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SOLAR COOKERS - A STEP TOWARDS SUSTAINABLE DEVELOPMENT.

An analysis of the impact of solar cooking practices in Ajmer District, India.

Linn-Cathrin Juell

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linnca@gmail.com

Noragric
Department of International Environment and Development Studies
P.O. Box 5003
N-1432 Ås
Norway
Tel.: +47 64 96 52 00
Fax: +47 64 96 52 01
Internet: http://www.nmbu.no/noragric

Declaration

I, Linn-Cathrin Juell, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature……..

Date……

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Abstract

This study aims to investigate the added value of solar cookers beyond energy by analyzing the implementation of solar cookers in Ajmer District, India. Furthermore the thesis seeks to evaluate the potential solar cooking technology to promote sustainable development.

Carbon-based biomass is a traditional source of energy in rural India, and accounts for over 90 per cent of the energy used for cooking purposes in the state of Rajasthan where the research for this study is conducted. Dependence on biomass for cooking is associated with negative environmental, economic and health impacts. Solar cooking technology may present a viable alternative to reduce the harmful effects of using carbon-based biomass. The assumption is that clean energy sources for cooking can provide multiple benefits such as improved health, reduced emissions and pressure on local natural resources, and increased income as a result of increased time autonomy.

Specifically the study aims to identify factors that enable or limit the success or failure and explore how people decide to adopt the use of solar cookers or not and how this impact people's lives. The aim is to evaluate if solar cooking technology meet the criteria of appropriate technology and contributes to sustainable development. The discussion of the findings is based on the theory of appropriate technology, the capability approach and the innovation decision process theory.

I argue that the implementation of solar cookers in Ajmer District leads to multiple benefits. Especially the women involved in the solar cooking project experience great change in their lives by being socially and economically empowered. Although the solar cooking technology seems to meet all dimensions of sustainability, I argue that the wider effect of the experienced success is influenced by different factors involving economic affordability, sociocultural norms and political structures. Barefoot College and the Women Barefoot Solar Engineers Society have improved the livelihood of many rural people by adding solar energy to their lives. However, the appropriateness of the technology is limited by the fact that the device is too expensive for most people and does not fit the schedule of daily routines. The sustainability and the confirmation of the technology rests on several factors, and the potential of solar cooking technology to contribute to sustainable development will not be fulfilled un less it is affordable for the end-users.

Abbreviations

IEA	International Energy Agency
IDT	Innovation Diffusion Theory
INR	Indian rupee
IPCC	International Panel on Climate Change
LPG	Liquefied Petroleum Gas
OECD	Organization for Economic Co-operation and Development
SCOT	Social Construction Of Technology
SHG	Self-Help Group
TED	Technology, Entertainment, Design
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environment Programme
WBSES	Women Barefoot Solar Engineers Society
WHO	World Health Organization
WMO	World Meteorological Organization

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1. INTRODUCTION

"*At the heart of tackling climate change is bringing power to the worlds poorest people without choking the planet with rising carbon emissions.*"[1]

The world is facing a global energy crisis that is putting lives and our environment at risk. And this global burden is hitting the poorest the hardest. Most of the people currently living without access to electricity are located in developing countries, and most of them in rural areas. There is an urgent need to transform the global energy sector at all scales (IPCC, 2014).

The need for a profound transformation of the world's energy consumption pattern has been widely recognized within the climate change discourse. A wide range of reports have been written about sustainable energy, however, little has been written about sustainability from the perspective of developing countries. In countries where there is a number of people without energy access, the worry about sustainability is often overshadowed by immediate concerns to cover basic needs of life (Ahuja & Tatsutani, 2009). Acknowledging the traditional view of that there is a positive correlation between economic growth and energy access, this study aim to explore the links between energy, technology and sustainable development.

Households in developing countries, especially rural areas, rely on carbon-based biomass as their primary energy source. High dependence on biomass is clamed to have negative environmental, economic and health impacts (The World Bank, 2013). The dependence on traditional biomass for cooking is time consuming and is associated with a number of harmful affects. There is an assumption that improved cooking stoves can give multiple benefits, and there is a considerable amount of documentation of the negative impact of using traditional biomass for cooking. Significant amount of studies have been carried out on the impact on implementing improved cooking stoves (WMO & UNEP, 2014). However, there is limited access to documentation regarding the implementation of cooking technologies based on renewable energy sources.

[1] http://www.theguardian.com/environment/2014/sep/30/-sp-narendra-modi-india-solar-renewables-energy (Access date: 03.02.15)

India is the country where the highest number of people lives without of access to secure energy sources. India has made and effort in developing strategies of energy access and security in the country, but there is lack of actions in doing so. We have seen an increasing number of solar electrification projects in parts of India, although few of these directly target the poorest people living in remote areas. For rural people living in India solar cooker technology can be a suitable solution to promote sustainable development.

Cooking represents a large part of the primary energy demand in India. Therefore, solar cookers may present a viable alternative to the use of conventional cooking methods in developing countries, such as firewood and kerosene. Even though solar energy cannot completely replace fossil fuels, it can be used as an effective mechanism to mitigate consequences of climate change, reduce deforestation and promote the socioeconomic development of poor people.

The literature review for this thesis reveals that there is lack of academic writing considering the adoption of solar cooking technology and its impact on people's lives. Most of the literature underlines the potential advantages of using solar cookers but provides little empirical evidence is offered. This thesis investigates the potential impact the uptake of appropriate technology for cooking can have on sustainable development. This is done by observing the practices of households using traditional biomass for cooking and by interviewing women solar engineers and users of solar cookers in Ajmer District, India. The aim is to contribute to gaps in knowledge on successful adoption of sustainable cooking technology in rural areas.

