Bsc(Hons) Renewable Energy Dissertation

Identifying the barriers to the deployment of solar cookers in the energy-poor households of sub-Saharan Africa

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Module: CSM3403

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Date: May 2012

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Abstract

This document aims to identify the barriers to the deployment of solar cookers in the energy-poor households of sub-Saharan Africa for one to be able to create policy frameworks aimed at abolishing these. Descriptions of the socio-economic impacts of traditional cooking methods and of solar cookers' way to oppose these constitute the introductory chapters of this paper. The barriers are reviewed in the subsequent chapters and ways of overcoming them are suggested all along the text.

Technical barriers are due to weather and other environmental elements, problems in the design, materials and supply of solar cookers, lack of infrastructure - especially in rural areas - and general long cooking times and discomfort in leaving the cookers outdoors.

Public perception barriers are the result of strong traditions and beliefs deep-rooted throughout Africa, gender inequalities, different conceptions of solar cookers' benefits depending on rural or urban living conditions, misunderstanding of potential financial benefits, solar cookers' high capital costs, pride in not getting indebted and the poor image associated with cheap designs and low social classes.

Finally, institutional and governmental barriers are often the consequence of poor promoting strategies and project planning, poor or lack of collaboration between governments, NGOs and financial institutions, and lack of background literature, coordination between subsidisation and commercialisation, local small-scale institutions in the solar cooking sector, communication and transparency in publications, monitoring and follow-up of projects, pro-poor energy policy frameworks, political will and lack of access to some regions of Africa due to warfare, terrorism and others.

Creating suitable promoting programmes and collaboration between all involved actors is key to the successful dissemination of solar cookers in sub-Saharan Africa.

Acronyms & Abbreviations

AFRECA: Association for Renewable Energy Cooking Appliances

AFREPREN/FWD: African Energy Policy Research Network

AREA: African Renewable Energy Alliance

ISC: Integrated Cooking System

JWW: Jewish World Watch

NGO: Non-Governmental Organisation

SCI: Solar Cookers International

SHE: Solar Household Energy

PCIA: Partnership for Clean Indoor Air

ProBec: Programme for Basic Energy and Conservation in Southern Africa

UN: United Nations

UNDP: United Nations Development Programme

UNEP: United Nations Environmental Programme

UNESCO: United Nations Educational, Scientific and Cultural Organisation

UNHCR: United Nations High Commissioner for Refugees

Author's Note

This paper was written with the hope that it will be useful for people wishing to enter the field of solar cookers in developing countries by giving a simple overview of the barriers in sub-Saharan African communities. The work was made for the author's bachelor degree at the University of Exeter and was limited by 10 000 words hence why most efforts had to be directed towards finding the faults in the system rather than praise its progress and good actions. Although some sections might sound pessimistic regarding some efforts made in the field and might seem harsh to some organisations, this document aims in no way to undermine the incredible efforts made by hundreds of associations who started from nothing and potentially saved thousands of lives. The author has never been on the field and therefore has a very limited idea on what happens there on a day-to-day basis. For the purpose of transparency and sharing of information, authorisation is given to any reader who wishes to modify and add to the text in order to enlighten other readers.

Many members of the Solar Cooking World Network, SCI and JWW have contributed to the writing of this text. These include Patricia McArdle, member of SCI, Bernhard Müller, founding member of the Solar Cooking World Network, and Sharon Clausson, solar cooker inventor, amongst others who humbly asked for their names not to be mentioned – these people know who they are, thank you.

1. Introduction

The global energy crisis has been felt more than ever by industrialised countries since the two oil crises of the 1970s. However, there has always been a far greater hidden energy crisis which now affects more than 2.7 billion people[1] who depend solely on detrimental solid fuels such as biomass and coal for their most basic energy needs. Energy access is a fundamental aspect towards the general development of a nation. This link has been recognised by the United Nations Development Programme (UNDP), the World Bank and the European Commission which all consider that giving energy access to the poor would contribute to achieve at least seven out of the eight Millennium Development Goals[2].

Although the African continent hosts a plethora of different natural resources, sub-Saharan Africa's energy crisis is the most severe with less than 30%[3] of its 850 million inhabitants[4] having access to electricity. Around 657 million people[5], i.e. more than three quarters of the total sub-Saharan population, depend entirely upon biomass and coal as primary cooking fuels which corresponds to 58%[6] of the total energy use of the region, with these figures rising in rural parts of the continent[7]. The colossal problem of having adequate means of cooking in sub-Saharan Africa can be tackled by harnessing solar energy, which the African continent possesses abundant resources of. Solar cookers offer a cheap solution to reduce the consumption of non-renewable and dangerous fuels for the continent's rapidly growing energy requirements. Even though they seem to present many advantages, solar cookers are not being distributed as widely as they could be due to several types of barriers which have led many projects to failure.

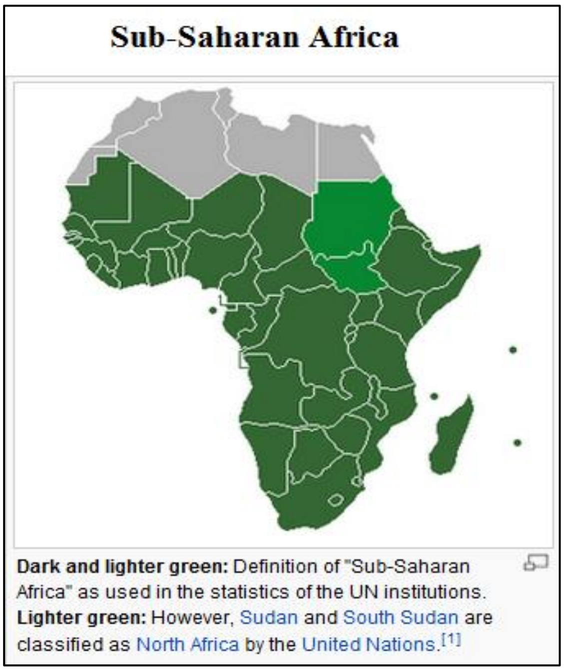

Figure 1.1: Defining "Sub-Saharan Africa" (Wikimedia Foundation 2012)

[1] Differ Group 2012
[2] Practical Action 2009
[3] The World Bank 2011a
[4] The World Bank Group 2010
[5] Differ Group 2012
[6] The World Bank 2011a
[7] Schlag & Zuzarte 2008

This document aims to identify the barriers to the deployment of solar cookers in the energy-poor households of sub-Saharan Africa, as understanding them is the first step towards creating appropriate policy frameworks. In order to assess the potential of these technologies, it is also necessary to explore the ways of overcoming those barriers. The first section consists of a description of the current situation and the environmental and socio-economic implications of traditional cooking methods. The subsequent section focuses on solar cookers and their potential in sub-Saharan Africa; it includes a description of the three main types of technologies available and it refers to the technical and socio-economic advantages of these. The last section reviews all the barriers to the deployment of solar cookers and suggests how to overcome these. It includes technical, financial, public perception, institutional, political and other types of generic barriers. That last section also refers to the different types of programmes implemented to try to solve these issues at an international and national level, both as governmental and independent bodies.

2. Methodology

After an initial standard research on an internet searching network and discovering the main actors involved in the spreading of solar cooker technologies, the author established how to gather the desired information. This had to be done via the examination of some of the main actors' publications. These actors are Solar Cookers International (SCI), Solar Household Energy (SHE), Jewish World Watch Solar Cooker Project (JWW), the Partnership for Clean Indoor Air (PCIA), GIZ, UNDP, United High Commissioner for Refugees (UNHCR), United Nations Environmental Programme (UNEP), Solar Ovens Society and Practical Action amongst others which have all been identified on the Solar Cookers World Network's website. Because recent information was not always easy to gather, the author contacted via a forum some of Solar Cookers World Network's affiliates (see the Acknowledgements section for names) who helped re-directing the search and gave additional information. Statistics and numbers were largely obtained from the websites of The World Bank, the UNHCR and the International Energy Agency. Other articles were found from other searching networks such as Science Direct. Hard materials were only briefly used as most of them contain outdated information and the most recent publications are mostly available on the internet.

3. Africa's Energy Crisis

3.1 Traditional Cooking Method

Sub-Saharan Africa's energy sector can be divided in two regions: South Africa dependent mostly on coal and the rest of sub-Saharan Africa which almost entirely relies upon biomass[8] (see figure 3.1).

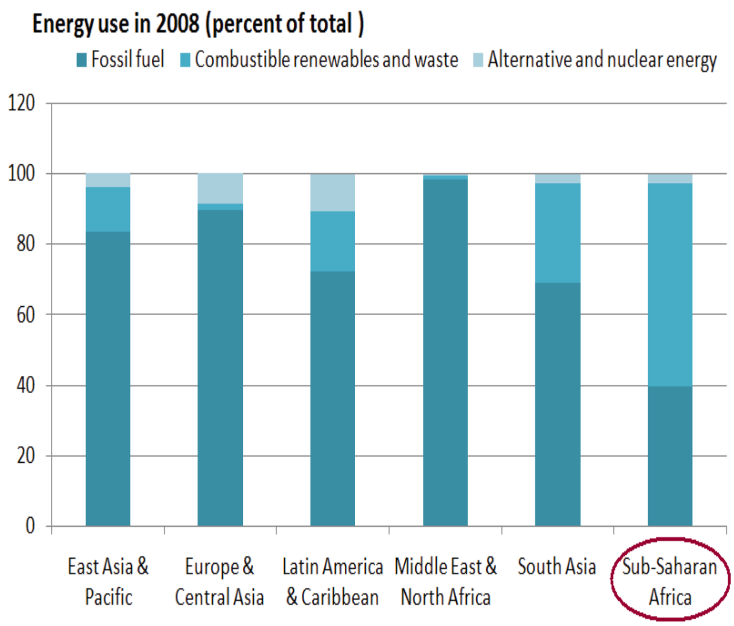

Figure 3.1: Energy Use in 2008 (The World Bank 2011a)

Traditionally, biomass and coal are used for cooking on a three-stone fire system (see Figure 3.2). This consists of balancing a pot over three stones disposed in a triangular shape on the ground with enough spacing between them in order to introduce more fuel as the users are cooking. Although this system is only 15%[9] efficient, it is a quick and easy way of cooking. Being the first cooking method mankind created, it is much ingrained in the culture, especially when it comes to family bonding or other traditions. Other advantages include the warms and light provided by the fire along with the smoke which keeps mosquitoes and other insects away[10] – an important health matter as malaria killed close to 600 000 Africans in 2010 alone[11].

