

system, earthing poles, stay sets, insulators and load limiting devices. The mechanical components of a micro-hydro scheme include a penstock pipe, turbine, and valve, drive system¹¹⁴ and expansion joints. A plant that produced between 100 kW and 1,000 kW is considered a mini hydro plant.¹¹⁵

Micro and mini hydro plants are installed mainly for **rural electrification**. Usually, user households are provided limited power such as 50W, 100W, 200W. The power can also be used for various end-use applications such as saw milling, hauling, battery charging and other small cottage industrial uses.¹¹⁶

Advantages: A battery charged using this system can provide energy all day long. The system is robust and has a long lifespan (up to 40 years); it requires relatively low maintenance, and can be produced in the country.

Disadvantages: Hydropower systems are quite loud and require constant water flow from a water reservoir. The system may require a long wire system to reach the household and depends on an expensive battery to store energy which lasts for only about 3 years. Electricity will be produced for as long as there is a constant water flow; it will also produce excess energy. Special attention should be given to this excess electricity as it could overwhelm the system if not properly managed, hence regular monitoring and maintenance may be required.

CASE STUDY: Women's empowerment through the Rural Energy Development Programme (REDP), Nepal¹¹⁷

Enhancing access to energy is an extremely challenging task in Nepal where one-third of the population lives below the US\$1 per day threshold. Poverty is widespread. The situation is worse for women who fare the lowest in the human development and empowerment index. Literacy levels in the hill districts are very poor, especially for women (less than 10 per cent), who also face additional constraints including high workloads, near total absence of exposure to the outside world, isolation and poor social infrastructure.

Initiated in 1996, REDP aims to enhance rural livelihoods through the installation of micro hydro-power systems. Expansion of sustainable rural energy systems is seen as key to economic development and poverty reduction. The programme emphasizes community mobilization, bottom-up participatory planning and decentralized decision-making. Productive income-generating activities are promoted as end uses of the energy supplied, and skills training is provided to promote agricultural and home-based businesses.

The programme has implemented several measures to promote women's involvement and enhance their income levels, including:

- Women have been identified as one of the vulnerable groups, and their empowerment highlighted as one of the six basic principles of the REDP community mobilization process.

¹¹⁴A drive system transmits power from the turbine shaft to the generator shaft or to a shaft powering other devices. It also changes the rotational speed from the one shaft to another when the turbine speed differs from the required speed of the alternator or device. CRT/Nepal (2005)

¹¹⁵BUN-CA (2002c).

¹¹⁶CRT/Nepal (2011)

¹¹⁷Dutta, S. and Oparaocha, S. (2010).

CASE STUDY: Women's empowerment through the Rural Energy Development Programme (REDP), Nepal (continued)

- At the community level, REDP's operational modality requires one man and one woman from each household to participate in programme activities such as training of COs (Community Organizations) and FGs (Functional Groups)¹¹⁸, training on other matters, implementation and benefit-sharing thereby ensuring gender balance.
- In programme communities, separate male and female COs receive training; they meet on a weekly basis and are provided targeted capacity building inputs.
- The women in community organizations have a distinct voice in local affairs and their capability for independent and collective action has increased. Some of the micro hydro schemes in the remote districts in far-western Nepal (an area where women have the lowest social status) are even chaired by women.
- The programme provides loans to men and women to set up enterprises, through an Enterprise Development Fund (EDF), and from weekly savings of Community Organizations. Each household is encouraged to start at least one enterprise (energy or non-energy).
- Potential entrepreneurs, men and women, are provided information, enterprise development training and exposure visits, and are linked with city-based markets.
- With the above inputs, women's involvement in small-scale and cottage enterprises has increased. The number of such enterprises has increased from 400 in 1996 to 700 in 2005.



Source and photos: Micro Hydro Plant (left) and close up of the generator (right), A.V. Rojas, ENERGIA.

Environment impacts: Depending on the topography a canal and a dam have to be built thereby altering the natural river ecosystem. These constructions (depending on size and construction specifications) can have severe negative impacts¹¹⁹ on the original riverbed disturbing the natural water temperature as well as flow and result in low dissolved oxygen levels harmful to aquatic life. Migrating fish species are sometimes unable to cross the dam and therefore are not able to reach reproduction areas upstream. There is a good chance that the area on which the reservoirs and dams have been built was originally covered by

¹¹⁸**Community Organizations (CO)**, are organizations of people living in close proximity and willing to work together in the micro hydro project. Members include at least one male and one female member from each beneficiary household. A **Functional Group (FG)** is a higher level community organization, set up to manage the micro hydro systems and is responsible for decisions about electricity distribution, electricity tariffs, employee management, operation and maintenance of the schemes.

¹¹⁹BUN-CA (2002c) and World Commission on Dams (2000).

vegetation. After flooding, the remaining vegetation and accumulated sediments can cause the release of the greenhouse gas methane. However, small-scale hydro power systems may be able to produce emission-free energy day and night and have relatively low impacts on the environment.

The hydro-power generator including the tubes, pipes and the battery itself can have negative impacts, while the material used for the turbine, the tubes and the battery for energy storage can also have negative impacts on the environment when the chain of production – from the production of certain metals and the fossil-fuel-based plastic, to the manufacture of the generator, pipes and battery, to the transportation to the end user consumer – is factored in. Land is degraded during the mining operation to source the metals and fossil fuels for the manufacture of the plastic components. Similarly, the process is energy and water intensive with associated high levels of GHG emissions. However, these impacts must be weighed up against the benefits brought by easy, durable and relatively long-lasting (up to 50 years) power generation. The batteries used in the process must be integrated into a recycling programme after their ultimate use as they contain materials (e.g. lead) that are harmful for the environment.

Gender considerations: Better visibility during the evening or early morning hours may reduce the occurrence of accidents and make daily chores more manageable. In addition, the availability of light extends the number of productive hours, making it propitious for women to engage in additional income-generating activities and community tasks, as well as for girls and boys to study on these new available hours. Improved energy access could, however, make it necessary for family members to negotiate the use of certain appliances during particular times of day to ensure the interests and needs of all members to be served (for example, do not use the radio or TV during food preparation, when a grinder or mixer may be in use).

6.2.1.3 Photovoltaic technology (PV)



Source and photos: Miniature Artisanal Solar Panel, Solomon Islands, Oceania, C. Gras

Photovoltaic solar energy is the conversion of solar energy into electricity. This conversion is carried out using flat photo-voltaic (PV) plates commonly referred to as **solar panels**. The resulting electricity is then stored in batteries for night-time use.

Solar panels are available in different sizes, ranging from a few watts to 300 watts; they can produce DC electricity in the range of 12-60 volts, and can be used for applications such as:¹²⁰

- Charging electrical lanterns and laptop computers (4-6 watts)
- Packaged systems (20-100+ watts) for off-grid residential lighting and entertainment (radio/cassette, TV/VCR)
- Grid connected power (from hundreds of kilowatts to a megawatt or more)

A packaged system or **Solar Home System (SHS)** uses the sun as an energy source and is used to provide basic electricity services to households especially in off-grid areas.

¹²⁰UNDP & IIIIEE at Lund University (2009).

The volume electricity generated by a solar home system depends on the conversion efficiency of the solar PV panels, the intensity of the sun, cloud cover or other shading, and the number of solar PV panels installed. Similarly, the number and size of batteries installed determines how much electricity can be stored. Thus there is a relationship between the number of solar PV panels and the number of batteries in a solar home system. A whole range of conventional appliances can be operated on a solar home system (2-4 fluorescent lamps, a radio and a TV). Care should however be taken to ensure that appliances are as energy efficient as possible and that no heating appliances are used.¹²¹

The **PV or Solar Lantern** was designed for countries with limited supplies of electricity and consists of a portable electronic lantern and a portable PV panel that converts solar energy into electrical energy. The lantern consists mainly of a fluorescent lamp powered by a battery, which can be switched on and off.¹²² The lantern provides a bright beam of light and, as it is portable, can be used indoors or outdoors. Solar lanterns can either be hung from high places (ceiling, door) or carried by the handle and can be used for home or commercial lighting.

PV technologies have also been used to design **Solar Street Lamps**. The system comprises the lamp, the PV panel, charge controller, the storage battery and the lamp-pole (hollow metal or wood). Switching off the lamp is either done by an auto On/Off electronic switch or timer. When installing solar street lamps, there may not be a need to dig trenches or lay underground cables as the power will be generated by the sun (no need to connect to a grid). Costs are related to the installation and there should not be on-going costs or standing charges depending on the consumption. Solar street lamps running on **LED** (Light Emitting Diodes) lighting removes almost completely the need for changing lamps as LED lights have a long lifespan (see section on LED).

Solar street lamps are available in various sizes ranging from 6 to 45 watts and can provide from 4 to 12 hours of light depending on size of solar panels and batteries.¹²³ To give an example, 18-Watt (1,800 lumens) LED solar lamps can be used for street lighting, park and open lighting.¹²⁴ Other possible locations for LED solar street lamps include bus shelters, footpaths in parks and car parks, play areas, countryside roads, industrial buildings and harbour sides.

Advantages: PV panels are very clean (no GHG emissions) and absolutely silent in their production of electricity; they reduce dependence on fossil fuels or grid-based consumption. The battery provides safe energy all day long. This technology can be produced locally and there are examples where women have become solar technicians.

Disadvantages: PV panels are dependent on the availability of sunshine year-round with a minimum of 4.5 hours per day. In arid regions the lack of rain can cause accumulations of dust on the panel surface which would lessen the effectiveness of the device. The system depends on an expensive battery to store energy which only lasts about 3 years; the system needs maintenance and power generation may vary depending on the cleanliness of the panels. Prices of the technologies vary, and in some cases it may be difficult for poor families and communities to purchase a particular PV system if these need to be imported.

Environmental impacts: PV panel power systems use sunlight to produce emission-free energy throughout the day, and for such reason, the impacts on the environment are relatively low.

¹²¹CRT/Nepal (2011)

¹²²Sunlabob (2007).

¹²³Khemani, H. (2009).

¹²⁴Essandoh-Yeddu and Mensah-Kutin, R. (2011).

However, PV panel power systems reveal their negative environmental impacts¹²⁵ when the production chain is factored in the assessment, and associated to the mining, the production of plastic components derived from fossil fuels and other raw materials, the manufacturing of the panels, wiring and battery, to the transportation and finally, to the end consumer. More specifically, land is degraded to source the raw materials; metals, minerals, rare earths and fossil fuels. The processing is water and energy-intensive and, in addition, outputs GHG emissions. Nevertheless, the assessment must weigh up the negative impacts against the benefits these technologies yield, such as easy power generation systems of a relatively-long lifespan, to determine their sustainable viability. The batteries for solar energy storage must be integrated into a recycling programme after serving their ultimate use, as they contain harmful materials (e.g. lead) for the environment.

Gender considerations: Better visibility during the evening or early morning hours may reduce the occurrence of accidents and make daily chores more manageable. In addition, the availability of light extends the number of productive hours, making it propitious for women to engage in additional income-generating activities and community tasks, as well as for girls and boys to study on these new available hours. Improved energy access could, however, make it necessary for family members to negotiate the use of certain appliances during particular times of day to ensure the interests and needs of all members to be served (for example, do not use the radio or TV during food preparation, when a grinder or mixer may be in use).