1.1. Objectives of the study

The departure of this study comes from the growing support given to solar cookers and their potential to meet all dimensions of sustainability. The study aims to explore the links between energy, technology and development and investigate if solar cookers have any impact beyond energy. The thesis will consider if the use of solar cookers can promote sustainable development and identify by what means. This overall framing of the aim of the study leads to the discussion of appropriate technology and its role to promote sustainable development. The objectives of the research are:

Investigate the added value of solar cookers beyond energy

- What factors determine the success or failure of solar cookers?
- Why do people choose to use solar cookers?
- How do solar cookers impact people's lives?

Investigate solar cookers potential to promote sustainable development

- How appropriate is the solar cooking technology?
- How do the solar cooker technology lead to development?

A qualitative case study approach is employed to address these the research objectives. A combination of data collection during my fieldwork and analysis of existing literature is the basis of the arguments disseminated in this thesis.

In chapter 2 I am to outline the theoretical framework that has been employed in this thesis to guide data collection. The theory of appropriate technology, capability approach and innovation diffusion is applied to analyze the social, economic and environmental impact of the adoption of solar cooking. In chapter 3 the methodology of the research is explained in detail. Chapter 4 will give and overview of energy sources and consumption in India and the potential to use solar cookers, before the solar cooking process at Barefoot College is assessed in chapter 5. Here a predefined set of factors is used to test if they have an enabling or limiting influence on he achievements of the solar cooker technology. In chapter 6 and 7 I extend the discussion to of how solar cooking technology can contribute to sustainable development. The concluding chapter will provide recommendation to further evolve the implementation of solar cookers in India.

2. THEORETICAL FRAMEWORK

This chapter will start off by explaining the sustainable development approach as the thesis seeks to investigate the potential of solar cookers to meet all dimensions of sustainability. For this purpose it is important to know why people decide to adopt solar cooking technology. To identify factors that enable or limit the achievements of the solar cooking case, the Innovation Diffusion Theory and Innovation Decision Process is applied. In addition, a set of predefined factors about the adoption of technology is used to test if these dimensions influence the decision about whether to adopt the solar cooking technology or not. The capability approach is employed to explore the impact the solar cooking technology has on people's lives.

After explaining the sustainability approach the chapter will continue to explain how solar cookers are understood as an intermediate technology/appropriate technology to promote sustainable development. The successful implementation of intermediate technology requires a social understanding of technology and transition management. This chapter will thus offer further insight to the links between energy, technology and development by elaborating on the theories of appropriate technology, socio-technical systems and transition management of technology.

2.1. Sustainable development: the three dimensions

The term sustainable development was emerged with the UN report *Our Common Future*, published in 1987 by the World Commission on Environment and Development (also commonly known as *the Brundtland Report*). The same report (p. 41) also includes the clearest definition of sustainable development as: *"development which meets the needs of the present without compromising the ability of future generations to meet their own needs.*"[2] The term was again accepted by international leaders in 1992, when the principles of sustainable development was established at the United Nations Conference on Environment and Development, in Rio de Janeiro, Brazil[3].

[2] http://www.un-documents.net/our-common-future.pdf (Access date: 10.05.15, p. 41)
[3] http://www.un.org/wcm/webdav/site/climatechange/shared/gsp/docs/GSP1-6_Background%20on%20Sustainable%20Devt.pdf (Access date: 03.02.15)

The concept of sustainable development emerged in a time when the concern of the state of the global environment was rising. The UN Commission on Environment and Development was set down to develop a strategy for a common future, a sustainable future for all. It was increasingly realized that economic growth alone could not meet all means of development across the world. This was the initiative of building a more comprehensive framework for development, including more dimensions than economic growth. Sustainable development involves the three pillars of economic growth, social inclusion and environmental protection. Where people, economy and society are dimensions that need to develop, while the nature, life support and community must be sustained[4].

By sustainable development the international community aimed to ensure that children survive, receive a healthy life, take part in quality education and also can expect a longer life. The intention of sustainable development is to ensure equity and equal opportunities for all. Reducing environmental risks and scarcity and regulating consumption patterns, a switch to so-called green economy can lead to sustainable development. To ensure that future needs are not compromised, the sustainable development approach protects biodiversity and ecosystems, ensuring that the natural life support systems is kept intact to support the human life being[5].

In addition to the original three dimensions of sustainable development, this thesis is including a forth dimension of *empowerment.* This is in order to enhance the important role of women in achieving sustainable development. Sustainable development will not be achieved by leaving half of the population behind. The next section will describe the empowerment dimension in light of sustainable development.

2.2. Empowerment: Adding a fourth dimension to sustainable development

It is considered that the social dimension of sustainability do not fully cover all aspects of empowerment, empowerment is added as a fourth dimension to the concept of sustainable development.

Empowerment is a concept that is difficult to define but indeed necessary to embark on when talking about sustainable development. For several reasons it is important to link gender

[4] http://www.un-documents.net/our-common-future.pdf (Access date: 10.05.15)
[5] http://www.un-documents.net/our-common-future.pdf (Access date: 10.05.15)

equality with sustainable development. The efforts made to achieve a sustainable future cannot ignore the rights, dignity and capabilities of half the world's population. Sustainability actions must address the disproportionate impact on women and girls of economic, social and environmental shocks. Empowering women is not only necessary to achieve sustainability, but will strengthen and improve the effectiveness the actions to achieve sustainable development (UN Women, 2012).