Figure 3.2: Three-Stone Fire (Reed 2010)

[8] Karekezi & Kithyoma 2003
[9] UNHCR 2002
[10] Onyango-Oloo 2006
[11] WHO 2011

3.2 Environmental Impacts

Although the activity of burning biomass has a neutral carbon cycle, poorly managed reserves of wood quickly lead to deforestation (see Figure 3.3) and such a phenomenon has nefarious effects on the environment. The highest rates of deforestation are found around areas where refugee populations reside; the total population of concern in Africa was of more than 10 million in 2010 with the highest concentrations being in Central, East and West Africa[12] (see figure 3.4). A study carried out by the UNHCR in 1998 concluded that cooking activities from these groups are responsible for nearly 70% of the surrounding deforestation[13]. For basic theoretical cooking needs, one to two kilograms of wood should be consumed per person per day; however, in poorly managed situations, this number rises up to

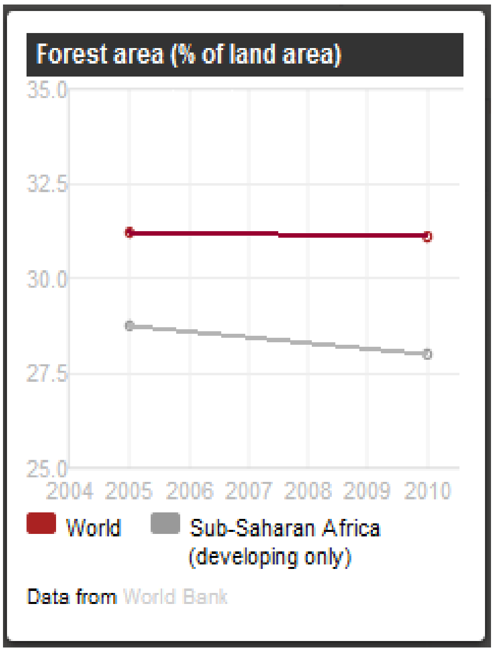

Figure 3.3: Deforestation Index in Sub-Saharan Africa (The World Bank 2012)

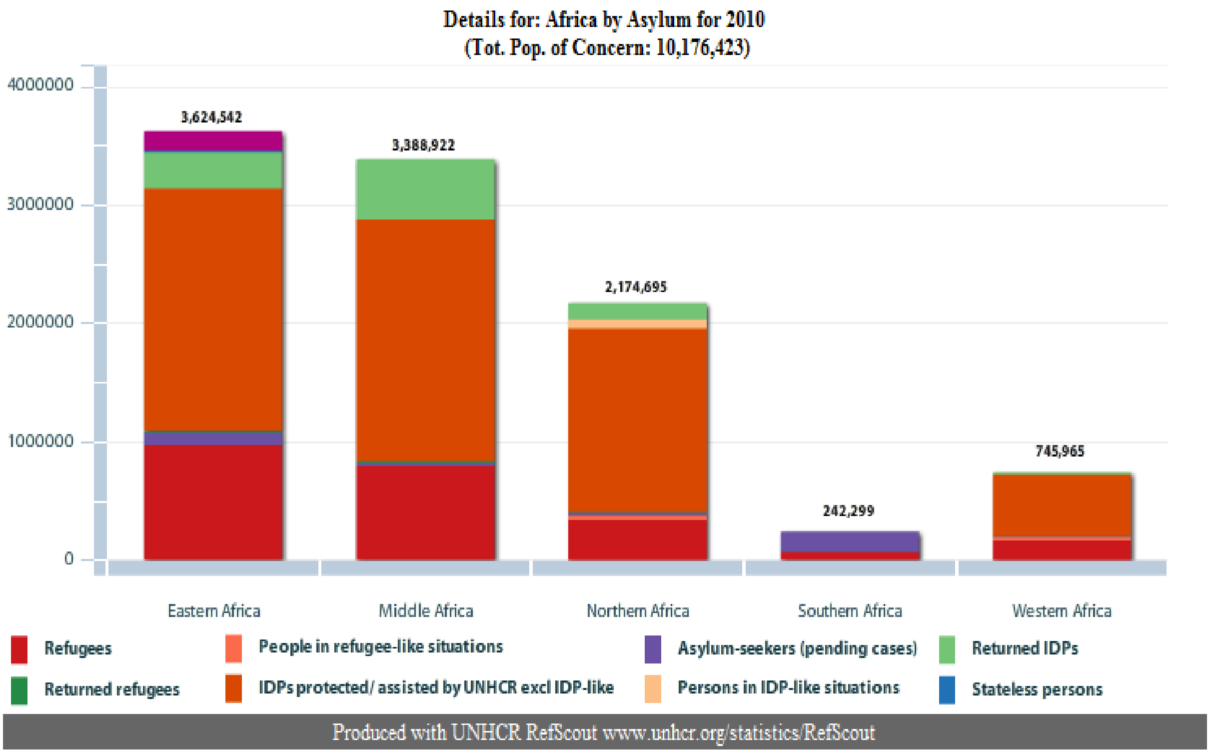

Figure 3.4: Refugee Population in Africa in 2010 (UNHCR 2012)

12 UNHCR 2012
13 UNHCR 1998

three kilograms[14]. Although autochthone populations also have an effect on their biomass reserves, refugee camps put a lot more pressure on their environment since thousands of people can be displaced and relocated within a few days, sometimes in places where the ecosystem is rich and has been undisturbed for decades. Their immediate basic needs drive them to search for any close resources of fuel and uncontrolled wood collection rapidly occurs[15].

The residential sector is said to contribute to 26% of black carbon emissions for which cooking fuels are the main responsible[16]. The lack of photosynthesis due to the loss of biomass drives up carbon dioxide levels leading in turn to what is known as "global warming" and ultimately to climate change. The local populations then become the victims of the formation of micro-climates of which desertification, floods and droughts are the consequences likely to have the most severe impacts[17]; there is currently growing concern over the Sahara's southward expansion[18].

3.3 Socio-economic Impacts

3.3.1 Direct Health Impacts

In addition to CO_2 emissions, the burning of biomass releases carbon monoxide, particulate matter, nitrogen oxides, benzene, sulphur and arsenic which are toxic to humans. Indoor Air Pollution (IAP) causes respiratory diseases which kill 1.6 million people each year – one every twenty. The inhaled smoke is estimated to be comparable to a daily intake of two

Figure 3.5: Smoke in the Kitchen (Benanav N.d.)

[14] UNHCR 2005
[15] UNHCR 1998
[16] AGECC 2010
[17] UNHCR 2005
[18] Whitfield 2005

packs of cigarettes[19]. Health risks include Acute Respiratory Infections, Chronic Obstructive Pulmonary Disease, lung cancer, pneumonias, tuberculosis and cataracts[20] amongst others. The fire itself can become a source of danger especially for children[21].

Due to gender inequalities on the continent, women are largely in charge of cooking and their exposure levels to smoke are two to four times greater than men's; children's are even higher. The levels of pollution they are exposed to can be 100 times greater than those recommended by the World Health Organisation. IAP is progressively starting to being acknowledged as the fourth major global cause of mortality[22].

Other secondary health effects include heat strokes and back pain along with other similar orthopaedic injuries[23] caused by the walks organised to gather wood over increasingly longer distances every day – sometimes up to 10 kilometres or more[24] - with 20 kilograms[25] of firewood on the head on average per person. Some spend over 40 hours a week collecting biomass fuel[26] with trips sometimes lasting a few days[27]. These walks can also result in dangerous encounters with animals: there are several cases of death from snake bites to elephant attacks[28] and many come back injured. Other types of danger from these walks include the risk of walking on landmines[29] from previous conflict areas.

Figure 3.6: Women Gathering Wood in Darfur (Farrow 2009)

3.3.2 Social Impacts

The walks mentioned above are the source of fear to many women and children in developing countries, particularly in refugee camps where there is tension with local populations who might consider any types of local resources as their property, hence creating political

[19] Differ Group 2012
[20] Blacksmith Institute 2008
[21] Solar Household Energy 2012
[22] Knudson 2004
[23] Solar Household Energy 2012
[24] Le Breton 1995
[25] Schlag & Zuzarte 2008
[26] Solar Oven Society 2012
[27] Hanna & McArdle 2012
[28] PCIA 2010
[29] Solar Energy Household 2012

tensions. Indeed, thousands of women and children take daily the risk of being assaulted, kidnapped, tortured and murdered to collect firewood. Some women are even rejected by society because of the red colour of their eyes from infections from the smoke which is said to give them "witches" looks[30].

Because so much time is wasted on the collection of fuel, education and many other activities are left aside which contributes to national issues such as illiteracy[31]. Such effects contribute to large differences in the number of girls and boys that attend school.