6.2.1.4 Bio fuels

Biofuels are liquid fuels produced from plant products, including pure plant oil, biodiesel and bioalcohol.¹²⁶

Bioalcohol is produced by fermentation of sugars and starches from edible agricultural feedstock rich in carbohydrates, such as sugar cane, sugar beet, grain, wheat, molasses, and potato or fruit waste. Currently, it is even being developed by fermentation of cellulose from non-edible sources such as trees, wood, straw and grasses.¹²⁷ The carbohydrate-rich crop mass is transformed primarily into **bioethanol**¹²⁸ (the most common biofuel worldwide), but also into **biopropanol** and **biobutanol**. Bioalcohol can power a generator to produce electricity, or feed a biofuel stove for cooking purposes.

Biodiesel is produced by transesterification¹²⁹ of vegetable oils or animal fats; and more specifically, from sources such as jatropha, sunflower, soy bean, corn, peanut, cotton, palm oil, rapeseed, mustard, hemp and algae. It is also processed from tallow, fish oil, and recycled cooking oils, feedstock not available in the necessary quantities to supply for energy services, though.¹³⁰ Oil rich seeds from the *Jatropha*¹³¹ plant are harvested and pressed to release their oil, which is then transesterified and refined. Biodiesel can power a generator to produce electricity.

¹²⁵ BUN-CA (2002d).

¹²⁶ Karlsson, G and Banda, K (2009).

¹²⁷ IEA (2007).

¹²⁸ Karlsson, G and Banda, K (2009).

¹²⁹ Transesterification is a chemical process that turns vegetable oil or animal fat into biodiesel by means of an alcohol (often methanol or ethanol) and a catalyst (often potassium or sodium hydroxide). The products of this reaction are crude biodiesel and crude glycerine, with an excess alcohol. The process is followed by distillation. Bates, L. (2007).

¹³⁰ IEA (2007).

¹³¹ Karlsson, G. And Banda, K. (2009).



Source and photos: Palm extraction in Rio Grande de Buba, Guinea-Bissau, P. Tous

Plant oils can perform as a cooking fuel; however, to date there has not been sufficient independent testing on their use for biofuel stoves, and although on the recommendation of the Global Alliance of Clean Cookstoves,¹³² the US EPA completed testing, the results are not yet available.

Advantages: Biofuels can be used to replace diesel or petrol in generators with non-polluting vegetable oil. Biofuels can be produced locally where the seeds are available and grown on a small scale. This industry may improve livelihoods and support local activities (such as mechanization of agriculture).

Disadvantages: Power and electricity generation systems can be noisy. Furthermore, good planning is indispensable, as the growing and harvesting periods of crops that will build up the masses of carbohydrate feedstock as well as those of oil-rich seeds or other oil-rich plant parts of fatty feedstock can stretch from several weeks to months. When energy production fosters large monoculture plantations, deforestation may worsen. Similarly, when biofuel crops replace edible crops, food security might be threatened. The power generating and electricity generating systems can be noisy; furthermore, good planning is required as the growing period of the plant mass/oil rich seeds between harvests can stretch from several weeks to months, so good planning is required. If grown as energy crops (large monoculture plantations), these crops run the risk of increasing deforestation. Similarly, substituting production of food crops for biofuel crops can threaten long-term food security.

Environmental impacts: The main environmental advantage of bio-fuels is that they replace conventional diesel and petrol used in small-scale electricity generators with vegetable oils or bio-alcohol; clean fuels that reduce air pollution and emissions. However, they may also have negative impacts on the environment.¹³³ Bio-fuels are made from oil-rich seeds or other oil-rich plant parts (e.g. canola or sunflower), and bio-alcohol from carbohydrate-rich crops (e.g. sugar cane or sugar beet). The growth and processing of these plants or plant parts to obtain vegetable oils or bio-alcohol rely on considerable resources; mainly on vast agricultural lands, and an intensive use of large volumes of water and fertilizer. In an ideal scenario of minimal impact, these processes should be controlled and environmentally friendly to reduce consumption of resources and output of GHG emissions as possible. Additional resources are invested in transporting vegetable oils and bio-alcohol to the end consumer. In light of this and for ensuring the lowest environmental impacts, it is important to select the most efficient mode of transport.

Gender considerations: Biofuels have gender implications on social, cultural and energy matters. Replacing traditional fuels with biofuels can reduce drudgery -mainly of women and girls- associated to fuel wood collection. Furthermore, traditionally and to support themselves, women use and sell non-timber-forest products; such as the collection and trading of oil-rich seeds from the zone. Harvesting these seeds for the production of biofuels could offer women an additional source of income. Moreover, the creation of associations (cooperatives, self-help groups, among others) for a biofuel industry carry further earning

¹³²Global Alliance for Clean Cookstoves,(n.d.)

¹³³UNESCO (2009).

opportunities and add value to the resources these women profit from. However, there may be problems of land tenure if the oil-rich seed plants are grown on privately owned land: in some cultures women are denied the right to inherit property, which restraints their access and control of the seeds on those plots of land.

6.2.2. Biogas lamps

It is possible to generate light using the biogas generated from a biodigester. This is achieved by connecting a **biogas lamp** to the already existing gas tubing system which supplies the kitchen gas stove in the household. Gas lamps function in the same way as those powered by LPG; they contain a gas mantle which is used to light the biogas within the lamp.¹³⁴

Biogas lamps are not very energy-efficient and as a consequence they may become very hot. If they hang directly below the roof they may be a fire hazard.

The maximum luminosity of biogas lamps is comparable to that of a normal 25-75 W light bulb. Their luminous efficiency ranges from 1.2 to 2 lm/W. By comparison, the overall efficiency of a light bulb is 3-5 lm/W, while that of a fluorescent lamp ranges from 10 to 15 lm/W. One lamp consumes about 120-150 litres of biogas per day.

The bright light of a biogas lamp is the result of incandescence, i.e. the intense heat-induced luminosity of special metals, so-called 'rare earth' metals like thorium, cerium, lanthanum, etc. at temperatures of 1,000-2,000 C.¹³⁵



Source and photo: Biogas lamp, Biogas RUMAH (BIRU)

Advantages: Biogas can replace fossil fuels or LPG to provide lighting; it relies on an existing (and autonomous) biodigester.

Disadvantages: Biogas lamps may have an open flame and require an existing biodigester. The mantles do not last long. It is important that the gas and air in biogas lamps are thoroughly mixed before they reach the gas mantle, and that the air space around the mantle is adequately warm. Finally, the location of the lamp should be chosen with care to avoid fire hazards.

Environmental impacts: With the exception of the construction or installation of the biodigester, biogas lamps do not have a big impact on the environment. The system converts very active methane gas into less harmful carbon dioxide and water during the burning process. The by-product of biogas production is a very effective crop fertilizer.

¹³⁴Botero, R. (2010a) and Botero, R. (2010b)

¹³⁵ISAT and GTZ, (n.d.)

However, the process requires large volumes of water to dilute the manure mixture. This requires year-round availability of sufficient volumes of water to feed the biodigester daily. Excessive water consumption could result in harm to nearby fragile ecosystems if the resource is limited during a particular season (dry season). The nutrient-rich liquid fertilizer has to be handled carefully to avoid direct and uncontrolled discharge into nearby water ecosystems. These ecosystems could be further damaged as a result of nutrient overload which can cause algae-blooming and reduce the volume of oxygen available to levels where other life forms (e.g. fish) in the river or pond are unable to survive.¹³⁶ Depending on the material used to build the lamps (e.g. PE plastic foil and PVC tubes) and the method of construction, the biodigester may have a relatively short lifespan. This short lifespan (the “Taiwan” model has an approximate lifespan of less than 5 years) would result in increased consumption of the resources and energy needed to produce them.

Gender considerations: The utilisation of biogas for lighting should not be to the detriment of cooking efficiency due to a simultaneous use. On the contrary, supplying lighting as a complementary energy service to cooking may optimize the use of this fuel, and even carry further benefits as it may reduce drudgery for women. Better visibility during the evening or early morning hours reduces the occurrence of accidents and makes daily chores more manageable. In addition, the availability of light extends the number of productive hours, making it propitious for women to engage in additional income-generating activities and community tasks, as well as for girls and boys to study on these new available hours.

6.2.3. Efficient lighting systems using fluorescent lamps or LED lamps

Although not an RET, efficiency plays an important role in lighting systems. Modern electric light bulbs (fluorescent lamps or LED lamps) are highly efficient and result in maximum energy savings. Wise use of lighting, such as switching off lights when they are not in use, also helps to reduce electricity consumption. Similarly, fitting lights with timers and motion sensors so that they are only switched on when needed, helps ensure that no energy is wasted. Therefore, it is recommended to use these lamps as well as energy saving practices and devices to increase the efficiency of RETs.¹³⁷

The traditional light bulb is also known as an **incandescent light bulb, incandescent lamp** or **incandescent light globe**. Incandescent light bulbs work by heating a metal filament wire to a high temperature until it glows, producing light.¹³⁸ Incandescent light bulbs are cheap to manufacture and work equally well on either alternating current or direct current. As a result, they are widely used for household and commercial lighting. However, incandescent light bulbs are being replaced by more efficient lights, including fluorescent lamps, compact fluorescent lamps and LEDs.¹³⁹

A **fluorescent lamp** or **fluorescent tube** is a gas-discharge lamp that uses electricity to stimulate mercury vapour. The mercury atoms produce short-wave ultraviolet light that causes a phosphor to fluoresce, producing light.¹⁴⁰ A fluorescent lamp converts electrical power into useful light more efficiently than an incandescent lamp. Lower energy costs typically offset the higher initial cost of the lamp. The lamp fixture is more costly because it requires a ballast to regulate the current through the lamp.

¹³⁶ Botero, R. (2010a), and Botero, R. (2010b)

¹³⁷U.S. Department of Energy (n.d.).

¹³⁸Kulshreshta, D.C. (2009).

¹³⁹Rahim, S. (2010).

¹⁴⁰Kulshreshta, D.C. (2009).



Source and photo: C. Delbert

Compact fluorescent lamps (CFLs) are small-size fluorescent lamps. Many produce a warm white light that is indistinguishable from incandescent bulbs. Some can be screwed into incandescent lamp sockets. They have a long life with the added convenience that frequent replacement is not necessary. The CFLs consume only a quarter or even less electricity to produce the same amount of light as incandescent light bulbs. CFLs can produce light outputs equivalent to the standard incandescent bulbs (i.e. 40, 60, 75 and 100 Watts). CFLs use more exotic materials than ordinary fluorescent tubes and cost considerably more.¹⁴¹



Source and photo: LEDs, F.M. Schmitt, IUCN

Light emitting diodes, commonly called LEDs, do dozens of different jobs and are found in all kinds of devices. For example, they form numbers on digital clocks or transmit information from remote controls. Collected together, they can form images on a television screen or illuminate a traffic light.¹⁴² Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material; the lifespan of an LED surpasses the short life of an incandescent bulb by thousands of hours.¹⁴³

An LED produces light when electrons move around within its semiconductor structure.¹⁴⁴

LED is long-lasting: its lifespan can range from 25,000 to 100,000 hours depending on temperature.¹⁴⁵

Although LEDs have been around as a technology for many years, the use of LED for home lighting has not really taken off. The problem is that while LED emits a lot of light, the structure of an LED causes some of that light to get trapped inside. Therefore an LED bulb has traditionally been dimmer than an incandescent bulb and has not been well received as most people want their lamps and ceiling fixtures to be bright. Recently, this problem has been addressed and it is now possible to find LED replacement bulbs that emit light equivalent to a 60-watt incandescent light bulb, which makes them a viable technology for basic lighting needs at home.