Empowerment and power are interconnected concepts that should be seen as processes with great impact on the life structure of human beings. According to Kabeer (1999), power can be thought of as the "ability to make choices". Meaning that a disempowered person or community would be denied to make choices. Empowerment as a process therefore refers to a process of change resulting in increased ability to make life choices in a context where this ability was previously denied (Kabeer, 1999). The outcome of a women's empowerment is than greater control of material and intellectual resources and a challenge tot he patriarchy ideology and gender- based discrimination of women. The empowerment process is not against men, but rather against the system of patriarchy and discrimination (Batliwala, 2013). It was also seen as especially important to enhance this dimension in the context of the study, where it is recognized that many women are suppressed to men due to sociocultural norms and religious views. To empower women, they must be released from physically hardship, time intensive activity and unhealthy practices and given opportunities to contribute to social-economic development, personal growth, community involvement and improved health (Green, 2001).

2.3. Critique of the sustainable development approach

Sustainable development has been debated ever since the Brundtland Commission established the term in 1987[6], but progress to achieve sustainable development remains slow. Scholars representing different discourses have criticized several aspects of the sustainable development approach. The core element of sustainability is to promote social and economic development while protecting the environment. Banerjee (2003) argues that this is an attempt to reconcile two incompatible goals of economic growth and environmental protection. Economic growth and environmental protection are contradictory concepts, as many scholars have perceived. Indeed, Redclift (2005) criticize the sustainability approach for being an

[6] http://www.un-documents.net/our-common-future.pdf (Access date: 27.04.15)

oxymoron. Furthermore the approach is criticized for being to vague and difficult to operationalize. Brown (2011) argues that this leaves it open for any interpretation of sustainable development.

All of this creates obstacles for integrating social, economic, cultural and environmental policies to achieve sustainable development. Great efforts have been made to promote sustainable development as a holistic concept that intentionally aims to integrate the three dimensions of social and economic growth and environmental protection to ensure sustainable growth in the world. However, some barriers to implement policies to achieve sustainable development are identified. Among them are social barriers like population growth, unsustainable consumption and production patterns. Inadequate economic and financial barriers are also holding back the progress. And the lack of specific targets at all levels makes it difficult to monitor and measure the progress of the effort[7].

The next sections will continue to describe how together energy and technology play important roles in achieving sustainable development.

2.4. Energy and development

Traditionally, economic development has been strongly linked to the increase of energy use and growth of greenhouse gas emissions. Access to energy sources has been an important driver of development in industrialized countries and emerging economies. Energy helps to reduce poverty, increase food production, provide clean water, improve health, enhance education, address climate change issues, promote economic opportunities and empower young people. Access to energy sources is widely recognized as a prerequisite to achieve sustainable development[8].

Our current energy system is mainly based on fossil fuels contributing to climate change by emissions of greenhouse gases to the atmosphere. But renewable energy can assist in breaking the traditional correlation between economic development and energy, contributing to sustainable development. Despite this observation, billions of people still live without access to electricity or clean cooking facilities. Most of these people live in developing

[7] http://www.un.org/en/ecosoc/newfunct/summary_of_ediscussion_final.pdf (Access date: 30.04.15)
[8] http://www.se4all.org/decade/energy-sustainable-development/ (Access date: 25.04.15)

countries, and mainly in rural areas. Energy security and the contribution energy consumption has on climate change are two of the biggest challenges to achieve sustainable development (OECD & IEA, 2010). Globally there are 1.4 billion living without access to electricity and among the 2.7 billion people relying on biomass for cooking, over 800 million live in India according to numbers from 2009 published by OECD and IEA (2010).

Clean water, sanitation, health care services, cooking and heating are essential human needs that require reliable access to energy. OECD and IEA (2010) enhance that there is a positive correlation between income rates and access to energy. People living in relative poverty have low electrification, when income rises there is a rise in electrification. Access to electricity rise faster than access to so called modern cooking facilities.

Understanding sustainable development as described including the three pillars of social and economic development and environmental protection have made it possible to frame sustainability issues. The United Nations is reinforcing actions to encompass all dimensions of sustainable development, and substitution of fossil fuels with renewable energy sources. Renewable energy sources have the potential to contribute to the three-pillar model of sustainable development. Renewable resources, in contrast to fossil fuels, sustain natural capital, have no emissions of black carbon, and do not reduce the potential for future harvest (Sathaye, Lucon, & Rahman, 2011).

The interaction between renewable energy and development can be understood at different scales, global, regional and local. As consumption of fossil fuels is a large contributor to climate change one of the greatest motivations behind increasing the use of renewable energy sources is to mitigate anthropogenic driven climate change. This will require a change in energy consumption at all levels (Sathaye et al., 2011).

The consequences of using traditional carbon-based fuels for cooking are adverse. Due to the associated harmful effects caused by indoor air pollution the World Health Organization estimate that 1.45 million people die prematurely every year. This number is higher than the people dying from diseases like tuberculosis and malaria, and it is expected to rise towards 2030 (OECD & IEA, 2010). Furthermore, the extensive practices related to the consumption of fuels like firewood are time consuming. This limits especially women to attend educational and income generating activities. The large dependence on biomass for cooking

is putting pressure on local natural resources but also impact the social and economic part of human's lives.
It is projected that renewable energy must play a central role in mitigation strategies to reduce greenhouse gas emissions. But to meet the challenges at local level in rural parts of the world, the renewable energy solutions must be technically feasible and economic efficient. Therefore it is important to gain knowledge about technological capabilities and framework for optimal solutions for mitigation. In order to develop the best mitigation solutions one must have a sociocultural understanding of the local context where the technology is to be implemented. Energy technologies are embedded in the societies and natural environment. Which underlines the necessity to assess both social and environmental impacts of renewable energy technologies.