Finally, other indirect effects of the deforestation linked to using three-stone fires include the displacement of people caused by droughts and floods; these have recently contributed to the displacement of thousands of people especially in the East and Horn of Africa in 2011 where more than 250,000 Somalis were forced to leave their country[32]. Although the contribution to climate change per capita is much smaller in Africa than in industrialised countries (see figure 3.7), African nations are more likely to be impacted due to poor infrastructure and high dependence on local resources[33].

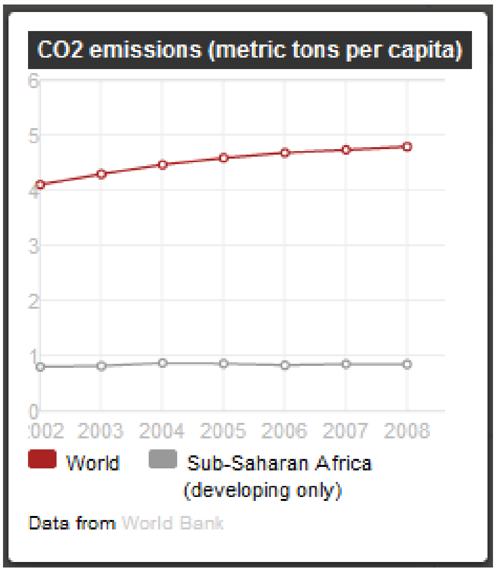

Figure 3.7: CO_2 Emissions per Capita (The World Bank 2012)

3.3.3 Economic Impacts

The cost of wood is rapidly increasing along with the number of families in developing countries who struggle to afford it[34]. A significant proportion of income is spent on fuel and it is often the case when people spend as much money, if not more, on the fuel rather than the food that will be cooked from it[35]. In time, when faced with shortages of supply, families must spend more time, energy and money trying to gather other types of resources[36].

[30] Scott 2004
[31] Schlag & Zuzarte 2008
[32] UNHCR 2012
[33] The World Bank 2011b
[34] Knudson 2004
[35] Solar Oven Society 2012
[36] Carmody & Sarkar 1997

4. Potential of Solar Cookers in Sub-Saharan Africa

4.1 African Climates and Solar Resource

It has been suggested that the simplest designs of solar cookers should be used within certain latitudes - between roughly 40° North and South of the equator which comprises the whole of Africa. The African continent can be divided in many different climatic areas (see figure 4.1), all of which are compatible with solar cooking[37].

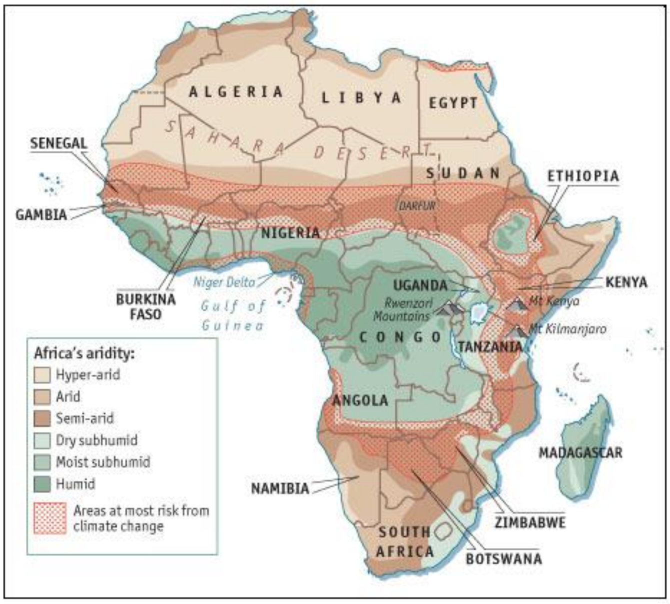

Figure 4.1: African Climates and Dangers of Climate Change (Green 2010)

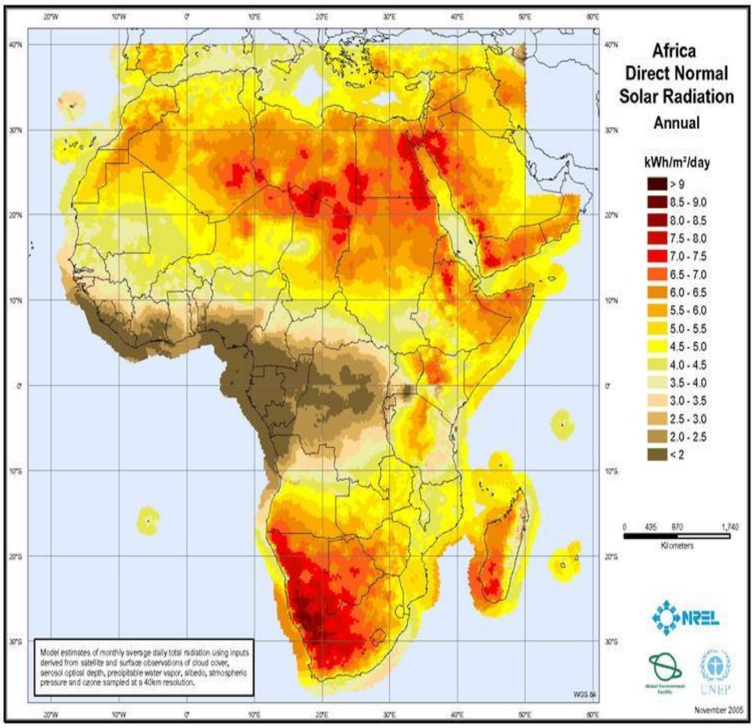

Figure 4.2: Africa's Annual Solar Radiations (National Renewable Energy Laboratory 2010)

The ideal climatic zones are desert areas – particularly in the Sahel region – as the number of clear sunny days can exceed 300 per year[38]. In these areas, solar radiations vary between 4.5 and 8.5 kWh/m^2/day (see figure 4.2).

[37] Knudson 2004
[38] Hanna & McArdle 2012

4.2 Solar Cooker Technologies

4.2.1 History of Solar Cookers

Solar energy was used for the first time thousands of years ago by the Greeks, Romans and Chinese for military purposes. The concept of solar cooking only appeared in 1767 by Horace de Saussure, a French-Swiss scientist who cooked a fruit inside the first version of a solar box cooker. Since then, many scientists contributed to the research and improved the original design. The first practical applications ensued in the 1950s[39], but it is only since the 1970s' oil crises that the potential impact of solar cookers was fully acknowledged. A few sporadic attempts were made towards dissemination until 1987 when SCI was created in order to unify the efforts and focus them towards a common target. SCI has estimated that solar cooking projects could benefit around two billion people around the globe[40].

4.2.2 Most Common Designs

Most solar cookers are designed in industrialised countries and there are currently hundreds of different designs available. However, most can be classified in one of these categories: panel, box or parabolic cookers. They all include the use of black pots as these absorb well sunlight[41]. The costs vary significantly depending on the design, insulation and material used (see section 5).

Parabolic cookers, or "curved concentrators", which are significantly more expensive than other designs due to their complex construction, have the highest ratings. Their parabolic shape (see figure 4.3) focuses the sun's radiation directly onto the pot and temperatures of 250°C can be obtained. Cooking times and practices are similar to those of conventional methods[42].

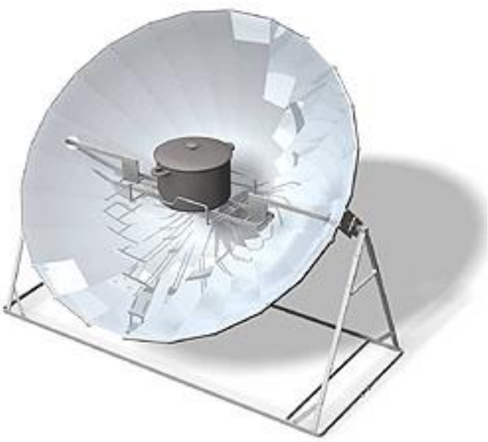

Figure 4.3: Parabolic Cooker (SCI N.d.)

[39] Solar Household Energy 2012
[40] PCIA 2010
[41] Kroon 2004
[42] Hancock et al. 2007


Figure 4.4: "Minimum" Solar Box Cooker (SCI 2012)

Box cookers (or solar ovens) are much simpler to construct – especially with local materials - but have significantly lower ratings and temperatures of 180°C[43]. They are insulated boxes making use of direct and diffuse sunlight[44]. Additional reflective panels can be added to the design to increase the rating. Depending on the size, box cookers have the advantage of being able to hold more than one pot as opposed to other designs. Their outer shell is usually made of cardboard (see figure 4.4), wood, plastic or metal[45].

Panel cookers, which combine the concepts of both parabolic and box cookers[46], are the most simple and low-cost design available. One particular design called the CooKit (see figure 4.5) has been widely distributed among African villages and refugee camps. Although they have significantly lower efficiencies and temperatures only reaching 100°C, they work just as well as box cookers in arid areas[47]. Reflective panels, usually made out of cardboard and aluminium foil, direct sunlight on the pot contained within a sealed plastic bag which lasts up to a month[48] and reduces heat losses. Panel cookers are extremely easy to transport and fold[49]. As for box cookers, legs can be added to the design to elevate the cookers should one desire to have it so[50].