¹⁴¹ Essandoh-Yeddu and Mensah-Kutin, R. (2011).

¹⁴² Shubert, F. (2006).

¹⁴³ Taub, E. (2010).

¹⁴⁴ Houghton Mifflin Company. (2005).

¹⁴⁵ Rosenthal, E. and Barringer, F. (2009) and Levy, A. (2009).

Why are fluorescent lamps and LEDs more efficient than incandescent light bulbs?

Fluorescent lamps have a power efficiency of between 20 to 30 per cent whereas LED lamps have an efficiency level of 50 per cent. In comparison, a common conventional incandescent light bulb produces heat with 95 per cent of the consumed energy and uses just 5 per cent to light up its surroundings.

Advantages: CFLs, fluorescent lights and LEDs are more efficient than incandescent light bulbs and have a longer lifespan. LEDs are more shock resistant and last even longer than fluorescent lamps.

Disadvantages: Fluorescent lamps contain toxic mercury and need to be properly disposed of or recycled. LEDs should also be properly disposed of or recycled.

Environmental impacts: Fluorescent lamps and LED systems have a low impact on the environment as they last a long time and are highly effective, with one LED or fluorescent lamp replacing up to 15 conventional incandescent light bulbs during their lifetime.¹⁴⁶

Nevertheless fluorescent lamps contain small quantities of the toxic chemical mercury, while LEDs can contain small amounts of toxic lead and arsenic. At the end of their useful life, both should be recycled to save resources. CFLs and LEDs themselves carry some negative impacts,¹⁴⁷ while the materials used in the manufacture of CFLs and LEDs also have negative environmental impacts when the chain of production is taken into account – from mining for the metals, to production of fossil fuel-based plastics used in the CFLs and LEDs, to their transportation to the end consumer. Throughout these processes land is degraded to obtain the raw materials including metals, rare earths and the fossil fuels used in the plastic components. Similarly, the process is energy and water intensive with associated high levels of GHG emissions. However, these negative impacts need to be weighed up against the benefits the products bring including their long lifespan and as a long-lasting source of light, to determine their sustainable viability.

Gender considerations: Purchasing power and decisions about investment in efficient lighting may not come under the responsibility of the same person. It may be necessary to engage in an awareness-raising exercise among women and men so that they fully understand and are able to agree to the trade-off between a high initial investment and future savings in electricity consumption as a result of the replacement of incandescent light bulbs.

6.3. Domestic heating

Mortality rates rise progressively when outdoor air temperatures fall outside the range of 20-25C.¹⁴⁸ Where ambient temperatures fall significantly below this, households, schools and work premises must be heated to prevent hypothermia, particularly among the elderly or infirm whose mobility may be restricted.¹⁴⁹

Regardless of the heating technology used, ideally the exchange of fresh and cold air within a room should always be kept to a minimum during the day by limiting the number of times windows and doors are opened and the amount of time they remain open. Continual opening and closing of doors reduces the efficiency of heating systems.¹⁵⁰

¹⁴⁶European Commission (n.d.)

¹⁴⁷Energy Star (2010) and Lim, S.R. et al (2011).

¹⁴⁸Wu et al. (2004).

¹⁴⁹Practical Action (2010).

¹⁵⁰Idem.

Gender considerations

Are these technologies known to women and men?
Who has the decision-making power to purchase them?
Who would benefit from the usage of these technologies?
Who produces and distributes domestic heating technologies?

6.3.1. Solar collector for heating

Solar collectors offer an effective solution for domestic heating. The solar collector is installed on the roof of the house; it heats up cold air coming through a pipe system or from a bigger duct from the room above. This warm air is then conducted through the pipe system back into the rooms using a small electric blower system. This constantly circulating warm air heats up the house quite effectively.¹⁵¹

Advantages: This system is very clean and absolutely silent. It can be produced locally and requires little maintenance.

Disadvantages: The system requires year-round sunshine of about 4.5 hours per day or more.

Environmental impacts: Solar collector technologies implemented for domestic heating are environmentally friendly. However, solar collector technologies reveal their negative environmental impacts when the production chain is factored in the assessment, and associated to the mining, the production of plastic components derived from fossil fuels and other raw materials, the manufacturing of the solar collectors, to the transportation and finally, to the end consumer. More specifically, land is degraded to source the raw materials; metals, minerals and fossil fuels. The processing is water and energy-intensive and, in addition, outputs GHG emissions. Whenever possible, and in order to minimize impacts, solar collectors should be assembled in local workshops and use recycled materials instead of pristine ones. The small electric fan that distributes the air should be powered by a PV system. Nevertheless, the assessment must weigh up the negative impacts against the benefits these technologies yield, such as the long lifespan of the materials, to determine their sustainable viability.

Gender considerations: By reducing the need to collect traditional firewood for heating, solar collectors can contribute towards reducing the burden on women. In addition, they may result in positive impacts on the health and well-being of family members, especially women and children, by reducing indoor air pollution and creating a comfortable indoor temperature.



Source and photo: Solar Collector for heating, C. Mueller, Fundación EcoAndina

¹⁵¹Mueller, C. (2011b)

6.3.2. Power and heat coupled systems for heating

Where an electricity generator powered by biogas or biofuels (for example plant oil) is already in operation, this can be used to generate heat for domestic heating. The heat generated by the device can be conducted through an insulated water filled tube system into a nearby home where it can serve as a heating system. Within the house, warm water pipes from the generator carry the warm water around the bottom of the walls which warms the air in the rooms; the cold water is transported back to the generator where it is warmed up again.

Advantages: The system is relatively cheap as the energy system serves a double purpose.

Disadvantages: The system requires a pre-existing electricity generator powered by biogas or biofuels.

Environmental impacts – biogas: With the exception of the construction or installation of the biodigester there is no significant impact on the environment. The system converts methane gas into less harmful carbon dioxide and water during the burning process. A very effective crop fertilizer is also produced as a by-product of biogas production. However, large volumes of water are required to dilute the manure mixture. This system therefore requires year-round availability of sufficient quantities of water to feed the biodigester daily. Excessive consumption of water could harm nearby fragile ecosystems if the resource is limited during certain seasons (dry season).

The nutrient rich liquid fertilizer must be handled carefully to avoid uncontrolled discharge into nearby water ecosystems. These ecosystems could sustain further damage as a result of nutrient overload which leads to algae-blooming and reduces the available oxygen to levels where other life forms (e.g. fish) in the river or pond are unable to survive.¹⁵² Depending on the materials used in its manufacture (e.g. PE plastic foil and PVC tubes), the biodigester may have a relatively short lifespan. This short lifespan (the “Taiwan” model has an approximate life expectancy of less than 5 years) could result in increased consumption of the resources and energy required to produce these materials.

Environmental impacts – bio fuel: The major advantage of biofuels is to reduce air pollution and emissions by replacing the petrol or diesel required to power small-scale electricity generators with cleaner biodiesel, vegetable oils or bio-alcohol. However, they can also have negative impacts on the environment.¹⁵³ Biodiesel is made either from vegetable oils (e.g. canola or sunflower seeds) or animal fats, while bio-alcohol is produced from carbohydrate-rich agricultural feedstock (e.g. sugar cane or sugar beets). Large-scale production and subsequent processing of these plants or plant parts into vegetable oils or bio-alcohol require considerable resources including large areas of agricultural land, and large volumes of water and fertilizer. To minimize these negative environmental impacts, these processes should be carried out in a controlled and environmentally friendly manner to reduce resource consumption and minimize emissions. The vegetable oil and bio-alcohol have to be transported to the end consumer resulting in additional consumption of resources. Care should therefore be taken to select the most efficient means of transport to reduce these impacts.

¹⁵²Botero, R. (2010a) and Botero, R. (2010b)

¹⁵³UNESCO (2009)

Gender considerations: Reducing the reliance on traditional biomass for domestic heating could reduce the burden on women associated with gathering firewood. In addition, it may have a positive impact on the health and well-being of all family members, especially women and children, by reducing indoor air pollution and creating a comfortable indoor temperature.

6.3.3. Improved stoves for traditional biomass fuels

Domestic heating is an important function of household stoves and heating appliances, particularly at higher altitudes. Because a single stove often serves for both cooking and providing heat, domestic heating is a consideration among people purchasing stoves. However, depending on customs and traditions, people may use a separate stove to heat their homes, particularly if heating is not needed all of the time.¹⁵⁴

An optimized stove that uses traditional biomass fuels such as wood, dung, charcoal and agricultural wastes could also be used to warm up the kitchen in a domestic household during the cold season. The **Improved Metallic Stove (IMS)** is an example of a device which is specially designed for domestic heating and cooking for people living in high altitude regions in Nepal. The IMS is also specially designed to protect people's health from the effects of smoke as it extracts the smoke from the room through a chimney. It has three pot holes of different sizes to allow cooking of rice, lentils and vegetable dishes, while at the same time providing hot water continuously from a small attached tank for washing purposes. There is also a bread roasting slit for baking roti/bread directly on the exposed flame/fire inside the combustion chamber. This stove has a double bottom, which is insulated with mud underneath, and a firebox, from where the flames of the fire directly hit the pots. Draughts can be regulated through an adjustable vent in the main door and a damper in the chimney.¹⁵⁵

Advantages: Improved stoves are relatively cheap and easy to build using locally sourced materials; biomass stores energy without the need for a battery.

Disadvantages: The efficiency of IMSs may not always be high and some still have open flames.

Environmental impacts: The use of improved stoves (ISs) and biomass fuel/fuelwood needs to be considered in relation to their impacts on the environment.¹⁵⁶ In the need of sufficient biomass fuels, such as fuel wood, animal manure or rice husks, firewood is, most often, the preferred choice. Yet, demand for firewood may exceed the supply of sustainably grown fuel wood around villages or cities. However, demand most likely exceeds supply of sustainably grown fuel wood around villages or cities. Overexploitation and uncontrolled harvest of fuel wood (including roots, young trees and shrubs) in already damaged and unsustainably managed ecosystems can result in massive deforestation, followed by land degradation and erosion. A more effective approach would be the controlled use and distribution of fuel wood harvested in a sustainably maintained forest ecosystem according to a management plan that integrates a multi-stakeholder approach.

There is evidence to suggest that improved stoves save thousands of tons of fuel wood. Where large quantities of wood are used in urban areas or locally deforested rural areas, controlled use could be significant in reducing deforestation. More importantly, women in their role as forest managers and tree

¹⁵⁴Practical Action (2010).

¹⁵⁵CRT/Nepal (2011).

¹⁵⁶Staton, D. and Harding, M. (n.d.)

planters do contribute to reforestation.¹⁵⁷ The use of more efficient household cooking fuels has been estimated to contribute to greenhouse gas reductions, though compared with total volumes this is not significant.

Gender considerations: Cleaner indoor air has a positive impact on the health and well-being of family members, especially women and children, by reducing indoor air pollution; additionally, by creating a more comfortable environment the incidence of other illnesses may also be reduced. The burden on women and girls is reduced through reduced cooking time and reduced demand for biomass for cooking and heating.