2.5. Technology and development

Since its beginning technology has been offered as a solution for a better world by eliminating diseases and improving the living standards of human beings. A significant amount of so- called developing countries are helped by technology transfer and technological innovations in order to achieve development (Vergragt, 2006).

Essentially three meanings can be applied to the word 'technology'. The first meaning refers to technology as *tools and instruments* to give humans the ability to shape nature and solve problems, as in tools for hunting, agriculture, irrigation and water management etc. Second, technology can be understood as *knowledge* to create things or solve problems. During the first industrial revolution the transition of technology as a practical tool towards knowledge based technology started. Lastly, technology encompasses *culture* as in our understanding of the world. After the Second World War information and communication technology, biotechnology, computers and Internet emerged, starting the transition of technology as culture (Vergragt, 2006).

Technology can contribute to sustainable development by reducing emissions, increasing efficiency and propose alternatives to scarce resources and improve livelihoods. But not all kinds of technologies are appropriate for sustainable development. Finding the 'right' technology to promote socioeconomic development in a suitable context without depressing environmental resources is a great challenge. Introducing advanced technologies innovated to

suit the industrialized and western context to rural areas in developing countries can create more problems than solutions. Rather developing solutions based on demystifying advanced technology combined with traditional knowledge and practices is suggested to be more sustainable and fit the local conditions better (Vergragt, 2006). Schumacher (1973) proposed a new way of presenting and using technology, what is often called intermediate or appropriate technology. This technology was envisioned to suit developing countries, as a midway between high-innovative technology and indigenous practices. Intermediate technology has been advocated as a solution to promote rural development and gained support as a mechanism to achieve sustainable development. On the other hand, this technology approach has received criticism of being to 'cheap', 'second best' or 'second hand'.

The right technologies to make development sustainable are already available today. The challenge is rather to deploy them in the right way. In the context of rural development the key challenge is to create links between the people with the ideas, the end-users with local knowledge and financing mechanisms. To come up with technologies suitable for specific local context, a social understanding of technology is required.

2.6. Social understanding of technology

This thesis employs a social understanding of technology, and argues that technology is not social and political neutral. Meaning that it is recognized that several social factors interact with technological factors and influence the opportunities of people and communities to achieve technological and social change (Winther, 2011). To provide a background for such understanding this section will include an overview of the socio-technical system approach and consider how energy can be understood as culturally and socially embedded. I will start off by explaining Hornborg (2013) reconceptualization of technology before I move on to look at Wilhite (2013) understanding of energy sustainability through social practice theory.

The book *Cultures of energy: power, transitions*, *technologies*, explore the concepts of energy and argue that our beliefs about energy shape how we use it. The argument is brought further to say that the responses to the energy crisis the world is facing now is blocked by fundamental cultural and political factors, rather than technological. The aim of the book is to direct the field of energy studies towards a new path by enhancing cultural values and

relationships regarding how people perceive and access energy (Strauss, Rupp, & Loue, 2013, p. 10).

In the same book, Hornborg (2013) offers a radical reinterpretation of technology by discussing the phenomena of modern technology as a total social fact. For some, such an understanding might be radical as it moves away from the deeply rooted notions of technological progress and modernization. But Hornborg (2013) argues that such a reconceptualization of the phenomena will make it easier to embrace the global energy crisis that we are currently facing. Instead of proceeding with an understanding of the crisis that is divided between discourses of energy scarcity, environmental degradation, resource depletion, climate change, global inequalities and financial collapse, he argues that it is necessary to realize that all these concerns are dimensions of a single problem. It is time to understand the current energy consumption patterns enjoyed by those who have access to modern technology is causing increased entropy as in increased level of CO2 in the atmosphere. This byproduct of growth is compromising the ability of future generations to meet their own needs. As long as economic growth is associated with extensive consumption of fossil fuels, our cultural understanding of growth and progress is incompatible with natural capacity (Hornborg, 2013). Hornborg (2013) continue to argue that it is necessary to incompatibility between material conditions and cultural constructions in order to find truly sustainable solutions to create human economies.

As opposed to Hornborg, Wilhite (2013, p. 67) is concerned about the local level of energy consumption and propose a new way of understanding energy sustainability through social practice theory by examining the imbalance of energy consumption in OECD countries and non-OECD countries. Arguing that individuals use their knowledge and experience to interact with things in practice, but also that the things can influence the action of individuals. The author uses this approach to examine how our everyday habits relate to energy consumption and sustainability. Wilhite (2013) tries to move the perception of energy consumption as individual actions towards something that is a result of interaction between things, people, knowledge and social contexts. This understanding of energy is in line with the socio-technical systems approach.

The socio-technical systems approach is a way of understanding the dynamic interaction between people and technology that together create socio-technical change. A socio-technical

system has been defined as “a configuration of heterogeneous technical and social elements, including technical devices or artifacts, organizational aspects, involved actors and social practices in the implementation and use as well as competences linked to the technologies” (Ulsrud, Winther, Palit, & Rohracher, 2015, p. 35). In this dynamic interaction of power relations, discourses and meanings related to the technology and ways of using the technology are enhanced as important elements. Individuals and collective actors gradually develop socio-technical systems by experimenting and learning, where the outcome is uncertain. Innovative ways of organizing renewable energy sources for cooking are less embedded in dominant socio-technical structures than conventional energy technologies (Ulsrud et al., 2015).