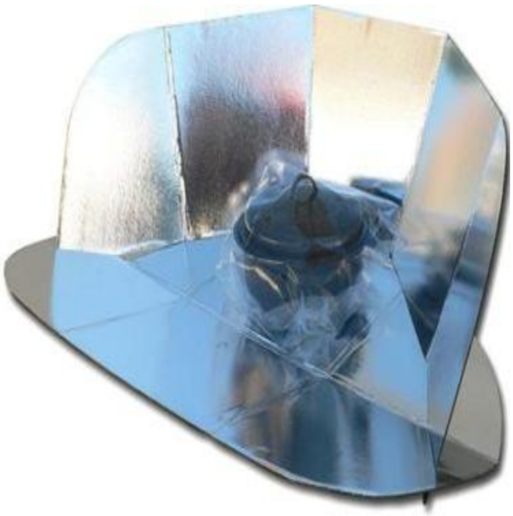
Figure 4.5: Panel Cooker - Model CooKit (SCI 2012)

[43] Hancock et al. 2007
[44] Kroon 2004
[45] Teach a Man to Fish 2010
[46] Teach a Man to Fish 2010
[47] Kroon 2004
[48] PCIA 2010
[49] Kroon 2004
[50] Coyle 2006

4.2.3 Best Practices

There are a few methods worth knowing to decrease the cooking time such as adjusting the orientation of the cooker towards the sun which needs to be done on average every 15 minutes with parabolic cookers and every 2 hours or more with the other designs[51]. The tilt can also be adapted depending on the time of the day, month and latitude. Other improvements include cutting the food into small pieces, placing ingredients that take longer to cook on the hotspots of the cooker, using tight fitting covers for the pots etc[52]. Further examples can be found from PCIA (2010) and Hanna & McArdle (2012) amongst others.

4.3 Benefits of Solar Cookers

4.3.1 Technical Advantages

Solar cookers save between 1[53] and 2[54] tons of wood fuel per year (subject to the source) and can potentially be used as stand-alone systems. Theoretically, there are no negative health impacts associated with solar cooking (see section 5.1.2), and since the outer shell does not get significantly hot, children can safely attend to the food[55]. Solar cookers save time as they do not require stirring nor to be attended as often as with traditional cooking methods, with the exception of parabolic cookers[56].

As opposed to other types of renewable energies, solar cookers are non-permanent structures; therefore, they can quickly be deployed in cases of emergency, particularly panel cookers. There is no technical planning necessary, and it has been reported that because of their good transportability, many refugees bring them back once repatriated[57]. The cookers can be made from recycled or local materials[58]. The company Tetra Pak contributed to such a scheme by providing SCI with waste material such as used cardboard or foil[59].

Other technical advantages include the minimum amount of water or oil needed for the cooking which makes the food healthier. Moreover, the food cannot burn, hence there is less

[51] Hancock et al. 2007
[52] PCIA 2010
[53] Teach a Man to Fish 2010
[54] SCI 2006
[55] Hanna & McArdle 2012
[56] Hanna & McArdle 2012
[57] Klingshirn 2006
[58] Hanna & McArdle 2012
[59] SCI 2006

wastage and cleaning involved[60]. These are particularly important factors where the access to water is restricted[61].

4.3.2 Socio-Economic Advantages

On top of all the benefits associated with the use of solar cookers mentioned in the sections above, this technology enables women and children to spend more time attending to other activities e.g. education. Some women have even started baking businesses with solar cookers, something which could not have been feasible had three-stone fires being used. More surprisingly, men have also started using the technology as it is perceived as "clean and modern". This welcoming change in behaviour could be the start of a gender revolution on the continent as men and women share the familial responsibilities[62].

Solar cookers save fuel, and hence save the part of a household's income dedicated to the purchase of firewood. The cost of the cooker - which when subsidised can be sold around $4(US) for panel and box types or even less[63] - is therefore quickly repaid. The deployment of solar cookers can have significant impacts on the local economy as it creates jobs: in refugee camps, refugees have started several times little workshops to manufacture and repair solar cookers[64]. Local businesses also see their demand rising as the need for materials is felt and thus end up employing new personnel[65].

Finally, when properly taught about climate change, women have reported the satisfaction of knowing they are making a difference and providing a safer future to their children[66].

[60] Hanna & McArdle 2012
[61] SCI 2010
[62] Coyle 2006
[63] Teach a Man to Fish 2010
[64] SCI N.d.
[65] Carmody & Sarkar 1997
[66] Knudson 2004

5. Barriers to the Deployment of Solar Cookers

5.1 Technical Barriers

5.1.1 Weather and Other Environmental Concerns

One of the major barriers to solar cooking is total dependence on the weather. The cookers are thought to be effective when the sun is perceived as strong and the atmosphere is warm but the intermittency created by clouds still affects cooking times[67]. Because parabolic cookers are so demanding in terms of readjustment, many have rejected the technology due to the amount of dedication required. Furthermore, cooking times in different parts of sub-Saharan Africa vary and might not be in tune with ideally sunny hours, particularly for breakfast and dinner e.g. South Africa where most of the cooking is done in the early evening[68].

Furthermore, elements such as rain, sand and dust – and ultimately cleaning - damage significantly the cookers which can see their rating reduced by 25%. Erosion particles also pose problem as they contribute to lower levels of solar radiation as witnessed in programmes in Burkina Faso[69]. The wind is an additional burden particularly for parabolic cookers which can easily be blown away due to their particular design[70]. These issues can be solved by improving the design and using higher quality materials. However, these adjustments create other financial barriers as evoked in subsequent sections.

5.1.2 Design and Material Related Issues

A good design is a design that meets the users' needs. Several factors must be taken into account such as the number of people cookers can feed, the number of pots these can therefore hold, their desired size, their functionality, whether they allow sufficient time to cook once the women come back from the market with the purchased food[71], whether their appearance matches the aesthetic standards of the community, are permanent structures and must be placed outdoors[72] etc. - more details are given in section 5.2. Each type of solar

[67] Coyle N.d.
[68] Hancock et al. 2007
[69] Anon 2012
[70] Hancock et al. 2007
[71] Coyle 2006
[72] Aalfs N.d.

cooker designs has its drawbacks and advantages over others. The table below (figure 5.1) summarizes these.

Comparison of Different Types of Solar Cookers							
Type	**Cost**	**Safety**	**Ease of build**	**Cooking speed**	**Cooking capacity**	**Longevity**	**Other**
Panel	Lowest	Safe	Easy	Several hours	4-6 people	Lowest (cardboard susceptible to moisture & insect degradation)	Easy to transport, need to replace plastic bag, no adding possible for some designs e.g. CooKit
Box	Low	Safe	Easy	Several hours	Dependant on size	Medium/ depends on materials	Adding or stirring impossible on some designs
Parabolic	High	May cause burns & eye injury	Complicated (requires specialised materials)	Similar to conventional stove but requires adjustment to the sun every 15min	Dependant on size	High/ depends on materials	Potential to burn food (same as on traditional fires)
Sources: Black: Solar Cooking Plan 2012 Blue: Aalfs N.d.							

Figure 5.1: Comparison of Different Types of Solar Cookers (Solar Cooking Plan 2012 & Aalfs N.d.)

The low quality associated with some designs enables distributors or Non-Governmental Organisations (NGOs) to reduce the costs for end-users. Therefore, certain cookers are fragile, such as panel cookers like the CooKit of which the main component, made of cardboard, is vulnerable to moisture and insects degradation. Box cookers' glass plates break easily and are difficult or expensive to purchase in many parts of Africa[73]. It is worth noting that the cost, ease of build, safety and longevity of each cooker can be significantly changed with different types of material which could partially solve the issues. In addition, with sufficient training, the safety issues linked to the use of parabolic cookers can be avoided[74].

5.1.3 Inaccessibility of Materials and Lack of Infrastructure

The low-cost types of solar designs can easily be made locally by semi-skilled artisans; however, these require materials which are not always accessible, especially in rural areas where most of sub-Saharan Africa's population lives (see figure 5.2). Difficult materials to obtain usually consist of anodised plates of aluminium or foil, hardened glass[75], mirrors,

[73] Jongbloed 2006a
[74] PCIA 2010
[75] Anon 2012

black pots and plastic bags. NGOs are often obliged to build the cookers in their countries of origin –usually industrialised ones- and then sell them abroad at subsidised prices while also giving pans and bags for free. The demand for new bags is an excellent indicator to the frequency of use of solar cookers – however it has proved to be quite low in the past[76]. A market study made in South Africa in 2003 stated that 11% of the people who did not adopt solar cookers simply could not use them due to the unavailability of black pots[77].

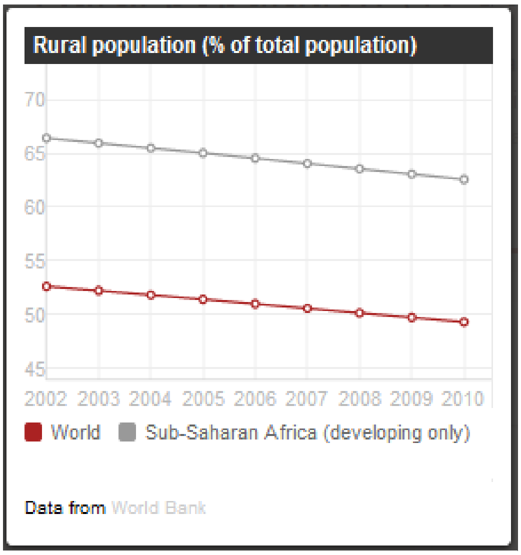

Figure 5.2: Rural Population of Sub-Saharan Africa (The World Bank 2012)

The need for local shops is high as customers also need maintenance and after-sale services[78]. South Africa manufactures some parabolic cookers but the lack of expertise and/or adequate materials makes their designs imprecise[79]. Ultimately, problems associated with distribution and supply lie within the lack of infrastructure in sub-Saharan Africa and its associated logistical issues. The potential users of solar cookers reside in areas where only 10% of the roads were paved in 2004 - which drives up transportation costs and makes distribution difficult[80] - and where the access to electricity is almost inexistent and literacy is rare[81]. This eventually leads to administrative problems and difficulty in creating data which altogether jeopardise solar cooking projects[82]. Burkina Faso's solar cooking sector is particularly affected by this lack of infrastructure which is why it is developing more slowly that in South Africa[83].