6.4. Cooling

Cooling is necessary for the preservation of food and medicines and for keeping spaces at habitable temperatures in hot countries. It can save lives by offering refrigeration for vaccines and preserving perishable food items; a source of income, offering improved livelihood activities or enabling new earning opportunities; and a source of comfort in hot climates.¹⁵⁸

Cooling is often the preferred method for preserving meat, fish, dairy and fruit and vegetables since the produce is not significantly changed by the process. Without preservation facilities and the ability to lengthen the time that produce remains fit for consumption, it is a challenge for poor families to vary food production and their diets.¹⁵⁹

Moreover, health care infrastructure relies on refrigeration for blood, vaccines and medicines.¹⁶⁰ Poor people in many rural areas simply do not have access to the basic health supplies required for maternal care, and for preventing and treating sickness, disease and HIV/AIDS, as vaccines and medicines must be kept refrigerated to retain their potency.¹⁶¹

Gender considerations

- Who has the decision-making power to purchase these technologies?
- Who would benefit from the use of these technologies?
- Who produces and distributes cooling technologies?
- What impact do these cooling technologies have on women and men?

¹⁵⁷Dutta, S., et al (2005).

¹⁵⁸Practical Action (2010).

¹⁵⁹Idem.

¹⁶⁰Modi, V. et al. (2005)

¹⁶¹Practical Action (2010).

6.4.1. Solar powered refrigerator

The solar powered refrigerator operates with electricity generated from a solar photovoltaic panel. It usually has thicker walls than regular refrigerators and uses highly efficient motors. It can be used for many applications, including the storage of perishable foods or for preservation of vaccines in locations where there is no grid supply.¹⁶²

The biggest design challenge is the intermittency of sunshine (only several hours per day) and the unreliability on the sun (sometimes it may be cloudy for days). Either batteries (electric refrigerators) or phase-change material are added to provide constant refrigeration.¹⁶³

Advantages: Solar refrigerators can preserve and maintain food and medicine.

Disadvantages: Freezer and refrigerator systems need a freezing chemical that can be harmful for the environment.

Environmental impacts: Freezer and refrigerator systems need a freezing chemical that, depending on the technology, can be more or less harmful for the environment. PV panel power systems use sunlight to produce emission-free energy throughout the day, and for such reason, the impacts on the environment are relatively low.

However, solar collector technologies reveal their negative environmental impacts when the production chain is factored in the assessment, and associated to the mining, the production of plastic components derived from fossil fuels and other raw materials, the manufacturing of the solar collectors, to the transportation and finally, to the end consumer. More specifically, land is degraded to source the raw materials; metals, minerals and fossil fuels. The processing is water and energy-intensive and, in addition, outputs GHG emissions. Whenever possible, and in order to minimize impacts, solar collectors should be assembled in local workshops and use recycled materials instead of pristine ones. The small electric fan that distributes the air should be powered by a PV system. Nevertheless, the assessment must weigh up the negative impacts against the benefits these technologies yield, such as the long lifespan of the materials, to determine their sustainable viability.

Refrigeration and the environment

Conventional refrigeration technologies raise significant environmental concerns in terms of their contribution to ozone layer depletion and global warming. Refrigerators which contain ozone depleting and global warming substances such as chlorofluorocarbons (CFCs) in their insulation foam or their refrigerant cycle are the most harmful. After CFCs were banned in the 1980s they were replaced with substances such as hydro-chlorofluorocarbons (HCFCs; commonly known as Freon), which are ozone depleting substances¹⁶⁴ and hydro-fluorocarbons (HFCs).

If a conventional refrigerator is inefficient or used inefficiently, it will also contribute more to global warming than a highly efficient refrigerator. The use of solar energy to power refrigeration strives to minimize the negative impacts refrigerators have on the environment.

¹⁶²Essandoh-Yeddu and Mensah-Kutin, R. (2011).

¹⁶³UNEP (2005).

¹⁶⁴World Bank Group. (1998).

Gender considerations: Solar powered refrigerators offer women in remote communities the opportunity to preserve food efficiently and for longer periods. They also allow them to stock and sell cold foods or drinks, thereby generating an income. In addition, they allow health centres in rural and non-grid communities to preserve the vaccines and drugs necessary for child and maternal health.

6.4.2. Efficient electrical appliances – electric ventilation and refrigerators

Traditional appliances, such as electric fans, ventilators or air conditioners can be helpful to cool air to more comfortable temperatures. In larger areas, portable electric or separately installed air conditioning can be used. When purchasing these appliances, it is recommended to search for the most efficient models available. Lower electricity consumption may be a good trade-off against a potential higher initial investment.

It is possible to adopt a similar approach when buying a refrigerator. If available, investing in an efficient model may be more cost-effective in the long run.

Advantages: Cooling appliances can make life more pleasant in high temperatures while refrigerators help preserve perishable foods as well as medicines.

Disadvantages: Cooling appliances need electricity; in addition, air conditioning systems and refrigerators need a freezing chemical that can be harmful for the environment.

Environmental impacts: Freezer and refrigerator systems need a freezing chemical that, depending on the available technology, may be more or less harmful for the environment. Electrical appliances reveal their negative environmental impacts when the production and disposal chain is factored in the assessment, and associated to the mining, the production of plastic components derived from fossil fuels and other raw materials, the manufacturing of the solar appliances, to the transportation and finally, to the end consumer. More specifically, land is degraded to source the raw materials; metals, minerals and fossil fuels. The processing is water and energy-intensive and, in addition, outputs GHG emissions.

Gender considerations: The ability to live and work in clement temperatures may yield positive impacts for the health and well-being of all family members; in turn this may reduce the workload of women, as traditionally they are usually responsible for tending to sick family members.

6.5. Earning a living

Access to energy provides several livelihoods opportunities:¹⁶⁵

- Creation of new earning opportunities – certain activities, such as selling cold drinks and ice cream, welding and machine operating are only possible when modern energy services are available.

¹⁶⁵Practical Action (2011).

- Improvement of existing activities – modern energy services can improve the efficiency or productivity – and thus profitability – of some activities. Examples include lighting that enables shops to stay open later, irrigation that improves agricultural yields, or milling that adds value to grains.
- Reduction of opportunity costs – for many people, particularly women, energy-intensive tasks such as collecting firewood and cleaning soot-blackened pots can take hours out of each day. Access to modern energy solutions allows these tasks to be done more quickly, and thus frees up time and physical energy for other activities, including income-generating ones.

What can better energy access do for women?¹⁶⁶

Better energy access could directly enhance women's income-earning activities. We know from anecdotal evidence that women use biomass energy in their micro-enterprises, especially food processing, and use electricity to extend the working day for home industries and agriculture. Donor-supported projects have shown how 'energy enterprises' that manufacture or sell energy equipment, such as cooking stoves, or produce energy for sale, such as the multi-purpose platforms, can be successfully owned and operated by women. But mostly, women's energy enterprises have operated at small scale and their sustainability under market conditions is not clear.

It is necessary to highlight that women have an important role to play as energy entrepreneurs. In this sense, the design, construction, maintenance and distribution of renewable energy technologies offers an important job creation opportunity for women and men. This is an aspect which tends to be insufficiently addressed, as technical jobs are traditionally considered to be men's work.

Additionally, it is necessary to recall that poor women tend to work in cottage industries or in the informal sectors of the economy. Therefore, investments in technologies which reduce opportunity costs are key to supporting their income generation efforts and should be addressed at the policy level.

Gender considerations

Which economic activities can be powered by available renewable energy technologies?
 Who could engage in the design, distribution and commercialization of these technologies?
 Which economic activities could become more efficient through reliance on renewable energy technologies?

NOTE TO READER: This section builds on technologies previously explained or addressed in the above sections. They do not refer to the advantages/disadvantages/environmental impacts or gender considerations *per se*.

¹⁶⁶Dutta, S., et al (2005).

6.5.1. Creation of new earning opportunities

Renewable energy technologies may provide the opportunity for women and men to engage in new economic activities. The range of possibilities is limitless: a keen entrepreneurial mind is all that may be needed to identify them. The following section highlights the role that women could play as key energy managers and entrepreneurs in the implementation of these new earning opportunities.

6.5.1.1. Women as energy providers

Solar battery chargers

The solar battery charging centre concept is a modified form of the stand-alone solar PV system that provides battery charging services in remote or off-grid areas. It has a larger and more robust series of controllers and charging points capable of handling two or more batteries at a time. The batteries to be recharged are fixed to the charging units; it may take about a day to charge a typical car battery on a sunny day (i.e. 5-6 hours). On a cloudy day it may take two-to-three days.¹⁶⁷

Given the characteristics of this technology, it would be possible for an organized group of women to manage a solar battery charging centre, and at the same time provide basic maintenance and repair services. These centres could be located close to the homes of the women who could alternate their work in the centres with their household chores.

Multifunctional platforms

The Multifunctional Platform (MFP) is a concept developed by UNDP and deployed in a number of West African countries, as well as in Tanzania and Zambia. The MFP consists of a small diesel engine mounted on a chassis, to which a variety of end-use equipment can be attached, including grinding mills, battery chargers, vegetable or nut presses, welding machines, etc. It can also support a mini-grid for lighting and electric pumps for a small water distribution network or irrigation system.¹⁶⁸ The logic behind this system seems to be catching on in other regions of the world such as in Char Montaz, in Bangladesh, where women's cooperatives are also exploring the use of MFPs.¹⁶⁹

The primary impact of the MFP has been on women's work, where it has reduced many of their daily burdens and opened up new livelihoods opportunities. MFPs have been deployed among women's organizations. The acquisition of the platform is voluntary. For now, local artisans provide the installation, maintenance and repair of the platform.

¹⁶⁷Essandoh-Yeddu and Mensah-Kutin, R. (2011).

¹⁶⁸Burn, N. and Coche, L. (2001).

¹⁶⁹For further information on this case please refer to: <http://www.psl dhaka.net/enterprice.htm>

The platform frees up two to six hours of a rural Malian woman's day by eliminating some of the burden associated with lack of modern energy services. It also provides income-generating opportunities, raising owners' annual incomes by US\$40 to US\$100, and allows them to pursue other endeavours, such as education or other activities. Multifunctional platforms have actually succeeded in elevating women's social status. One Malian woman called the machine a 'silent daughter-in-law' in reference to the duties it performs. **The success of multifunctional platforms in Mali highlights the interdependency of all aspects of development and modern energy consumption.** Women who own and manage a multifunctional platform machine have higher incomes, economic independence, more time for education, and ultimately a higher social status and a higher quality of life.¹⁷⁰

In places where *Jatropha* is grown, a device, powered by the MFP, can crush the *Jatropha* seed. The oil produced can be processed as biodiesel, allowing the MFP to produce biodiesel for its own operation.¹⁷¹

6.5.1.2. Women as engineers – building solar technologies

Donor-supported projects and specific interventions by not-for-profit organizations and technology institutes have supported poor, sometimes illiterate women and men to become energy technicians – also known as 'bare-foot engineers'.

CASE STUDY: Women's micro-enterprise in Bangladesh¹⁷²

Prokaushali Sangsad Limited (PSL), a Dhaka-based organization, has been promoting a rural women's micro-enterprise through a cooperative model, in Bangladesh. The project is located at Char¹⁷³ Montaz, an isolated rural island in southern Bangladesh, a five-hour motorboat journey from the nearest commercial centre. Char Montaz has a population of about 2 million people; however, an electric grid extension to this area will not be economically viable within at least the next 20 years. Therefore there is a high demand for alternative modern lighting.

In September 1999, 35 women came together to form the Coastal Electrification and Women's Development Cooperative (CEWDC), a women-owned cooperative. Since its establishment, the cooperative has been providing energy services to the un-electrified rural areas of Char Montaz and four neighbouring islands.