By exploring the possible contribution of social science research to create a better understanding of energy systems, Rohracher (2008, p. 147) define energy systems are “socio-technical configurations where technologies, institutional arrangements, social practices and actor constellations (such as user-producer relations and interactions, intermediary organization, public authorities) mutually depend on each other, and are embedded into broader contexts of cultural values, socio-economic trends (globalization, individualization, etc.)”. Thus, socio-technical systems approach focuses on the social embedding of technology i.e. how technology is influenced by social practices values and institutional settings. The potential long-term viability of a technology depends on the social and economic organization of a socio-technical system, and not only the attributes of the implemented technology (Ulsrud, Winther, Palit, Rohracher, & Sandgren, 2011).

A further contribution to the social understanding of technology is the Social Construction of Technology (SCOT) approach. The argument of SCOT is that technological artifacts are developed based on the different meanings that social groups give to the technological artifact (Lauritsen, 2007). This is an ontological perspective that is based on social constructivism, which is in contrast to technological determinism that considers technology as independent from any social factor. According to technological determinism will changes in technology lead to societal change, without considering that people’s agency have any impact on technological artifacts (MacKenzie & Wajcman, 1985).

To employ a social understanding of technology in this case, it is important to investigate in what way solar cookers are adopted and impact people’s lives. This will also make it easier to

identify the factors that enable or limit the achievements of solar cooking technologies. To explore the links between energy, people and development, the thesis will assess how appropriate the solar cooking technology is.

All over the world we find technologies that play a significant role in promoting socioeconomic development and environmental protection. But we see lack of successful implementation of these technologies. Offering technologies developed by western institutions to local communities without considering the need of the end-users is not a sustainable solution. Sustainable development in a local context would mean to provide solutions that can empower the community socially and economically, while protecting the local environment. Technological change in developing countries is not only about innovation of new technology, but also about adapting and adjusting existing products and processes in the local context[9]. Access to appropriate technologies can promote steady improvements in living conditions and increasing incomes. Next is an introduction to appropriate technology, its history and purpose as a mechanism to promote development.

2.7. Appropriate technology

With climate change on our neck and its following consequences, the world is facing with an increasing number of social, economic and political problems. Our technology-driven world and current development policies have in many terms failed to reach out to the poorest and to mitigate the continuing consequences following expanding production and consumption pattern in the world. The theory of appropriate technology questions the current direction of social, economic and technical development and offers an alternative path to sustainable development.

Dr. Ernst Fredrich Schumacher was the first to introduce the concept of *intermediate technology* initially in the early 1960s and later on in his book *Small is Beautiful* that was published in 1973. Today the concept is most known as *appropriate technology*. Appropriate technology is referring to the type of tools and simple machines that poor farmers and people in rural areas are able to take in use, or to learn how to make, in order to improve their livelihood. Such technology can be understood as self-help technology or inventions suitable for rural areas in developing countries (Schumacher, 1973).

[9] http://www.un.org/en/development/desa/policy/untaskteam_undf/thinkpieces/28_thinkpiece_science.pdf (Access date: 25.04.15)

Small is beautiful was a radical challenge to the contemporary economic position of the 20th century. While the growing economy of the western part of the world led to bigger markets, bigger political entities and more opportunities for more people, Schumacher (1973) believed that such economic scale caused a dehumanization of people and making the economic system determine peoples lives. Human relations and craft skills became less important and instead humans became actors of pure production. Decision-making was not enhancing the need of human beings, but based on profitability. In contrast, Schumacher (1973) wanted a people-centered economy that to his believes would lead to economic and human sustainability. An important contribution to Schumacher's theory is the work of Marilyn Warning (1988) who enhanced the valuable role of the unpaid work made by women.

By introducing intermediate technology Schumacher (1973) propose a theory about the basic role of technology in the service of actual human needs. He lifts the concern about underemployment, unemployment and low productivity in developing countries. Schumacher (1973) argues that in order to stimulate economic development in poor areas one must enhance intermediate technology. Appropriate technology enhances the need of the end-users in order to improve their livelihood by stimulating economic growth, promote social progress and technical improvement and implement progressive technology that can change over time according to the ability and need of the end-user. Ways of doing that would be to (1) upgrade existing traditional ways of doing things, (2) simplify western technology or (3) implement new inventions. Much of the information and expertise needed to develop appropriate technology would exist in the western part of the world, but it is necessary to make it accessible to mobilize in an understandable way to the end-users. Such technology would involve equipment that is easy to use and suitable to maintain and repair at the spot. In this way, Schumacher (1973) argue, that appropriate technology is more suitable for developing countries rather than adopting western technology. The best way of using scientific knowledge and technical skills is to apply it in a way that will serve human needs, all over the world. Also in societies where there is need for technology on a small scale and where there is plenty of labor but little capital (Schumacher, 1973).

2.7.1. Critique and barriers of the appropriate technology approach

Even though the appropriate technology approach is considered to have substantial support from a various discourses, the approach has received considerable criticism.

Pearce (2011) argue that a too rigid understanding of the definition of appropriate technology can be a significant barrier. Carr (1985) understands appropriate technology as denying developing countries the same technology as found in the developed part of the world. Further it is argued that modern technology is not right for developing countries and should therefore be served second-best solutions. Such an understanding of the concept is misleading the purpose of appropriate technology. Appropriate technology aim to implement technology that is more suitable to local conditions and is capable to meet the needs of the people without damaging the environment.

2.8. The appropriateness of solar cookers

Appropriate technology is acknowledged as technology that can be made with local materials by local people at an affordable price providing benefits to individuals and local community and reduced pressure on natural resources. The criteria of appropriateness enhance that this technology approach put concerns about people and the environment at center. This study investigates how appropriate the technology of solar cookers is in Ajmer District, India.