Furthermore, access to information is difficult especially for insular populations[84]; this lack of awareness must be addressed as populations do not realise the implications of their fuel choices or do not know of their alternatives[85]. Finally, the lack of infrastructure in rural areas drives promoters to advertise their products near reliable networks in urban areas where the

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[76] Kroon 2004
[77] Pouris & Wentzel 2006
[78] Kroon 2004
[79] Anon 2012
[80] Schlag & Zuzarte 2008
[81] Coyle N.d.
[82] Coyle N.d.
[83] Anon 2012
[84] Knudson 2004
[85] Schlag & Zuzarte 2008

competition is fiercer and the market is harder to penetrate[86]. Once again, the solution resides in solving issues locally and through governmental schemes[87]. Ways of achieving this are discussed in section 5.3.

5.1.4 Other Technical Barriers

The potentially largest barrier to the acceptance of solar cookers is the long cooking time required for the simplest designs as opposed to other technologies[88] (see figure 5.3 and 5.4). Meals containing meat particularly need several hours before being edible, which is not always achievable if the food is purchased late in the day.

Controlled Cooking Test.

Time used to boil 5 liters of water by selected clean cookstove types, including a solar cooker. Source: Aprovecho Research Centre.

Characteristic	Three stone fire	Rocket stove	Institu-tional stove	Solar cooker
Time to boil	38	38	32	70

Figure 5.3: Solar Cooking Times Vs. Conventional Technologies (Differ Group 2012)

Since cookers require outdoor space, energy-poor households living in urban environments see themselves obliged to place their device on the roof or other locations difficult to access[89]. Leaving the food to cook unattended outdoors also has its drawbacks as the cookers can be damaged by children or animals and even sabotaged by neighbours. Placing cookers on a table has been done before but adds discomfort as the table needs to be moved around[90]. Thefts and poisoning of the food have also been reported[91].

Cooking Times

Do not open pot and stir food while it is cooking. Start early to allow time for cooking
Approximate cooking times for 4 pounds (2 kilos) of food on a sunny day:

1–2 hours	3–4 hours	5–8 hours
Eggs	Potatoes	Large roasts
Rice	Vegetables (roots)	Soup and stew
Fruit	Some beans, lentils	Most dried beans
Vegetables (above ground)	Most meat	
Fish	Bread	
Chicken		

Figure 5.4: Example of Cooking Times for Principal Ingredients (Hanna & McArdle 2012)

Finally, solar cooking is only rarely used as a stand-alone system[92] except in extreme cases e.g. in refugee camps; most people continue to gather

[86] Schlag & Zuzarte 2008
[87] Mele 2012
[88] Knudson 2004
[89] Kroon 2004
[90] Kroon 2004
[91] Curtis 2006
[92] Klingshirn 2006

firewood to meet their energy requirements. Solar cookers ultimately only save up to 40%[93] of fuel which makes people doubt their utility (see section 5.2).

5.2 Public Perception

5.2.1 Traditions and Beliefs

The African continent is host to more than 3000 ethnic groups[94] which have their own traditions, rituals and beliefs. Some African women like the hot smoky kitchen atmosphere as it enables them to gather while keeping the men away[95]. In parts of Uganda, a man removing the three stones out of the fireplace indicates his wish of divorce. In other parts of the country, stoves made by the husband's mother are a sign of acceptance of the daughter-in-law; if the later builds her own stove she is believed to be cursed with infertility[96]. Others yet reject square box cookers as they believe circular shapes to be the mark of perfection[97]. This can be remediated by encouraging future users to build their own design as they are more likely to come up with an aesthetic aspect conform to their norms[98], hence enforcing the feeling of ownership for the technology[99].

It is in remote areas where the traditions are unshaken that the acceptance levels of the technology are the lowest[100]. Due to lack of education and access to information, people often do not believe that the sun alone is capable of cooking[101] and turn themselves to their own beliefs for explanations. As a result, many conclude that solar cooking is the act of the devil, the result of black magic and even run away. However, this can be turned to the promoters' advantage as the Sabbath, part of the three main monotheistic religions, encourages the use of solar energy; word-of-mouth can then become a powerful tool[102].

Promoting new technologies requires thorough examination of all these different cultural aspects as they have often been the reason behind the slow spreading of solar cookers. Appropriate promotion strategies are suggested in section 5.3.1.

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[93] Hancock et al. 2007
[94] Reader 1999
[95] Coyle 2006
[96] Impact Carbon 2012
[97] Coyle 2006
[98] Aalfs N.d.
[99] Mele 2012
[100] Coyle 2006
[101] PCIA 2010
[102] Coyle 2006

5.2.2 Gender Inequalities

In sub-Saharan Africa, household – especially financial - decisions rest on the shoulders of men even though women are in charge of cooking[103]. Particularly in rural areas, firewood is considered as a free resource and its collection has no real perceived value. Although this is not necessarily a gender issue, as it has always been the women's task, men do not recognise the dangers associated with the use of three-stone fires and therefore do not feel the need to invest into a new technology[104]. Hence, justifying solar cookers' benefits to groups of men can be challenging[105]. Some got scared that their wives would have more free-time to gather with other women and acquire new skills[106] while others embraced the technology as they saw a good opportunity for women to take over some of their own tasks[107]. Women have also expressed the fear of being beaten up by their husbands should the food look or taste different to usual[108]. They have been observed to be much more flexible to adapt to solar cooking systems while men desire to maintain their normal eating times regardless of the benefits the technology could bring to their household[109].

In some cultures, men and women have to be addressed separately[110]. This can be an advantage as women feel freer to speak openly, however it is important to get all local leaders together to encourage communication between the sexes and for the men to understand all the implications of collecting firewood and cooking with traditional methods (see section 5.3.1). Recognising the problem is the first step towards the adoption of solar cookers[111].

5.2.3 Adoption Criteria of Energy-Poor Communities

Field studies proved that there are three key elements to the adoption of clean cookstoves against traditional cookers: reduction of firewood consumption, similar cooking times and similar or better functionality[112] (see figure 5.5).

[103] Impact Carbon 2012
[104] Coyle 2006
[105] Impact Carbon 2012
[106] Coyle 2006
[107] Kroon 2004
[108] Coyle 2006
[109] Klingshirn 2006
[110] Hanna & McArdle 2012
[111] Hanna & McArdle 2012
[112] Differ Group 2012

Apart from parabolic designs, panel and box cookers take a while to cook food and although they give more time to the cooks, adding ingredients and activities such as frying or roasting are impossible thus cooking some key traditional or regional meals is not always an option[113]. The food also has a different texture and brighter colour when cooked in solar ovens and lacks the smoky flavour given by three-stone fires[114]. Furthermore, the cooks are usually reluctant to "risk" their one daily meal on an unknown technology[115]. The alternative must be dire enough for people to be willing to change completely their habits, or solar cookers must be used in combination with other technologies e.g. Integrated Cooking Systems (see section 5.3.1).

Key factors and methods for evaluating clean cookstove performance and salability

Key factors rated by importance for adoption and salability, health and environmental benefits. Identified 'must have' factors and recommended testing method for the various key factors..
Rating: 1: High importance, 3: Low importance. Testing methods: L = Laboratory, F = Field, S = Survey

Key factors	Adoption & salability	Health benefits	Environmental benefits	'Must have' factors	Testing method
Fuel reduction	1	2	1	X	L, F
CO reduction	2	1	1	X	L, F
PM reduction	2	1	1	X	L, F
Reduced/similar cooking time	1	2	2	X	L, F
CO2 reduction	3	2	1	X	L, F
Long lifetime	2	3	3		F
Low breakage rate	3	3	3		F
Improved safety	2	1	3	X	F, S
Improved cleanliness	3	3	3		F, S
User friendly size/usability/functionality	1	3	3	X	F, S
Affordable price	2	3	3		S

Figure 5.5: Key Factors and Methods for Evaluating Clean Cookstove Performance and Saleability (Differ Group 2012)

Finally, the adoption criteria differ between urban and rural communities. Near cities, firewood is more expensive[116] therefore urban populations are motivated by benefits they can make by saving fuel. Rural populations are more driven by the reduction of dangerous journeys to gather wood. The potential for health improvements rarely affects their decisions[117]. Neither pollution nor climate change are of any preoccupation, while they would be one of the main selling arguments in industrialised countries. Rural communities will also perceive more the halt to some firewood-related businesses and promoters must ensure that it is well understood that local solar businesses have even more potential of hiring[118].

113 Coyle 2006
114 Kroon 2004
115 Coyle N.d.
116 Schlag & Zuzarte 2008
117 Aalfs N.d.
118 Hanna & McArdle 2012

5.2.4 Perceived Financial Benefits

Even though solar cookers constitute the cheapest form of renewable energy technology and can be heavily subsidised, their price is still considerably high for populations that live in extreme poverty (see figure 5.6). Furthermore, even when households secure a disposable income, cooking rarely ranks among priority expenses[119].