- The cooperative manufactures high quality DC lamps and charge controllers suitable for solar home systems (SHSs). Other services include battery charging, selling, installing and maintaining SHSs, selling electrical goods and market electrification.
- The women involved in the project run the manufacturing plant that produces the lamps, and are certified by the local government to run their business as a cooperative.
- Besides lamp manufacturing, women are also learning about quality control, business development and marketing. If a woman constructs and sells two lamps a day, her daily income increases by 100 Taka (approximately US\$2). This is equivalent to the daily wages of a skilled labourer, and thus raises both her income and her social status.
- The cooperative advertises its products by organizing public meetings, distributing handbills, setting up billboards and posters, and organizing product demonstrations at several locations.
- A detailed marketing plan was developed by the women covering items such as business location, customer characteristics, target markets, competition, electricity demand, marketing goals and strategies, and budget considerations.

¹⁷⁰GENI. (2008).

¹⁷¹UN (2007).

¹⁷²Dutta S. and Oparaocha S. (2010).

¹⁷³A char is an island formed by deposits of previously eroded land. Their stability is variable; some remain for decades while others may be eroded away within a year.

CASE STUDY: Women's micro-enterprise in Bangladesh (continued)

- Profits have been used for investments in other income-generating activities, such as raising poultry and livestock, and fishing.
- Since 2003, the solar electrification programme also offers micro-credit for purchase of small solar home systems by rural households. Currently 100 households in Char Montaz are enjoying the services provided by the cooperative.

Salient features of the Char Montaz implementation approach are:

- A systematic identification of community and gender-based needs
- Tapping opportunities for rural women and their families to generate non-farm income
- Helping women make good use of their capacities in the keen administration of micro-credits, now available to them
- Rural women empowered through acquisition of technical and business training and skills

Over time, DC lamp manufacturing has been scaled-up to meet demand beyond the islands in the region, and in fact, the cooperative is now one of the Project Organizations (POs) under the World Bank-supported Rural Electrification and Renewable Energy Development Project. Under the Sustainable Energy Programme (SEP) of the Shell Foundation, the cooperative is now planning to set up two micro-enterprises, which will be engaged in sales and maintenance of solar home systems and operation of a diesel platform¹⁷⁴ on a commercial basis.¹⁷⁵



Source and photo: Woman assembling solar lamp circuit, Bangladesh, S. Huque, P.S.L.



Source and photo: Controller testing equipment, Bangladesh, S. Huque, P.S.L.

¹⁷⁴A platform built around a simple diesel engine that can perform a variety of tasks such as operating a cereal mill, seed press and battery charger.

¹⁷⁵PSL, (2002).

6.5.2. Improvement of existing activities

Renewable energy technologies can facilitate the implementation of already existing economic activities, including in the trade or agriculture sectors, for example:

6.5.2.1. Increasing agricultural yields by improving irrigation using RETs

PV water pumping

A solar water pump or PV Water Pumping System is simply a pump powered by a PV panel, which in turn is powered by the sun. A PV water pump has several components, including:¹⁷⁶

- solar panels or modules (including the support structure and tracking mechanism¹⁷⁷)
- solar pump (centrifugal or submersible pumps)
- the controller (for adjusting speed and power output depending on input from solar panels)
- electrical interconnections and earthing kit
- plumbing

A typical commercial solar cell has an efficiency of 15 per cent, which means that only one-sixth of the sunlight striking the cell generates electricity.¹⁷⁸ Low efficiencies mean that more cells are needed; this has implications on the cost, as the PV panels account for 50-80 per cent of the set-up costs of these systems.

Wind mechanical water pumping

Wind mills or **wind mechanical water pumps** convert the energy of wind into rotational mechanical energy to drive a mechanical water pump. Modern versions can pump water from depths of several hundred metres and can operate effectively at very low wind speeds.¹⁷⁹

6.5.2.2. Improving the quality of products using RETs

Dryers

A whole variety of food (fruit, vegetables or meat) can be preserved through drying or a process of dehydration. This can enrich the diet of a household allowing the family to eat fruit year-round, or provide a small business opportunity. A dried and preserved fruit like a pineapple, for example, can be transported with more ease in dried slices over long distances to the consumer. Additionally, treated products have an added value and can be sold at higher prices than untreated products.

¹⁷⁶Based on BUN-CA (2002d) and AURORE (2002)

¹⁷⁷Tracking mechanism, also known as “electrical tracking” or “dry banding”; a typical failure mechanism for electrical power insulators due to partial discharges that degrade their insulating capability and that could cause a breakdown.

¹⁷⁸CRT/Nepal (2011).

¹⁷⁹UNDP & IIIIEE at Lund University (2009).

Solar dryers

Solar dryers are devices that use free solar energy to dry agro-products. Some commonly used dryers are the cabinet dryer (a cabinet with shelves for trays), rack dryer (a portable rack), and tunnel dryer (horizontal sections of racks divided as energy collectors and drying racks).¹⁸⁰ Most of the solar dryers are based on natural air convection.

The simplest solar dryer is the **rack dryer**. The rack is composed of a box (most frequently made of wood), of a transparent top, and elevated on piers. The upper part of the box consists of an inclined plastic or glass sheet.¹⁸¹ Inside, the walls are blackened to absorb the incoming solar radiation that enters through the transparent cover. For ventilation, holes are made at the bottom and on the upper part of the rear wall.¹⁸²

The **cabinet dryer**¹⁸³ is a box of wider dimensions and divided in shelves for trays. The shelves can be made of a plastic woven screen that will allow air to go through. The food is placed on trays of similar characteristics. Both the divisions and the trays can be metal, for transmitting the heat to the products. Since air needs to go through, these must be pierced or show separations to allow such air circulation. This model is divided into two units: a glass or plastic covered heating chamber (green-house effect collector) and a drying chamber -divided in shelves for trays- that could directly expose food to solar radiation or be of a non-translucid, radiation-proof material to protect certain specific qualities of the food products; nutritional or even colours. The two units might be joint by a duct if the drying chamber is located at ground-floor, or by simple holes made into the upper part of the collector and the lower part of the drying chamber, if it is structurally elevated, to let hot air move from the first into the second, located at a higher level, and either by convection or by forced ventilation (air outlets or fans). Choosing direct perforations of the wall to divide the collector from the drying chamber, or choosing a duct, depends on each specific case and agents, but the decision always seeks for the least waste of useful heat through the process, and therefore, for the highest energy efficiency.

On the other hand, **the tunnel dryer** is a horizontal, continuous alternation of racks; a line of collectors followed by drying chambers, in an a-b-a-b-a-b- sequence, and the circulation of air, normally forced by a fan on one end.¹⁸⁴

Indistinctively of these three models, solar dryers can be also classified in terms of the exposure of the products to radiation or just to heat from the radiation that will not come into contact with them, or both, as: **direct, indirect or mixed-mode**.¹⁸⁵ The direct dryers let radiation go through a transparent surface (either glass or plastic) and into the food. The indirect dryers are those whose drying chamber is of a solid-dull material that will protect the food from any direct sunlight. Instead of absorbing energy directly, the separate collector feeds the heat that will dehydrate the products in the drying chamber. This type of

¹⁸⁰Almada, M. et al (2005).

¹⁸¹Weiss, W. and Buchinger, J (n.d.)

¹⁸²Almada, M. et al (2005)

¹⁸³Weiss, W. and Buchinger, J. (n.d.)

¹⁸⁴Idem.

¹⁸⁵Moreno, G (n.d.)

dryer preserves certain original food qualities. A third variation within this classification is the mixed-mode solar dryer, divided into two units; the collector and the drying chamber. Nevertheless, and in opposition to the indirect dryer, the drying chamber of a mixed-mode dryer exposes food to direct radiation by means of a transparent side or cover, besides feeding on the heat absorbed by the collector, and both sources seeking to dehydrate the products.



Source and Photo: Two unit rack solar dryer (left) and cabinet dryer (right), C. Mueller, Fundación EcoAndina

Solar collector

Food can be dried cleanly using hot air from an already existing solar collector on the roof which heats up air in a duct system. The hot air needs to be conducted using a small electric blower system through the duct which blows the air back into the drying box. This constantly circulating hot air dries the food effectively.

Biomass fuelled cabinet dryers

These dryers can be used to dry small quantities of produce. It is possible to construct dryers of a wide range of capacities depending on user requirements. The cabinet dryers can be constructed with bricks or using metallic components.

By using a cabinet dryer, less time is needed to dry the product as compared to natural drying. In addition, less fuel may be necessary to dry the product, as compared to open smoking of produce. Furthermore, the smoke does not come into contact with the produce, ensuring optimum quality of the dried produce. The dryers can be designed to run on different fuels like wood, coconut husk, and other wastes. This technology



Source and photo: Cabinet Dryer used by women to dehydrate shrimps, Cochin, India, A. V. Rojas, ENERGIA

can be used to dry agro-horticultural products such as areca nut, cardamom, pepper, ginger, curry leaves, tomato, onion, garlic, coconut, red chilli and coffee seeds which can be dried in both room dryers and cabinet dryers.¹⁸⁶

6.5.3. Reduction of opportunity costs

Access to modern energy solutions allows energy-intensive tasks to be carried out faster or in a more efficient manner, thereby freeing up time and physical energy for other activities, including income-generating ones. For example, women's time is a key constraint to agricultural production, income-earning and good family nutrition among the poor. There is good evidence of savings in time and effort of between 1 and 4 hours per day in cooking, fuel collection and food processing, when energy is made available for these tasks.¹⁸⁷

6.5.3.1. Electrical and other household devices

The availability of electricity or other energy sources, such as biogas, may help power household appliances capable of reducing the burden on women. These devices include sewing machines, flour mills, and pressure cookers.

6.5.3.2. [Informal] food enterprises

Stoves are used by many women in other home-based enterprises such as cooking and selling street foods, which often form their main source of income. Industrial stoves are used in schools, hospitals and workplaces.

6.6. Further resources

More information about the topics covered by this module can be found in the following resources:

Documents and websites

- Almada, M. et al. (2005). Guía de uso de secadores solares para frutas, legumbres, hortalizas, plantas medicinales y carnes. Fundación Celestina Pérez de Almada, SDC (Swiss Agency for Development and Cooperation) and UNESCO.
- Barefoot College, at: <http://www.barefootcollege.org/>
- BUN-CA (2002a). Manuales sobre energía renovable: Biomasa.
- BUN-CA (2002b). Manuales sobre energía renovable: Eólica.
- BUN-CA (2002c). Manuales sobre energía renovable: Hidráulica a pequeña escala.
- BUN-CA (2002d). Manuales sobre energía renovable: Solar Fotovoltaica.
- BUN-CA (2002e). Manuales sobre energía renovable: Solar Térmica.
- CRT/Nepal (2005). Manual on Micro Hydro Development. Prepared for INFORSE.
- ENERGIA (2009). Biofuels for Sustainable Rural Development and Empowerment of Women. Case studies from Africa and Asia.

¹⁸⁶TIDE (n.d.)

¹⁸⁷Dutta, S., et al (2005).