The potential attributes of solar cookers that are generally underlined is that it is suited for underdeveloped countries, especially rural equatorial regions where the sun is shining up to 300 days a year. In theory the technology is simple and easy to use, and can be produced by local material. By using solar energy for cooking a large amount of carbon-based fuels can be replaced. This will have implications for the daily routine of households especially concerning women and children who often are responsible for cooking practices. Traditionally women and children carry great burdens by collection fuelwood and by being exposed to indoor air pollution. Therefore the use of clean energy sources for cooking can improve the health of household members. Replacing traditional biomass with solar energy can also potentially reduce the total cost households spend on fuel for cooking, at the same time reducing the amount of black carbon emissions, eliminating the risk of fire and reduce the pressure on local natural resources. The potential time- savings occurring when replacing

traditional carbon-based biomass with solar energy can empower women and children and increase the opportunity to attend educational programs and take part in income generating activities (Jeuland & Pattanayak, 2012; The World Bank, 2013; WHO, 2014; WMO & UNEP, 2014).

Appropriate technology has been used to improve the human-well being in a sustainable matter. In this study solar cookers have been examined from a socio-technical point of view. To identify appropriate technology to fit local conditions and promote sustainable development it is necessary to understand technology as socially constructed. The Social Construction of Technology (SCOT) was first defined by Pinch and Bijker (1984). The theory they proposed and argument to support it suggest that the development of technology is an interactive process among technologists or engineers and relevant social groups. Previous technologies or innovations like the wheel, the bicycle or computers are all examples of technologies that shape and organize our world. Social stakeholders decide what technologies are useful, profitable, comfortable or meaningful (Pinch & Bijker, 1984). This is an opposition to technological determinism that states that technology is shaping the society.

In order to assess the appropriateness of the solar cooking technology in practice, the thesis have adopted and modified the criteria of evaluation presented by Wicklein (1998). In addition a set of appropriateness indicators is used as a guideline to evaluate if the solar cookers meet the criteria of appropriate technology. Below is a table that gives an overview of the indicators for appropriate technology, but first I introduce the criteria seen as useful to judge the appropriateness of the solar cooking technology:

(1) *System – independence*

The ability of the technology device to stand alone with the need of few or no other facilities or devices to support the function of the technology. Where assistance is needed, the full cost of the operation of the technology device must be considered.

(2) *Individual technology vs. collective technology*

One has to assess the sociocultural context of the area of where the technology device is supposed to be implemented. There is an acknowledge difference between societies that either value independent or collective commitment. In societies where individuality is valued the most, technologies must be system independent. While for

societies where collectivity is socially valued the technology can be more system dependent, where the overall group can take responsibility for operating the technological device. Based on this criterion the design of appropriate technology must consider the sociocultural context in which the technology will be used in order to serve the needs of the society.

(3) Cost of technology

The cost of appropriate technology is a strong factor that can determine the future of the operation of the technology. In order for the technology to be useful for the people in developing countries, the cost of device must be affordable.

(4) Risk factor

In every development of new technology there is a risk of success of failure. To minimize the risk of failure one should carefully consider the degree of both internal and external risks (Jequier, 1979). The first consider how well the appropriate technology will fit the local conditions for production. The latter risk factor considers how dependent technology is on supportive systems to be operated.

(5) Evolutionary capacity of technology

It is important that the appropriate technology can continue to develop and expand beyond the originally intended function. This will increase the possibility of the technological function to serve future needs and solve further problems. Without the ability to improve the technology, adoption of the technology will most likely be limited.

(6) Purpose of technology

This criterion measures whether the appropriate technology can serve several purposes. In difference from the original criterion proposed by Wicklein (1998), it is here also looking at multiple achievements of the technology. For instance in this case the criterion will ask if the solar cooking device can serve any purposes beyond energy for cooking.

Table 1: Appropriateness indicators

Desirability	Affordability	Availability	Accessibility	Transferability	Usability	Sustainability
• Acceptability • Stated need • Time saving	• Affordability • Money saving	• Technical support	• Community controlled • Gender-appropriate • Socio-cultural	• Knowledge, skills, feedback	• Ease of use • System independence	• Adaptability • Autonomy • Constructability and replicability • Durability • Effectiveness • Emissions • Energy efficiency • Income generating • Job creating • Maintainability • Reliability • Renewable energy • Reparability • Setting appropriate

2.9. The Capability approach

In order to meet the purpose of this study the Capability Approach is employed to assess the impact solar cooking technology have on people's lives. The capability approach is a normative framework that can be used to evaluate and assess human well-being (Robeyns, 2005).

The capability approach theory was developed in the 1980s initially by the Indian philosopher Amartya Sen, and further developed by researchers like Martha Nussbaum. The capability approach provides a broad normative framework for the evaluation and assessment

of individual well being. The approach differs from other traditional welfare theories by being highly interdisciplinary and by focusing on multidimensional aspects of well-being (Robeyns, 2012). The approach is an alternative welfare economic theory that focus on "the significance of individuals capability of achieving the kind of lives they have reason to value". This was in contrast to other traditional economic welfare theory that focuses on subjective well-being and availability of means to the good life. Measuring welfare based on the growth in national product, increased income or industrialization (Sen, 1999).

The capability approach perceives people as agents with individual goals and capability to make their own choices. Sen (1999) argues that the most important thing to do when measuring welfare is to identify what people are able to be and do. The focus is directly on the quality of life that individuals are actually able to live. The degree of 'quality' is analyzed by using the core concepts of 'functionings' and 'capabilities'. Functionings is understood as the state of 'being and doing'. For example 'being well-nourished'. Capability is referring to the actual freedom individuals have to choose between different lives. 'Achieved functionings' refers to the actual functionings people have achieved (Robeyns, 2005; Sen, 1999).