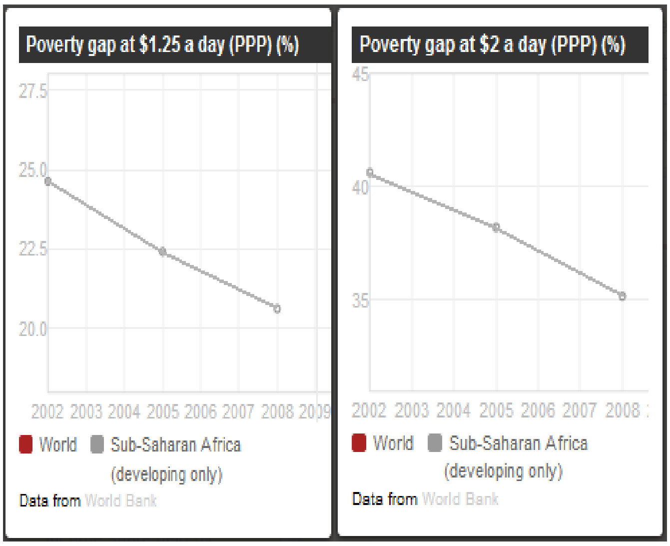

Figure 5.6: Poverty Gaps at $1.25 and $2(US) in Sub-Saharan Africa (The World Bank 2012)

In order to buy a cooker, one must have access to credit and this is not always available[120]. When it is, some women will refuse to take it as they are reluctant to be indebted. They would rather pay by instalments until they fully own the cookers which slows down the overall spreading process. The concepts of "investing", "saving" and "return on investment" are not fully understood in some places[121]. Solving this problem would have to be done via the slow-process of giving access to information to energy-poor communities. Further solutions are proposed in section 5.3.

5.2.5 Image of Solar Cookers

Some cookers are very low quality for distributers – mainly NGOs - to minimise their costs. However, surprisingly, the design of the cookers holds a significant importance to the end-users and some cookers have been rejected because the materials used were considered to be too "cheap". Yet, more sophisticated designs are too expensive for energy-poor households. The promoters must instil the idea that "simple is beautiful"[122].

Another discovery for promoters was the lack of sense of ownership described by targeted populations when cookers are distributed for free[123]. Even though NGOs are not able to fully subsidise expensive efficient cookers, end-users do not want to buy cheaper designs which

119 Coyle N.d.
120 Kroon 2004
121 Coyle 2006
122 Shakerin 2006
123 Differ Group 2012

have slower cooking times and lower prestige[124]. Some reported that they did not see the need to buy solar cookers if even the highest social classes rejected the technology[125]. Many admitted not using their cooker because they became “bored” with it[126].

As a solution, some promoters decided to advertise other non-cooking additional uses of solar cookers which seemed to have a significant impact on their audience[127]. These include preparing hot drinks like tea, making jams and sauces, drying vegetables and fruits, baking cakes, heating milk and pasteurizing water at 65°C. In addition, they have been used for killing insects contained within seeds, smelting, making wax, sterilising soil, warming irons to iron clothes[128], making the laundry[129], making cosmetics like karité butter[130], sterilising medical kit and distilling water for batteries[131]. Solar cookers are also so easy to use that they offer a decent alternative to handicapped women[132]. Other solutions include getting potential users involved in the construction of their own cookers and advertising Integrated Cooking Systems (ICS- see subsequent section). Finally, it should be important to the users that solar cookers are not viewed as a new gadget, but as a potentially life-saving device.

5.3 Institutional and Political Barriers

5.3.1 Poor Project Planning and Promoting Strategies

One of the reasons why solar cookers are not as widespread as they could be is because of the lack of faith in the technology established in the 1960s, 1970s and 1980s as a result to poor promotion[133]. Although the responsible promoters had all the honourable intentions, failures of projects due to weak strategies, lack of training[134] and immature technologies were much publicised and gave way to scepticism[135]. The customers’ initial enthusiasm died quickly

[124] Krämer 2009
[125] Jongbloed 2006a
[126] Pouris & Wentzel 2006
[127] Kroon 2004
[128] Ahmad 2009
[129] Hoedt 2006
[130] Hancock et al. 2007
[131] Kroon 2004
[132] Jongbloed 2006b
[133] PCIA 2010
[134] Coyle N.d.
[135] Aalfs N.d.

after discovering the technology's technical barriers which had not been explicitly divulged by the promoters, leading angry rumours to be rapidly dispersed[136].

Implementing viable long term projects takes time in the preparation. Project stakeholders need to design a project with enough financial grounds for an average period of 5 years[137] and enough back-ground research on the targeted populations, eventually with anthropologists, via face-to-face dialogues to learn about their customs, traditions, needs etc.[138]. The lack of back-ground literature available comprising reliable data, monitoring and project follow-up information[139] is also an important barrier. Barbara Knudson, key member of SCI, published in 2004 "State of the Art of Solar Cooking" in which she created a system which classifies the suitability of African countries depending on their infrastructure, geography and political stability[140]. In that same year was published a document listing the 25 countries more likely to benefit from solar cooking – of which 16 are sub-Saharan African - based on solar radiation and fuel scarcity[141]. There are no similar recently updated documents specifically targeted at the spread of solar cooking currently available.

Most promoting strategies made the error of advertising only one design, hence creating competition against other technologies and fuels but also against other solar cookers – which is why many disbelieve the benefits likely to result from full commercialisation of this technology as the diversity of prototypes can become a barrier to dissemination in itself (see subsequent section). The key is to firstly develop the simplest and/or cheapest cooker while informing the targeted audience about the different types of design available and letting it decide which is best suited for its needs. Projects must comprise a set of progressive phases to create a continuous feedback loop in order to remain flexible with the key decisions involved[142]. Such phase-by-phase type of approach is the best way to ensure that no negative repercussions result from wrong decisions made in the early stages of the project[143].

Furthermore, it has been established that due to many barriers, solar cookers cannot be advocated as a stand-alone system and presenting it as such is a fundamental mistake that

136 Hancock et al. 2007
137 Hanna & McArdle 2012
138 Coyle N.d.
139 AGECC 2010
140 Knudson 2004
141 SCI 2004
142 Onyango-Oloo 2006
143 Onyango-Oloo 2006

drives populations' scepticism even further[144]. Therefore, more and more institutions promote an appropriate mix of technologies called Integrated Cooking System[145]: this comprises a solar cooker, a heat-retention basket and an improved biomass cookstove. The solar cooker is to be used whenever the weather allows it while the heat-retention basket should keep warm pre-cooked food for several hours after the sun has set. The improved stove – of which the Rocket stove is the most popular design – saves up to 80% of the firewood[146] as opposed to three-stone fires and should only be used when the other two devices do not suffice. Panel and box cookers in particular enable households to have more time to gather wood to meet the rest of their energy demand[147]. This new strategy has only been clearly recognised thanks to Dr. Paul Krämer in 2008 at the EG Solar conference in Burghausen[148] and so it is yet too early to establish how successful the dissemination of such a system will be. However, the positive reactions from Sudanese women to a pilot project in the Iridimi refugee camp (Chad) give a lot of hope to all those promoting this new cooking method[149].

Figure 5.7: Integrated Cooking System (Whitfield 2005)

Once that key concept is integrated by the promoting institutions, these can start incorporating some basic elements into their strategies. One of them is making sure that the populations understand the urgent need to move on to clean stoves and what it can bring to them[150]. As well as promoting the purchase of solar cookers, it has been suggested to encourage just as much the action of using them[151]. The involvement from the start of local, regional and national male and female leaders along with any potential stakeholders will influence significantly the project's evolution[152]. Promotion times and locations must be carefully selected e.g. to sell at times when the income is highest for some i.e. end of harvest

[144] Onyango-Oloo 2006
[145] Whitfield 2005
[146] UNHCR 1998
[147] Onyango-Oloo 2006
[148] Anon 2012
[149] Hanna & McArdle 2012
[150] Hanna & McArdle 2012
[151] Hancock et al. 2007
[152] Hanna & McArdle 2012

time[153], or to promote in schools as children proved to be more approachable in Easter Chad refugee camps. Future solar cooks must see the food being prepared in front of their eyes and taste it before embracing the new technology; making use of local established institutions to organise perhaps a village feast is more likely to inspire them[154]. Cooking is mostly still considered as a private activity and promoting cooking-related devices can be perceived as invasive. Promoters must take care to expose solar cooking in public areas to avoid such reflexions[155]. Another promotion technique has been to inform Africans – notably Kenyans - on solar cookers via a trans-world radio[156].

Many institutions such as JWW are also ready to give advice as to where one can get appropriate training for staff to go and promote solar cookers on the field[157]. Training local men and women for male and female audiences respectively has also proved to be a successful approach[158], e.g. in Lesotho a few years ago[159]. The quality of the demonstrations and training sessions for using and manufacturing solar cookers has a far greater importance than the quantity of people present to these for successful implementations[160]. There are many other valid strategy elements proposed in several publications such as Hanna & McArdle (2012), PCIA (2010) and Hancock et al. (2007) which could all influence the success of a project.

5.3.2 Financial Barriers: Subsidies or Market Development?

As has been mentioned in section 5.2.4, solar cookers are cheap though still difficult to afford for the poorest communities. Historically, NGOs have taken on the responsibility of subsidising solar cookers. Millions of clean cookstoves have been distributed on this model between Africa and Asia[161]. However their reach is limited as they struggle themselves to find funding; even partial subsidies are not a viable long-term solution particularly for small NGOs.

[153] Impact Carbon 2012
[154] Hanna & McArdle 2012
[155] Klingshirn 2006
[156] Knudson 2004
[157] Hanna & McArdle 2012
[158] Coyle 2006
[159] SCI N.d.
[160] Solar Cooking World Network N.d.
[161] Differ Group 2012

The cookers themselves are not expensive to manufacture and distribute. Margaret Owino from SCI's East African office suggested an average figure of $40(US) for simple designs[162]; the cheapest model of all, the CooKit, only costs between $3 and $7(US)[163]. Most of the expenses go towards other operations - particularly raising awareness and educating[164]. Administrative matters can become a barrier themselves: Solare Brücke, a small German NGO, is keeping away from governmental grants as they impose on their beneficiaries a lot of structure, formalism and deadlines which limit the agency's flexibility[165]. The same is required from Clean Development Mechanism (CDM) projects and the initial hope this financial mechanism brought died with the failure of ACEH 1, the first CDM solar cooking project which went through a sudden change of methodology. Because of this and the small-scale aspect of some projects, other similar schemes were never carried forward[166].