- Global Alliance for Clean Cookstoves, at: <http://cleancookstoves.org/overview/what-is-a-clean-cookstove/>
- HEDON, Improved Cookstoves, at: <http://www.hedon.info/Improvedcookstove>
- IUCN, UNDP and GGCA (2009). Training Manual on Gender and Climate Change.
- Karlsson, G. and Banda, K. (2009). Biofuels for Sustainable Rural Development and Empowerment of Women. ENERGIA.
- MacCarty, N. (2009). Results of testing of the CleanCook and CookSafe Stoves for Fuel Use and Carbon Emissions. Aprovecho Research Centre.
- Practical Action South Asia (2011). Gender Mainstreaming in Energy Projects: Picohydro installations.
- Prado Ramos, G. (2006). Estudio de Scaling Up de Micro Centrales Hidroeléctricas: Experiencias de Soluciones Prácticas -ITDG.
- RCCE and CCRD (n.d.) Biogas Training Material: Improved VACVINA Model. For EASE.
- SODIS (2002). Solar water disinfection: A guide for the application of SODIS.
- Solar Cookers World Network, at: <http://solarcooking.wikia.com>
- UN (2007). Small-Scale Production and Use of Liquid Biofuels in Sub-Saharan Africa: Perspectives for Sustainable Development, Background Paper No. 2, DESA/DSD/2007/2.
- UNDP (2001). Generating Opportunities: Case studies on energy and Women.
- UNDP and ENERGIA (2004). Gender and Energy for Sustainable Development: a toolkit and resource guide.
- US-AID Hygiene Improvement Project (2009). Guide for Training Outreach Workers. Water treatment and Storage. Training Package for the Prevention of Diarrheal Disease.
- WHO (2006). Fuel for Life: Household energy and health.

Videos:

- Barefoot College. From Candles to Panels: 3 Bolivian barefoot solar engineers, at: <http://www.youtube.com/watch?v=l3kumzMGMHo>
- Barefoot College. Sierra Leone's First Women Barefoot Solar Engineers, at: http://www.youtube.com/watch?v=v_RT8pngx1A
- Leonardo Energy, Photovoltaic Systems, at: <http://www.leonardo-energy.org/fxchange/webcast/photovoltaic-systems/player.html>
- Setting up a Multifunctional Platform (5 videos), at: <http://www.ease-web.org/?p=31>

6.7. Possible exercises

The following exercises could be used to test and strengthen knowledge among training workshop participants.

Exercise 1. Energy services and technologies

Ask participants to think about a community they are familiar with and then ask them to answer the following questions:

1. Who chooses which energy technology is used?
2. How is it used?
3. Who benefits from this use?
4. Do you think this is the best technology available? Why?

Exercise 2. Borrowing from the manual

For each energy service, find a key gender-related question included in the text of this manual. Address the questions under each chapter and apply them to a cluster of technologies providing a specific energy service. Ask participants to draw on their own experiences to answer these questions.

Abbreviations

ARI	Acute Respiratory Infections
CEWDC	Coastal Electrification and Women's Development Cooperative
CFC	Chlorofluorocarbons
CFLs	Compact fluorescent lamps
Cos	Community Organizations
CRGGE	Collaborative Research Group on Gender and Energy
CRT/N	Centre for Rural Technology Nepal
DFID	United Kingdom Department for International Development
EDF	Enterprise Development Fund
ENERGIA	ENERGIA the International Network on Gender and Sustainable Energy
EnPoGen	Energy, Poverty and Gender Initiative
FGs	Functional Groups
GGCA	Global Gender and Climate Alliance
GHG	Greenhouse Gases
GNESD	Global Network on Energy for Sustainable Development
h/d	Hours per day
HCFCs	Hydro-chlorofluorocarbons
HDI	Human Development Index
HEDON	HEDON Household Energy Network
HFCs	Hydro-fluorocarbons
HIVOS	Humanist Institute for Development Cooperation
ICS	Improved Cooking Stoves
IEA	International Energy Agency
IMS	Improved Metallic Stove
IP	Indigenous People
ITC	Information Communication Technologies
IUCN	International Union for the Conservation of Nature
J	Joules
KW	Kilowatts
KWh	Kilowatts hour
KWh/d	Kilowatts hour per day
LED	Light Emitting Diodes
LPG	Liquefied Petroleum Gas
m/s	Meters per second
MDGs	Millennium Development Goals
MFP	Multi-Functional Platform
PEP	Permanent Education Programme, EARTH University

Abbreviations

PET	Polyethylene Terephtalate
PLWHA	People Living with HIV-Aids
POs	Project organizations
PV	Photo-voltaic
PSL	Prokaushali Sangsad Limited, Bangladesh
REDP	Renewable Energy Development Programme, Nepal
RET	Renewable Energy Technologies
SEP	Sustainable Energy Program
SHS	Solar Home Systems
SNV	Netherlands Development Organization
SODIS	Solar Water Disinfection
TV	Television
UK	United Kingdom
UNDP	United Nations Development Programme
UNIFEM	United Nations Development Fund for Women
UN WOMEN	UN Entity for Gender Equality and the Empowerment of Women
US EPA	United States Environmental Protection Agency
UV-A	Ultraviolet rays type A
V	Velocity
WHO	World Health Organization

BIBLIOGRAPHY

Documents

Almada, M. et al. (2005). Guía de uso de secadores solares para frutas, legumbres, hortalizas, plantas medicinales y carnes. Fundación Celestina Pérez de Almada, SDC (Swiss Agency for Development and Cooperation) and UNESCO. Asunción, Uruguay. Available at: <http://www.unesco.org.uy/educacion/fileadmin/templates/educacion/archivos/Guiasecaderosolar.pdf> Retrieved December 22, 2011.

Appropriate Infrastructure Development Group (AIDG) (2011). Biodigesters. Available at: http://aidg.org/index2.php?option=com_content&do_pdf=1&id=16 Retrieved December 26, 2011.

AUORE (2002). Best Practices in Solar Water Pumping. Tamil Nadu, India. Available at: <http://www.auore.in/Best%20practices%20in%20Solar%20Pumping%20manual.pdf> Retrieved December 22, 2011.

Barnes, D.F. et al. (1994). What makes people cook with improved biomass stoves. World Bank Technical Paper Nr. 242-Energy Series, Washington D.C., U.S.A. Available at: <http://www.hedon.info/docs/WhatMakesPeopleCookWithImprovedBiomassStoves.pdf> Retrieved December 28, 2011.

Bates, L. (2007). Liquid Biofuels and Sustainable Development. Practical Action. Rugby, UK. Available at: <http://practicalaction.org/liquid-biofuels-and-sustainable-development> Retrieved December 29, 2011.

Botero, R. (2011). El biodigestor de bajo costo, su aporte a la mitigación del cambio climático y su potencial para reducir la pobreza rural en América Latina y el Caribe. Universidad EARTH, Costa Rica.

Botero, R. & Carazo, L. (2010). Workshop “Seminario Biodigestores: Manejo de desechos sólidos y líquidos de la agroindustria & oportunidad de desarrollo para comunidades rurales”, Universidad EARTH, Costa Rica.

BUN-CA (2002a). Manuales sobre energía renovable: Biomasa. San Jose, Costa Rica. Available at: <http://www.bun-ca.org/publicaciones/BIOMASA.pdf> Retrieved December 22, 2011.

BUN-CA (2002b). Manuales sobre energía renovable: Eólica. San Jose, Costa Rica. Available at: <http://www.bun-ca.org/publicaciones/EOLICA.pdf> Retrieved December 22, 2011.

BUN-CA (2002c). Manuales sobre energía renovable: Hidráulica a pequeña escala. San Jose, Costa Rica. Available at: <http://www.bun-ca.org/publicaciones/HIDRA.pdf> Retrieved December 22, 2011.

BUN-CA (2002d). Manuales sobre energía renovable: Solar Fotovoltaica. San Jose, Costa Rica. Available at: <http://www.bun-ca.org/publicaciones/FOTOVOLT.pdf> Retrieved 22 December 2011.

- BUN-CA (2002e). Manuales sobre energía renovable: Solar Térmica. San Jose, Costa Rica. Available at: <http://www.bun-ca.org/publicaciones/SOLAR.pdf> Retrieved December 22, 2011.
- Burn, N. and Coche L. (2001). Multifunctional Platform for Village Power. Generating opportunities: Case studies on energy and women. UNDP, New York, U.S.A. Available at: <http://www.undp.org/environment/sustainable-energy-library.shtml> Retrieved December 26, 2011.
- Chant, S. (2006). "Re-thinking the Feminization of Poverty in Relation to Aggregate Gender Indices." Journal of Human Development 7.2., UNDP and Routledge Taylor and Tracis Group. Available at: http://personal.lse.ac.uk/chant/chantpdfs/Chant_JHD_PDF.pdf Retrieved December 26, 2011.
- Clancy, J. et al. (2005 a). The Gender Face of Energy: A Training Manual. Module 1. Enschede: University of Twente. Available at: <http://www.energia.org/fileadmin/files/media/pubs/Module%201%20revised%20june%202007.pdf> Retrieved December 22, 2011.
- Clancy, J. et al. (2005 b). The Gender Face of Energy: Gender Tools for Energy Projects. Module 2. Enschede: University of Twente. Available at: <http://www.energia.org/fileadmin/files/media/pubs/Module2-TPGenderToolsForEnergyProjects.pdf> Retrieved December 22, 2011.
- Clancy, J. and Dutta, S. (2005) Women and productive uses of energy: Some light on a shadowy area. Paper presented at the UNDP Meeting on Productive Uses of Renewable Energy, Bangkok, Thailand, 9–11 May 2005.
- CRT/Nepal (2005). Manual on Micro Hydro Development. Prepared for INFORSE. Kathmandu, Nepal. Available at: http://www.inforse.dk/asia/pdf/Nepal_Micro_Hydro_Manual.pdf Retrieved December 29, 2011.
- CRT/Nepal (2011). National Inventory on "Climate Change, Energy Access and Technology Transfer" in Nepal. Prepared for ENERGIA. Kathmandu, Nepal.
- Doss, C. et al (2008). Gender and asset ownership: a guide to collecting individual-level data. Policy Research working paper no. WPS4704. World Bank. Washington D.C., U.S.A.
- Dutta, S. et al. (2005). Empirical Evidence for Linkages: Energy, Gender and the MDGs. ENERGIA News, Vol. 8, No. 2, ENERGIA. Available at: http://www.energia.org/fileadmin/files/media/EN122005_dutta_etal.pdf Retrieved December 22, 2011.
- Dutta S. and Oparaocha S. (2010). Energy Services for Productive Uses: A Route to Women's Empowerment. Prepared for UNIFEM India.
- ENERGIA (2006.) Economic Empowerment of Women Through Small Business Enterprises. ENERGIA Fact sheets. Available at: http://www.energia.org/fileadmin/files/media/factsheets/factsheet_enterprises.pdf Retrieved December 29, 2011.

ENERGIA (2011). Mainstreaming Gender in Energy Projects: A Practical Handbook. Prepared by Elizabeth Cecelski and Soma Dutta for ENERGIA. Forthcoming.

ENERGIA/DfID Collaborative Research Group on Gender and Energy (CRGGE) (2006). From the Millennium Development Goals Towards a Gender Sensitive Energy Policy Research and Practice: Empirical Evidence and Case Studies. Synthesis Report. Available at: http://www.energia.org/fileadmin/files/media/pubs/dfid_synthesis.pdf Retrieved December 22, 2011.

Energy for Sustainable Development Online Course (2009). Glossary Energy and Sustainable Development. Lund: Lund University.

Energy Star (2010). Frequently Asked Questions. Information on Compact Fluorescent Light Bulbs (CFLs) and Mercury. Available at: http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf Retrieved December 26, 2011.

Essandoh-Yeddu and Mensah-Kutin R. (2011). Energy, Climate Change Resilient Technologies in Ghana. A National Inventory. Prepared for ENERGIA. Khandra-Accra, Ghana.

Fundación EcoAndina (n.d.). Soluciones sustentables. Energías alternativas, desarrollo local, cuencas hídricas, sustentabilidad ambiental, ciencia y tecnología, capacitación en zonas áridas y semi-áridas. Available at: http://www.oekoandina.de/images/stories/OekoAndina/EcoAndina/ecoandina_flyer.pdf Retrieved December 26, 2011.