In the context of poverty, the Capability Approach want to move the focus from variables like income, consumption, utility and primary goods to focus on capabilities (Tjelta, 2005). Development is in this context seen as the expansion of people's real freedom to live the kind of lives they want. Meaning being free to do what they want to do and be the person they want to be. In practical terms it means that the objectives of development policies must be to remove obstacles in peoples live to live the kind of lives they want. This will increase individuals opportunities to live the lives they want (Sen, 1999). The capability approach can also be used to identify underlying causes of the way individuals live their lives. Meaning the determinants for the relationship between people and commodities. Sen (1999) highlight the following factors that can impact the quality of peoples lives; individual physiology, local environment diversities, variation in social conditions, differences in relational perspectives and distribution within the family.

An important part of the Capability Approach is the term 'Capability Set'. Capability Set describes the set of functionings its possible for a person to achieve. Robeyns (2005) developed a Capability Model that illustrates how means (goods and services) and achieved

functionings are influenced by social, environmental and personal conversion factors. Special circumstances like personal history and psychology may also influence the choices people make from the capability set. The capability approach understands development as the expansion of people's freedom to live the life they want to live and do the things they want to do (Robeyns, 2005; Sen, 1999). In this way the thesis investigate the ways in which solar cooker technology leads to the expansion of a specific capability set.

2.9.1. Applying the capability approach in the context of solar cookers

The aim of this section is to explain how the capability approach is applicable to analyze the impact solar cooking technology have on people's lives. In this thesis a predefined set of capabilities relevant for solar cooking is used to explore if solar cooking can lead to sustainable development. If the empirical findings conclude that there is an expansion of the capability set, my theory says that this indicates positive development.

All goods have particular characteristics that make it of interest of individuals and each of the characteristics empower a functioning. It is assumed that solar cookers have the potential to serve several advantages that will improve the quality of life. With the reasoning of the capability approach this means that the interest people have in solar cookers is due to the advantages the object serve. Also, conversional factors will influence the relation between the good (solar cooker) and the functionings to achieve certain beings and doings (Robeyns, 2005).

Personal conversion factors like sex, skills and disability will have impact on how a person can convert the characteristics of solar cookers into a functioning. In bold, a person has to know how to use a solar cooker to take advantage of the different functionings of the solar cookers that can improve the quality of life. Social conversion factors like sociocultural norms and values can prohibit the use of solar cookers, and solar cookers will therefore not adequately help to enable functionings. Environmental conversion factors can have impact on the conversion of the characteristics of solar cookers into functioning if the geographical location prohibits the use of solar cookers, or if solar cookers are not available in certain areas. But if there is lack of energy sources in the area, the environmental conversion factor 'lack of fuel sources' may increase the use of solar cookers and enable different functionings (Robeyns, 2005).

As already mentioned, it is the possible advantages by using solar cookers that make solar cookers interesting for people. One of the purposes of this thesis is to investigate in what way these advantages are converted into functionings. The capability approach is used as an analytical tool to do so. But as underlined by Robeyns (2005) it is necessary to develop a list of relevant capabilities before the approach can be applied.

The capability set used in this study largely based on the reviewed advantages of using solar cookers presented by several international organizations and researchers. Following is an overview and explanation of the capabilities selected.

Table 2: Capability set for solar cooking

Capability	Assumption
Time savings	Women save time when not collecting fuelwood Solar cooking take less time
Health	Improved health due to less indoor air pollution
Income	Increased income and monetary savings
Political participation	Increased political participation
Education	More time and money for education
Social relations	More time to attend organized activities and increase social relations

Time savings

One aim of the study is to investigate if the use of solar cooking technology leads to an increase of freedom in the time use of its users. In this case this is regarding women as they are the once who are mainly responsible for the cooking practices. Two assumptions were made regarding the time saving perspective in this study. As most of the people living in the area of study relies on firewood for cooking it was assumed that the use of solar cooking

technology will reduce the time people spent on collecting firewood. Also, it was assumed that solar cooking could take less time compared to conventional cooking methods.

Physical health

This study investigates how and if solar cooking technology can improve the health of those affected by associated harmful effects of conventional cooking methods. Physical health in this case refers to the ability to live a life of normal length considering associated harmful effects of conventional cooking methods.

Income generating activities

A predefined assumption of the study is that as women do not have to spend time on collecting firewood and performing conventional cooking practices, they will have time to engage in income generating activities.

Political participation

Taking the assumption that the use of solar cookers will lead to time savings for women and their children a further assumption is taken to that part of this time can be used for political activities. This study assess if the use of solar cookers have increased political participation among women.