The dissemination of fully subsidised clean stoves has not proved to be successful[167] and having users building their own device has not worked either as some have stated that material costs were still far too great for their modest wages[168]. The natural progression of any technology is to evolve from the research, development and demonstration phase to full commercialisation. Amongst clean cookstoves, improved cookstoves are the only ones close to reaching that last stage[169] as they are cheap and less intrusive on traditional habits than solar cookers which, on the other hand, still require heavy subsidies from the governments to reach commercialisation in sub-Saharan Africa[170]. It is important though for subsidies strategies not to interfere with market development and to have clear patterns to strictly aim at the poorest communities[171]. If governments chose to make these subsidies also available to urban populations, they have to be high enough to enable the inner-city competition to continue[172].

Market development would be ideal to make the technology better known and accepted by selling higher quality models to richer communities and turn around the poor image given by inappropriate promotion strategies from the past. However, NGOs' subsidies have prevented

[162] Solar Cooking World Network N.d.
[163] SCI 2011
[164] Coyle N.d.
[165] Hoedt 2006
[166] Krämer 2009
[167] Differ Group 2012
[168] Carmody & Sarkar 1997
[169] Differ group 2012
[170] PCIA 2010
[171] Slaski & Thurber 2009
[172] Schlag & Zuzarte 2008

some local manufacturers from investing into this market[173] and so far it has proven challenging to find motivated local entrepreneurs with sufficient funds and capacity[174]. Currently, manufacturing could be considered on small local scales while other elements around it - from research to finances – still have to be taken in charge by larger sectors[175]. South Africa's market is the only one in the region to be expanding quite rapidly and shows great promise in becoming one of the leading countries of the sector[176]. Figure 5.8 shows an example of business modelling for box cookers.

Figures: Solar Box Cooker

Start-up Costs			
Item	Unit Cost	Unit (s)	Total Cost
Start-up Costs:			
Equipment to make boxes:			
Knife	$2	1	$2
Tape	$2	10	$20
Scissors	$2	1	$2
Other	$20	-	$20
Marketing:			
Advertising Budget	-	-	$100
Contingency Fund			$20
Total Start up Cost:			$164

Profit Calculation: 500 Cardboard Box Solar Cookers			
Item	Unit Cost	Unit (s)	Total Cost
Operational Costs:			
Materials:			
Inner Boxes	$0.50	500	$250
Outer Boxes	$0.70	500	$350
Other Materials	$1	500	$500
Contingency	$0.10	500	$50
Labour	$0.30	500	$150
Total Operational Cost:			**$1,300**
Solar Cooker Sales	$4.00	500	$2,000
Total Revenue			**$2,000**
TOTAL PROFIT			$700

$1.40 profit on every solar cooker sold (after start-up costs).

Figure 5.8: Business Modelling for Solar Box Cookers (Teach a Man to Fish 2010)

Finally, to consider a system combining partial subsidisation and commercialisation, end-users must have access to micro-credits, low-interest loans or even barter arrangements[177] - such as having to plant a certain amount of trees before receiving a solar cooker[178] - to either buy solar cookers or start solar cooking businesses. Failures have previously occurred due to the lack of interest on behalf of banks or their strict and high insurance arrangements[179]. Hiring systems "only for sunny days" have proven to be fairly successful in Burkina Faso. However, loan systems were only successful among higher social classes as many poorer

[173] Klingshirn 2006
[174] PCIA 2010
[175] Hanna & McArdle 2012
[176] Anon 2012
[177] Curtis 2006
[178] Onyango-Oloo 2006
[179] Karekezi & Kithyoma 2003

communities failed to repay their monthly fee on time[180]. In 2010, micro-finances were only beneficial to commercial schemes and not destined for domestic purposes[181]; since, not much has been published on the subject. As mentioned in section 5.2.4, many prefer the alternative of layaway plans. Funding schemes must also remove the gender barrier which prevents women from having access to credits in many countries[182].

The GEF Small Grant Programme supported by the UNEP and UNDP has contributed to solve some of these issues particularly in Senegal and South Africa by providing funding to some solar cooking initiatives[183]. The German NGO GIZ also contributes greatly towards the financing of some projects. Ultimately though, only national and inter-regional governments can propose adequate funding schemes and push banking institutions to take action on these issues and collaborate with others – e.g. the African Development Bank Group and the World Bank. Encouraging governments to provide funding for subsidies can be difficult as solar cookers do not have drastic effects on production[184]. Perhaps getting an insight on China's successful dissemination strategies – which combine both state-controlled and commercial dissemination of subsidised cookers – could contribute to similar fruitful deployments on the African continent[185].

5.3.3 Lack of Coordination and Linkage

A good collaboration between different institutions can be the catalyst to a successful implementation. China's effective dissemination of solar cookers is based on both considerable investments and collaborations between the government and the industry[186]. Before such alliances can be considered, internal problems within agencies must be solved. It has been reported that some ideas on the Aisha refugee camp's solar cooking dissemination programmes were not always fully supported by all members of the UNHCR – which has been the most active agency on the solar cooking front in the 1990s until the mid-2000s -

[180] Hancock et al. 2007
[181] PCIA 2010
[182] Carmody & Sarkar 1997
[183] SCI 2009
[184] Carmody & Sarkar 1997
[185] Hancock et al. 2007
[186] Klingshirn 2006

which led to considerable bureaucratic complications. Moreover, the project's success was barely acknowledged[187].

Some agencies also work in the same area but do not cooperate fully nor share information e.g. the World Food Programme, Jewish World Watch and CARE all working individually in Chad, as reported by an anonymous member of SCI (Anon). NGOs rely mostly on donations; hence, an important part of their revenues goes towards the advertising of their agency to other donors so as to appear more appealing than the "competition" i.e. other NGOs[188]. The resulting poor coordination drives some projects to end others. In order to gain control over deforestation around refugee camps, the UNHCR started a few programmes in the 1990s to distribute firewood to these populations. This proved to be ineffective as the refugees kept to their usual activities and tried to sell these given fuels in order to have a supplementary source of income for the family[189]. In the Daadab refugee camp, an American aid agency followed the same idea and was fully responsible at the time for ceasing all solar cooking activities in the area[190].

The lack of communication on activities or monitoring data between such agencies which do have the means to have it differently is troubling. Some though do try to collaborate, such as the Senegalese government which offered to fund manufacturing facilities for box cookers throughout the country in partnership with the UNDP which was to subsidise the first 1000 devices[191]. SCI developed several solar cooking projects with its partners in refugee camps in Kenya and Ethiopia which have been very successful and is now involved with several Chadian and Sudanese refugee camps with JWW and KoZon amongst others[192]. The German NGOs CARE and EG-Solar were also working together in the last few years to send efficient cookers to refugee camps in Chad. However, in such cases, other barriers get in the way such as domestic transportation issues which, in that last example, were only solved months later by the Chadian ambassador to Germany. The communication with the Chadian government was slow as the country often experiences shortages of electricity which can last up ten days[193].

[187] Knudson 2004
[188] Anon 2012
[189] UNHCR 1998
[190] Hancock et al. 2007
[191] PCIA 2010
[192] Sponheim 2012
[193] Anon 2012

Many others have tried to collaborate with NGOs or governmental agencies, but the failure of common projects led them to go their separate ways and to grow fearful of such collaborations[194]. Some past collaborations involved too many great actors e.g. the short-term irregular promotions launched by the UNHCR, UNESCO and World Food Programme[195]. SCI tries to overcome these barriers by creating an open network to share information and implementation techniques[196]. The Solar Cookers World Network website even includes a summary of all the different actors (individuals, NGOs and potential donors) and the latest news for 35 countries of sub-Saharan Africa[197].

As has been mentioned in several other sections of this document, working on small-scale has given far better results than on a larger one for the dissemination of solar cookers. This in itself challenges the model of commercialisation which would favour centralised over distributed generation. Creating reliable networks between urban centres and rural areas is a long expensive process which can only be addressed by large governmental schemes[198]. A simpler temporary solution is for regional and national leaders to collaborate with agencies and NGOs willing to act on small scales[199]. Local organisations or ministerial departments need to provide workforce for the completion of projects and need to get involved at the first stages in order to ensure the follow-up after the NGO has left the project[200].

However, smaller local businesses are thought to have a better chance at reaching the energy-poor rural communities[201] and should therefore be given a chance to invest at least partially in solar cooking projects[202]. The AFRECA network has been established in 2005 for southern African nations in order to regroup all manufacturers, suppliers and product developers of ICS elements in the region to raise awareness and create a reliable professional network[203]. No publications on the subject have attempted to determine its actual effects.

[194] Hoedt 2006
[195] Knudson 2004
[196] Coyle N.d.
[197] SCI N.d.
[198] Slaski & Thurber 2009
[199] Schlag & Zuzarte 2008
[200] Onyango-Oloo 2006
[201] Schlag & Zuzarte 2008
[202] Practical Action 2009
[203] AFRECA 2009

5.3.4 Other Political Barriers

As a reaction to the 1970s' oil crisis, African governments created energy ministries or departments which were partially in charge of developing renewable energy schemes. However, once the crisis was over, the funding and attention dedicated to these sectors dropped considerably[204] except for large centralised hydropower[205] and fossil fuel plants which only supply energy to a small part of the population. There are only very few clear strategies regarding the deployment of renewable energy technologies[206]; policies targeting the dissemination of solar cookers in sub-Saharan Africa are rare. The governments should also seek to implement a set of quality standards to be respected and oblige manufacturers to give guarantees to their customers in order to gain their trust. It has been suggested in 2006 that solar cookers could be imposed as part of a housing plan via subsidies; it appears that this idea has not been taken further[207].