Gaye, A. (2007). Access to Energy and Human Development. Human Development Report 2007/2008. Available at: http://hdr.undp.org/en/reports/global/hdr2007-8/papers/Gaye_Amie.pdf Retrieved December 22, 2011.

GNESD (2007). Reaching the Millennium Development Goals and beyond. Access to modern forms of energy as a prerequisite. Available at: http://www.gnesd.org/downloadables/mdg_energy.pdf Retrieved December 22, 2011.

Havet, I. et al (2009). Energy in National Decentralization Policies. For UNDP, New York, U.S.A. Available at: http://www.undp.org/energy/docs/Energy_Decentralization_r8.pdf Retrieved December 22, 2011.

Hazeltine, B. and Bull, C. (1999). Appropriate Technology: Tools, Choices, and Implications. San Diego, Academic Press.

Hivos and ENERGIA (2010). A Guide on Gender Mainstreaming in the Africa Biogas Partnership Programme. Prepared by ENERGIA. Available at: <http://www.energia.org/fileadmin/files/media/pubs/Guide%20on%20gender%20mainstreaming%20in%20the%20ABPP.pdf> Retrieved December 22, 2011.

Houghton Mifflin Company (2005). The American Heritage Science Dictionary. Massachusetts, U.S.A.

- IEA (2007). Biofuel Production. Energy Technology Essentials, ETE02, Paris, France. Available at: <http://www.iea.org/techno/essentials2.pdf> Retrieved December 29, 2011.
- IEA (2010) World Energy Outlook 2010. IEA, Paris, France. Summary available at: <http://www.iea.org/Textbase/npsum/weo2010sum.pdf> Retrieved December 22, 2011.
- IEA et al. (2010) Energy Poverty. How to make modern energy access universal? Paris, France. Available at: http://content.undp.org/go/cms-service/stream/asset/?asset_id=2822269 Retrieved December 22, 2011.
- ILO INSTRAW (n.d.). Women: New and Renewable Sources of Energy. Rome, Italy.
- ISAT and GTZ. (n.d.) Biogas Digest, Volume I, Biogas Basics. Eschborn-Frankfurt, Federal Republic of Germany. Available at: <http://www.gtz.de/de/dokumente/en-biogas-volume1.pdf> Retrieved December 22, 2011.
- IUCN, UNDP and GGCA (2009). Training Manual on Gender and Climate Change. San Jose, Costa Rica. Available at: http://cmsdata.iucn.org/downloads/eng_version_web_final_1.pdf Retrieved December 22, 2011.
- Karlsson, G. and Banda, K. (2009). Biofuels for Sustainable Rural Development and Empowerment of Women. ENERGIA. Leusden, The Netherlands. Available at: <http://www.energia.org/fileadmin/files/media/pubs/Libro%20Biofuels%20web.pdf> Retrieved December 22, 2011.
- Keam, S. and McCormick, N. (2008). Implementing Sustainable Bioenergy Production; A Compilation of Tools and Approaches. For IUCN. Gland, Switzerland.
- Knudson, B. (n.d.) State of the Art of Solar Cooking. Available at: <http://www.she-inc.org/sam.pdf> Retrieved December 22, 2011.
- Kulshreshta, D.C. (2009). Basic Electrical Engineering. Tata McGraw-Hill Education.
- Lauridsen, M.I. (1998). Evaluation of the impact on women's lives of the introduction of low cost polyethylene biodigesters on farms in villages around Ho Chi Minh City, Vietnam. Available at: http://www.aidg.net/index.php?option=com_remository&Itemid=34&func=fileinfo&parent=category&filecatid=48 Retrieved December 22, 2011.
- Legros, G., et al (2009). The energy access situation in developing countries. A review focusing on the least developed countries and Sub-Saharan Africa. For UNDP and WHO. New York, U.S.A. Available at: http://content.undp.org/go/cms-service/stream/asset/?asset_id=2205620 Retrieved December 22, 2011.

- Levy, A. (2009). Great Bright Hope to End Battle of the Light Bulbs, The Daily Mail, January 29, 2009 Available at: <http://www.dailymail.co.uk/sciencetech/article-1131183/Scientists-invent-2-bulb-60-years--theyre-greener-eco-bulbs.html?ITO=1490> Retrieved December 26, 2011.
- Lim, S.R. et al (2011). Potential Environmental Impacts of Light-Emitting Diodes (LEDs): metallic resources, toxicity, and hazardous waste classification. *Environ Sci Technol* 45 (1). Available at: <http://pubs.acs.org/doi/full/10.1021/es101052q> Retrieved December 26, 2011.
- MacCarty, N. (2009). Results of testing of the CleanCook and CookSafe Stoves for Fuel Use and Carbon Emissions. Aprovecho Research Centre. Oregon, U.S.A. Available at: <http://stoves.projectgaia.com/files/AprovechoStoveFuelReport2009.pdf> Retrieved December 28, 2011.
- Modi, V. et al (2005). Energy Services for the Millennium Development Goals. Achieving the Millennium Development Goals. Millennium Project. Available at: http://www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf Retrieved December 22, 2011.
- Mohdam, V. (2005) The Feminization of Poverty and Women's Human Rights. SHS Papers in Women Studies / Gender Research. No. 2. For UNESCO. Paris, France. Available at: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SHS/pdf/Feminization_of_Poverty.pdf Retrieved December 28, 2011.
- Moreno, G. (n.d.) Manual de Construcción y Operación de una Secadora Solar. UAM. Iztapalapa, México. Available at: http://cbi.izt.uam.mx/iph/archivos_profesores/50/archivos/4f197.pdf Retrieved December 24, 2011.
- Mueller, C. (2011a). X - SOL 100, Termotanque solar. Training Manual for Solar Collector Installation. Fundación EcoAndina, Argentina.
- Practical Action (2010). Poor People's Energy Outlook 2010. Rugby, UK. Available at: <http://practicalaction.org/docs/energy/poor-peoples-energy-outlook.pdf> Retrieved December 22, 2011.
- Practical Action, Regional Programme (2011). Gender Mainstreaming in Energy. Training Manual for Pico Hydro Installations. Colombo, Sri Lanka.
- Prado Ramos, G. (2006). Estudio de Scaling Up de Micro Centrales Hidroeléctricas: Experiencias de Soluciones Prácticas -ITDG. Lima, Peru. Available at: http://practicalaction.org/docs/energy/prado_estudio_de_scaling_up_en_mchs.pdf Retrieved December 26, 2011.
- Project Gaia (n.d. a). Clean burning Ethanol Stoves. Available at: <http://www.projectgaia.com/files/AboutProjectGaia.pdf> Retrieved December 28, 2011.
- Project Gaia, Dometic CleanCook (2010). Alcohol fueled stoves, Dometic CleanCook M1/M2 and A1/A2. Available at: <http://stoves.projectgaia.com/files/DometicCleanCookBROCH2010.pdf> Retrieved December 28, 2011.

- PSL. (2002). Char Montaz Women's Micro-enterprise: Album on micro-enterprise activities and lighting. Dhaka, Bangladesh. Available at: <http://www.psl dhaka.net/Album11.pdf> Retrieved December 26, 2011.
- Rahim, S. (2010). The Incandescent Bulb Heads Offstage After Century-Long Performance, The New York Times, June 28, 2010. Available at: <http://www.nytimes.com/cwire/2010/06/28/28climatewire-the-incandescent-bulb-heads-offstage-after-c-11795.html> Retrieved December 26, 2011.
- RCCE and CCRD (n.d.) Biogas Training Material: Improved VACVINA Model. For EASE. Available at: <http://www.ease-web.org/wp-content/uploads/2010/10/Biogas-training-material-for-technicians-and-users.pdf> Retrieved December 29, 2011.
- Real Academia Española (2001). Diccionario de la lengua española (vigésima segunda edición). Available via: <http://buscon.rae.es/drae/> Retrieved December 22, 2011.
- Rodriguez, L. and Presto, T.R. (2004). Biodigester installation manual. University of Tropical Agriculture Foundation Finca Ecologica, and University of Agriculture and Forestry Thu Duc, Ho Chi Minh City, Vietnam. Available at: http://www.aidg.net/index.php?option=com_remository&Itemid=34&func=filinfo&parent=category&filecatid=14 Retrieved December 22, 2011.
- Rosenthal, E. and Barringer, F. (2009). Green Promise Seen in Switch to LED Lighting, New York Times, May 29, 2009. Available at: http://www.nytimes.com/2009/05/30/science/earth/30degrees.html?ref=lightemitting_diodes Retrieved December 26, 2011.
- Shubert, F. (2006). Light-Emitting Diodes. Second Edition. Cambridge University.
- SODIS (2002). Solar water disinfection: A guide for the application of SODIS. Duebendorf, Switzerland. Available at: http://www.sodis.ch/methode/anwendung/ausbildungsmaterial/dokumente_material/manual_e.pdf Retrieved December 22, 2011.
- SODIS (n.d.) Water quality: Turbidity and water depth. Technical Note # 7. Available at: http://www.sodis.ch/methode/anwendung/factsheets/turbidity_waterdepth_e.pdf Retrieved December 22, 2011.
- Solar Cookers International. (2004). Solar cookers: how to make, use and enjoy. 10th Edition California, U.S.A. Available at: http://images3.wikia.nocookie.net/__cb20090108164304/solarcooking/images/5/57/CookKit_plans_detailed.pdf Retrieved December 22, 2011.
- Soluciones Prácticas (n.d.). Ficha técnica, Fundamentos de la Energía Eólica. Soluciones Prácticas - ITDG, Perú.
- Staton, D. and Harding, M. (n.d.) Health and environmental effects of cooking stove use in developing countries. Available at: <http://bioenergylists.org/stovesdoc/Environment/staton.pdf> Retrieved December 22, 2011.

- Sunlabob (2007). Solar Lantern: Presentation. Available at: http://www.sunlabob.com/documents/07-03-Solar_Lanterns_Presentation.pdf Retrieved December 26, 2011.
- Taub, E. (2010). LED Bulbs for the Home Near the Marketplace, The New York Times, May 16, 2010. Available at: http://www.nytimes.com/2010/05/17/technology/17bulb.html?ref=lightemitting_diodes Retrieved December 26, 2011.
- TIDE. (n.d.). Biomass Fired Tray Dryers. Bangalore, India. Available at: <http://www.tide-india.org/brochures%20and%20movies/dryer.pdf> Retrieved December 26, 2011.
- UNDP and ENERGIA (2004). Gender and Energy for Sustainable Development: a toolkit and resource guide. New York, U.S.A. Available at: <http://www.undp.org/environment/sustainable-energy-library.shtml> Retrieved December 26, 2011.
- UNDP (2010). Asia Pacific Human Development Report. Power, voice and rights. A turning point for gender equality in Asia and the Pacific. UNDP. Colombo, Sri Lanka. Available at: <http://hdr.undp.org/en/reports/regional/asiathepacific/RHDR-2010-AsiaPacific.pdf> Retrieved December 29, 2011.
- UNDP (2006). Energizing Poverty Reduction. A Review of Energy-Poverty Nexus in Poverty Reduction Strategy Papers. New York, U.S.A. Available at: <http://www.undp.org/environment/sustainable-energy-library.shtml> Retrieved December 26, 2011.
- UNDP (2007). Gender Mainstreaming: a Key Driver of Development in Environment & Energy. Energy & Environment Practice: Gender Mainstreaming Guidance Series. Sustainable Energy Services. Training Manual. New York, U.S.A. Available at: <http://www.undp.org/environment/sustainable-energy-library.shtml> Retrieved December 26, 2011.
- UNDP (2001). Generating Opportunities: Case studies on energy and Women. New York, U.S.A. Available at: http://waterwiki.net/images/2/26/GeneratingOpportunities_2001.pdf Retrieved December 26, 2011.
- UNDP (2007). Will tomorrow be brighter than today? Addressing gender concerns in energy for poverty reduction in the Asia-Pacific Region. New York, U.S.A. Available at: <http://www.undp.org/environment/sustainable-energy-library.shtml> Retrieved December 26, 2011.
- UNDP (2006). Human Development Report 2006. Beyond scarcity: Power, poverty and the global water crisis. New York, U.S.A. Available at: <http://hdr.undp.org/en/media/HDR06-complete.pdf> Retrieved December 26, 2011.
- UNDP (2000). World Energy Assessment. Energy and the Challenges of Sustainability. New York, U.S.A. Available at: <http://www.undp.org/environment/sustainable-energy-library.shtml> Retrieved December 26, 2011.