Government support is fundamental to the creation of pro-poor energy policies. However, governments' priorities often lie somewhere else than the need for spreading of solar cookers e.g. solving immediate needs through electrification or consolidation of national utility companies which require often unavailable highly-skilled staff[208]. Climate change itself is yet not fully recognised by all African nations[209]; among those who do, not all acknowledge the link between households' fuel-intensive cooking and deforestation[210]. However, in time, efforts have been made towards the establishment of targets to reduce dependence on firewood and coal. The East African Community has decided to give access to modern cooking systems to half the region's households by 2015, assisted by the German NGO GIZ and the UNDP. Eight southern African nations joined the ProBec (Programme for Basic Energy and Conservation) in order to reduce their requirements of firewood[211]. More recently, the Clean Cookstove Alliance set similar aims but although it claims to be technology-neutral, nothing seems to be getting done on the solar cooking front and the break-down of their budget is unclear[212]. The AFREPREN/FWD group has been in charge of creating energy policies since 1987, but again little information has been published on its

[204] Karekezi & Kithyoma 2003
[205] Carmody & Sarkar 1997
[206] Karekezi & Kithyoma 2003
[207] Klingshirn 2006
[208] Carmody & Sarkar 1997
[209] Karekezi & Kithyoma 2003
[210] Kroon 2004
[211] Schlag & Zuzarte 2008
[212] McArdle 2012

involvement with solar cookers[213]. Although there is much activity in the sector, nothing tangible has actually been published making it difficult to judge the progress of these targets and initiatives.

Another important generic barrier to the dissemination of solar cookers is the difficulty of access in some areas because of the poor stability of the country due to warfare, terrorism, kidnapping and others e.g. Mali's coup d'état, or Mauritania where connection was interrupted years ago with a solar cooking workshop for no apparent reason[214]. The risk to work in the Sahel region currently is so great - particularly for humanitarians - that many industrialised nations advise against any travelling in the area. This is unfortunate as the populations involved in such conflicts are the ones most likely to need solar cookers.

Additionally, the lack of willingness from governments and the amount of corruption resulting from the pressure of fossil-fuel lobbying companies has also been a significant barrier[215]. Nigeria in particular has been reported to have the highest levels of corruption: a German NGO Solare Brücke once sent a container full of solar cookers which hastily disappeared and significantly slowed down the project. Anon stated that the local manager of a Darfuri refugee camp rejected the concept of solar cooking possibly by fear of making the camp look "attractive" as this could entice other refugee populations and create further logistical complications[216].

6. Conclusion & Recommendations

Some issues mentioned in this document are too great to be simply solved with solar cooking, such as the lack of infrastructure (especially in rural areas), the gender barrier, the lack of education and the presence of conflicts, terrorism and corruption. Changes take time and solar cooking can only contribute to assisting the populations affected by these through appropriate long-term mechanisms. The key element to take into consideration for any implementation strategies is for the promoters to understand the needs of the population. The time commitment to the project and its preparation will have a great influence on the final outcomes. Promoters from NGOs must work in collaboration with each other where

[213] AFREPREN/FWD 2011
[214] Anon 2012
[215] Karekezi & Kithyoma 2003
[216] Anon 2012

applicable, with governmental institutions, with local businesses, with both male and female end-users and with any other stakeholders. Governments must ensure to remove as many barriers as possible for these NGOs to take action through the creation of pro-poor energy policies and must establish partnerships and funding schemes with financial institutions. Financial mechanisms such as subsidies must not get in the way of commercialisation and the populations' payment preferences must be taken into consideration. Local businesses must respect quality standards set by the government and must offer guaranties with the products they sell. Local solar cooker designers must be rewarded with strong Intellectual Property certificates.

Since quantifying precisely how different elements contribute to the overall success or failure of a process constitutes an extremely difficult task, standard indicators should be produced for everyone to measure progress in the same way thus enabling comparisons to be made. More monitoring and project follow-up procedures are needed. A small project with appropriate preparation, development and follow-up procedures has more chances of being successful than a large project aiming purely to disseminate as many cookers as possible. Any outcomes of such projects must be appropriately published and made available to the public and other implicated actors with complete transparency, preferably on the Solar Cookers World Network's website in order to regroup all information. SCI used to be the main actor in the solar cooking field. The rapidly rising number of new agencies gives hope to the sector; however, it would perhaps be wise to reunite all agencies and create a hierarchy with sub-divisions for each region of the world in order to ensure better communication, collaboration and structure (see Annex for names of some of the main actors in Africa).

Finally, efforts to increase the efficiency of solar cookers should be slowed down: even though they are necessary to keep up with new materials and changing prices for the best value-for-money combination, the most efficient cookers are not necessarily the most popular ones and can become expensive thus unaffordable. Money should be redirected to research the reduction of production, marketing and end-users costs[217]. Higher social classes must be appealed by the technology in order for the lower classes to be encouraged to invest themselves; promoters must bear in mind that the promotion strategies for both types of populations are significantly different, as they are for urban and rural populations or refugee camps and native villages. Appropriate research on each must be undertaken at the early

[217] Pouris & Wentzel 2006

stages of the project and traditions must be respected and understood. It is for the promoters to try to find a way around them or use them to their advantage.

Out of the many promotion techniques that exist, honesty as to what type of systems people are getting is fundamental to instil trust in the technology. Promoters must inform people that, without great amounts of dedication, solar cookers must be used in combination with other appliances in Integrated Cooking Systems. Promoters should also take the opportunity to raise awareness on other renewable energy technologies and how each technology complements each other. In the next decade, one shall be able to see whether such systems manage to get higher adoption levels and stimulate both demand and supply, hence making commercialisation possible, while pro-poor energy policies assist correctly the poorest households of sub-Saharan Africa.

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Annex

Some Important Actors in the Dissemination of Solar Cookers in Sub-Saharan Africa

<table>
<tr><th>Acronym</th><th>Name</th><th>Description</th><th>Website</th></tr>
<tr><td colspan="4">NGOs and Non-Profit Organisations</td></tr>
<tr><td>SCI</td><td>Solar Cookers International</td><td>First NGO to focus on solar cooking, active throughout the world.</td><td>http://www.solarcookers.org/ see also: http://solarcooking.wikia.com</td></tr>
<tr><td>SHE</td><td>Solar Energy Household</td><td>Second to SCI, very much active in Africa. Invented the HotSpot solar cooker.</td><td>http://www.she-inc.org/</td></tr>
<tr><td>JWW</td><td>Jewish World Watch</td><td>Works with several refugee camps in the Sahel region, particularly Chad.</td><td>http://www.jww.org/donate/solar-cooker-project</td></tr>
<tr><td>PCIA</td><td>Partnership for Clean Indoor Air</td><td>NGO which assists programmes with technical, logistic and financial support throughout Africa.</td><td>http://www.pciaonline.org/solarafrica</td></tr>
<tr><td colspan="2">KoZon</td><td>Dutch NGO which supports many other NGOs into implementing ICS systems in Africa.</td><td>http://www.kozon.org/english/index.php</td></tr>
<tr><td colspan="2">EG Solar</td><td rowspan="3">German NGOs launching many solar cooking projects in Africa, as described in the main text of the document.</td><td>http://www.eg-solar.de/english/home.htm</td></tr>
<tr><td colspan="2">Solare Brücke</td><td>http://www.solare-bruecke.org/</td></tr>
<tr><td colspan="2">CARE</td><td>/</td></tr>
<tr><td colspan="2">Kyoto Twist</td><td>Canadian NGO supporting other solar cooking projects in Africa with their own design.</td><td>http://www.kyototwist.org/</td></tr>
<tr><td>CORD</td><td>Christian Outreach for Relief and Development</td><td>Many religious NGOs try to make a difference too. CORD is only one example and works with small solar cooking projects in Chad and Burundi.</td><td>http://www.cord.org.uk</td></tr>
<tr><td>UNHCR, UNDP, UNEP and UNESCO</td><td>See Acronyms section</td><td>UNHCR and UNESCO were the first to implement solar cooking projects in refugee camps. Now joined by the UNEP and UNDP mostly to fund other NGO's projects.</td><td>http://www.unhcr.org
http://www.undp.org
http://www.unep.org</td></tr>
<tr><td>GEF</td><td>Global Environment Facility</td><td>Created by the UNDP to fund some projects. The GEF created the Small Grant Programme.</td><td>http://sgp.undp.org/index.cfm?module=activeweb&page=WebPage&s=AboutGEF</td></tr>
</table>

African Partnerships and Initiatives			
AFRECA	Association for Renewable Energy Cooking Appliances	Association which regroups all manufacturers, suppliers and designers of Southern Africa. Also works on policy frameworks.	http://www.afreca.org/
AFREPREN/FWD	African Energy Policy Research Network	Creation of policy frameworks and funding for some projects.	http://www.afrepren.org/
AREA	African Renewable Energy Alliance	Partnership trying to create the best conditions for the implementation of renewable energies in Africa.	http://www.area-net.org/
Global Alliance for Clean Cookstoves		Alliance creating international policy frameworks, standard testing methods, funding mechanisms etc.	http://cleancookstoves.org/
ProBec	Programme for Basic Energy and Conservation in Southern Africa.	Programme implemented by GIZ to solve cooking issues in the South African Development Community region. Ended in 2010.	http://www.probec.org/