- UNDP and IIEE at Lund University (2009). Section II, Module II-3: Renewable Energy Technologies. Lund: Lund University, Sweden.
- UNEP (2005). SolarChill - the vaccine cooler powered by nature. Paris, France. Available at: <http://www.unep.org/Ozonaction/information/mmcfiles/4489-e-SolarChill.pdf> Retrieved December 26, 2011.
- UNESCO, (2009). Biofuels and environmental impacts. Policy Briefs, No. 9, June 2009. For UNESCO, SCOPE, UNEP. Available at: <http://unesdoc.unesco.org/images/0018/001831/183113E.pdf> Retrieved December 22, 2011.
- UNICEF (2006). The State of the World's Children 2007: Women and Children - The double dividend of gender equality. New York, U.S.A. Available at: http://www.unicef.org/publications/index_36587.html Retrieved December 22, 2011.
- UNIFEM (n.d.a). The tragic reality of violence -Facing the Facts of Violence Against Women and the Millennium Development Goals. Fact Sheet 4. New York, U.S.A. Available at: http://www.unifem.org/attachments/products/MDGsAndGenderEquality_4_TragicRealityOfViolence.pdf Retrieved December 22, 2011.
- UNIFEM (n.d.b). The Unfinished Agenda -Balance Sheet of Progress and Backlogs on Gender Equality. Fact Sheet 2. New York, U.S.A. Available at: http://www.unifem.org/attachments/products/MDGsAndGenderEquality_2_UnfinishedAgenda.pdf Retrieved December 22, 2011.
- UN (2007). Small-Scale Production and Use of Liquid Biofuels in Sub-Saharan Africa: Perspectives for Sustainable Development, Background Paper No. 2, DESA/DSD/2007/2. Department of Economic and Social Affairs. New York, U.S.A. Available at: http://www.un.org/esa/sustdev/csd/csd15/documents/csd15_bp2.pdf Retrieved December 26, 2011.
- United Nations (2010). The World's Women 2010: Trends and Statistics. Department of Economic and Social Affairs. New York, U.S.A. Available at: http://unstats.un.org/unsd/demographic/products/Worldswomen/WW_full%20report_color.pdf Retrieved December 22, 2011.
- US-AID Hygiene Improvement Project (2009). Guide for Training Outreach Workers. Water treatment and Storage. Training Package for the Prevention of Diarrheal Disease. Washington D.C., U.S.A. Available at: http://www.c-hubonline.org/7796/502/Training_Water_Treatment_Global_Guide.pdf Retrieved December 29, 2011.
- U.S. Department of Energy (n.d.). Small wind electric system: A U.S. Consumer's Guide. U.S.A. Available at: http://www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf Retrieved December 26, 2011.
- Weiss, W. and Buchinger, J. (n.d.) Solar Drying. Austrian Development Cooperation and AEE INTEC Institute for Sustainable Technologies. Austria. Available at: <http://www.aee-intec.at/0uploads/dateien553.pdf> Retrieved December 24, 2011.

- WHO (2006). Fuel for Life: Household energy and health. Geneva, Switzerland. Available at: <http://www.who.int/indoorair/publications/fuelforallife.pdf> Retrieved December 22, 2011.
- WHO, (2011). Indoor Air Pollution and Health. Fact Sheet 292. Available at: <http://www.who.int/mediacentre/factsheets/fs292/en/index.html> Retrieved December 22, 2011.
- World Bank Group (1998). Ozone-Depleting Substances: Alternatives. Pollution Prevention and Abatement Handbook. Available at: [http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/ppah_pguiOzone/\\$FILE/HandbookOzoneDepletingSubstancesAlternatives.pdf](http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/ppah_pguiOzone/$FILE/HandbookOzoneDepletingSubstancesAlternatives.pdf) Retrieved December 26, 2011.
- World Commission on Dams (2000). Dams and Development: a new framework for decision making. Final Report. Virginia, U.S.A. Available at: http://www.internationalrivers.org/files/world_commission_on_dams_final_report.pdf Retrieved December 22, 2011.
- Wu, X. et al. (2004). Coping with the cold: space heating and the urban poor in developing countries'. Energy Economics, Vol. 26 (3).

Web-based resources

- Audubon Magazine (2006). Audubon statement on wind power, at: <http://policy.audubon.org/audubon-statement-wind-power> Retrieved December 28, 2011.
- Barefoot College, home page, at: <http://www.barefootcollege.org/> Retrieved December 22, 2011.
- Barnes, D. (2010) Measuring household lighting: survey design issues. Energy for Development and Poverty Reduction, [blog], 6 March 2010, at <http://www.energyfordevelopment.com/2010/03/measuring-household-lighting.html> Retrieved December 22, 2011.
- de Wachter, B. (2006). The Environmental Impacts of Renewable Energy. Available at: <http://www.leonardo-energy.org/drupal/node/1258> Retrieved December 22, 2011.
- ENERGIA, Home Page, at: <http://www.energia.org> Retrieved December 22, 2011.
- ENERGIA (2008a). E-learning Module 1, at: <http://www.moodle.energia.org/> Retrieved December 22, 2011.
- ENERGIA (2008b). E-Learning Module 2, at: <http://www.moodle.energia.org/> Retrieved December 22, 2011.
- ENERGIA (2008c). E-Learning Module 3, at: <http://www.moodle.energia.org/> Retrieved December 22, 2011.
- European Commission, Energy-Saving Light Bulbs at: http://ec.europa.eu/energy/lumen/overview/avariedchoice/index_en.htm Retrieved December 22, 2011.

GENI (2008) Technological Innovation: Multi-functional Platforms in Mali, [blog], 16 November 2008, at: <http://www.geni.org/globalenergy/research/ruralelectrification/casestudies/mali/index.shtml> Retrieved December 22, 2011.

Global Alliance for Clean Cookstoves, at: <http://cleancookstoves.org/overview/what-is-a-clean-cookstove/> Retrieved December 29, 2011.

HEDON, Improved Cookstoves, at: <http://www.hedon.info/Improvedcookstove> Retrieved December 22, 2011.

Khmani, H. (2009). Applications of Solar Energy: Part-4: Solar Street Lights. Bright Hub, [blog], 6 August, at: <http://www.brighthub.com/environment/renewable-energy/articles/5308.aspx> Retrieved December 26, 2011.

Project Gaia (n.d. b). The CleanCook, at <http://stoves.projectgaia.com/page.php?page=stoverview> Retrieved December 28, 2011.

SODIS, Home Page, at: <http://www.sodis.ch/index> Retrieved December 22, 2011.

Solar Cookers International (2010a). Solar Cooking Basics, How, at: <http://www.solarcookers.org/basics/how.html> Retrieved December 28, 2011.

Solar Cookers International (2010b). Solar Cooking Basics, Where, at <http://www.solarcookers.org/basics/where.html> Retrieved December 28, 2011.

Solar Cookers International (2010c). Solar Cooking Basics, Why, at: <http://www.solarcookers.org/basics/why.html> Retrieved December 28, 2011.

Soluciones Prácticas, at: <http://www.solucionespracticas.org.pe> Retrieved December 22, 2011.

The Royal Society for the Protection of Birds (2011). Policy, Wind farms, at: <http://www.rspb.org.uk/ourwork/policy/windfarms/index.aspx> Retrieved December 28, 2011.

TIDE, Cabinet Dryers at: <http://www.tide-india.org/products/06cabinet-dryers.html> Retrieved December 22, 2011.

UN, Millennium Development Goals, at: <http://www.un.org/millenniumgoals/> Retrieved December 22, 2011.

UNDP, Human Development Index, at: <http://hdr.undp.org/en/statistics/hdi/> Retrieved December 22, 2011.

UNDP and Millennium Development Goals, at: <http://www.un.org/millenniumgoals> Retrieved December 22, 2011.

UNIFEM, Facts and Figures, available at: UNIFEM.org/gender_issues/women_poverty_economics/facts_figures.php Retrieved December 22, 2011.

US Energy Information Administration, Forms of Energy, at: http://www.eia.gov/kids/energy.cfm?page=about_forms_of_energy-basics Retrieved December 22, 2011.

Wageningen University and Research Centre (2011). North Sea wind farm has positive net impact on fauna, researchers say. ScienceDaily, at: <http://www.sciencedaily.com/releases/2011/08/110808105949.htm> Retrieved December 28, 2011.

Interviews

Altenhenne, M. (n.d.). Global Ideas, DW-TV, Germany and Chiroque, J., Soluciones Practicas, Perú. Case study produced using material provided by M. Altenhenne (DW-TV), with his express authorization. Available at: <http://www.dw-world.de/dw/0,,13779,00.html>. Retrieved December 28, 2011.

Ardila, M. (2011). Mejoramiento del medio ambiente a través de la construcción de cocinas LORENA, Asociación para el Desarrollo de los Pueblos (ADP), Nicaragua. Case study produced using material provided by M. Ardila, with her express authorization.

Botero, R. & Carazo, L. (2010). Workshop “Seminario Biodigestores: Manejo de desechos sólidos y líquidos de la agroindustria & oportunidad de desarrollo para comunidades rurales”, Universidad EARTH, Costa Rica. Case study produced using material provided by R. Botero and L. Carazo, with their express authorization.

Oreamuno, C. (2010). Personal note, Consenergy, Costa Rica.

Schneider, J. (n.d.). Global Ideas, DW-TV, Germany and Mueller, C., Fundacion ECOANDINA, Argentina. Case study produced using material provided by J. Schneider (DW-TV), with his express authorization. Available at: <http://www.dw-world.de/dw/0,,13573,00.html>. Retrieved December 28, 2011.

Mueller, C. (2011b). Personal note, Fundacion EcoAndina, Argentina.

Videos

Barefoot College. From Candles to Panels: 3 Bolivian barefoot solar engineers, video in Spanish with English subtitles, at: <http://www.youtube.com/watch?v=l3kumzMGMH0>

Barefoot College. Sierra Leone's First Women Barefoot Solar Engineers, video in English, at: http://www.youtube.com/watch?v=v_RT8pngx1A

Leonardo Energy Photovoltaic Systems in English, at: <http://www.leonardo-energy.org/fxchange/webcast/photovoltaic-systems/player.html>

TATEDO-EASE. Setting up a Multifunctional Platform, 5 videos, at: <http://www.ease-web.org/?p=316>