Education

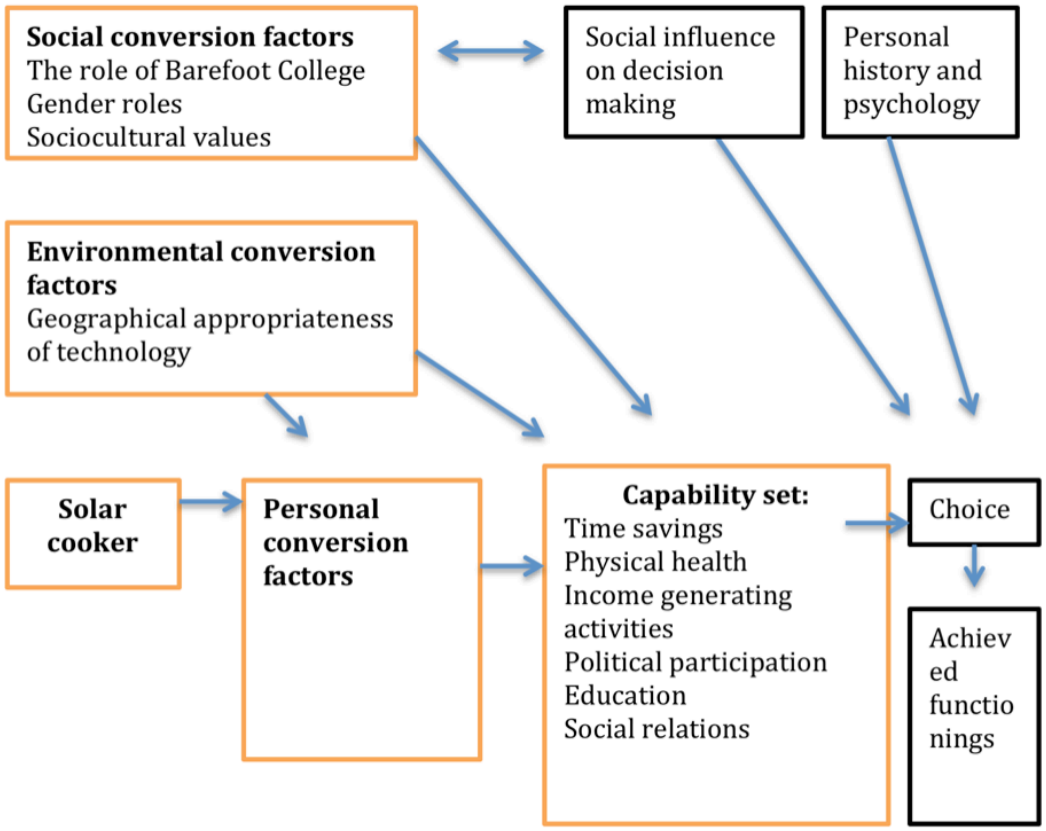
It is assumed that solar cookers result in time- saving and financial saving that can be used to take part in educational programmes. This study explore if solar cooking contributes to an increase in education.

Social relations

Social relations are considered as important factors, especially in the way of acquiring technology a social understanding. This approach points out that social conditions contribute to steer people's choices of implementation and adoption of technology. In this context, social relations refers to the aspects of social network and social support and how this affect the achievements of solar cooking technology (Robeyns, 2005).

By applying the capability approach and a capability set the aim is to explore how solar cookers may be of interest to people and in what way the use of this technology can impact people's lives. The figure below is a modified version of Robeyns (2005) framework applied to the context of solar cookers. The colored boxes identify the objectives analyzed in this study.

Figure 1: Conversion factors and capability set



2.9.2. Criticism of the capability approach

The Capability Approach has been criticized by different scholars and from different angles. Some claim that the capability perspective lack adequate attention on power relations and social structures. Others argue that the approach is too individualistic and encourage paternalism. And last, the approach is criticized to be difficult to operationalize (Robeyns, 2005; Tjelta, 2005).

To access the claim about the capability approach to be to individualistic, we have to distinguish between ethical individualism, methodological and ontological individualism.

When it comes to ethical individualism we are concerned about who or what should count in individuals evaluative exercises and decisions. Meaning that individuals are the only units of moral concern. Broadly defined, methodological individualism is explanatory individualism. Explanatory individualism perceives that everything can be explained by reference to individuals and their properties only. Ontological individualism make asserts about the nature of human beings, about the way they live their lives and about their relation to the society. Claiming that individuals are the building stones of a society. In other words, in the ontological understanding the society is consisting of individuals and their properties only. Similar to the explanatory individualism that states that societies can be explained by individuals and their properties (Robeyns, 2005). The capability approach grasps the ethical individualism, but does not rely on ontological individualism. Theoretical speaking, the capability approach consider social relations and the constraints and opportunities of social structures and institutions on individuals by recognizing the conversion factors that influence the choice of capabilities and functionings. Robeyns (2005, p. 109) conclude that once the distinction between ethical, ontological and explanatory individualism has been made, "…all critics of individualism accept that ethical individualism is a worthwhile endeavor".

Hill (2003) argue that the capability approach successfully recognize the impact of social institutions on human capabilities, but is lacking adequate analysis of institutionalized power in causing inequalities achievable individual opportunities. This makes it difficult to use the approach as an evaluative framework for human welfare. The lack of attention to power relations and social structures makes the theory not applicable to identify social cause of poverty and inequalities.

Last, the capability approach has been questioned whether it is operational and measurable. How can individuals identify, select and prioritize among valuable functionings? Sen has been criticized for not contributing with a list of distinct functionings that should be a part of an assessment of well- being. Nussbaum (2003) has contributed to the approach by adding a list of central human capabilities that she claims to be universal valid. Sen on the contrary argues that such a universal list is not adequate, as each context would need its own representative list of capabilities. Arguing that an universal list of capabilities can not meet all the different purposes of use (Robeyns, 2005).

Sen has responded to all the criticism by applying the capability approach in different contexts, illustrating how the approach can be used as a valuable analytical tool (Tjelta, 2005). The capability approach offers a framework that can provide understanding to phenomena (Robeyns, 2005) but offers little insight of the relationship between technology and social processes (Zheng, 2007). For that purpose other theories are applied. For the purpose of this thesis the contribution of Amartya Sen is acknowledged as it allows a contextualized list of capabilities.

2.10. The Innovation Diffusion Theory

The Innovation Diffusion Theory (IDT) is included in the theoretical framework in order to identify factors that enable or limit the possible achievements of solar cookers. The innovation diffusion theory thrives to explain how, why and to what rate technology communicated through cultures is taken up in social systems. Innovation is defined as an idea, behavior, or object that is recognized as new by its audience. While diffusion is defined as the process by which innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003).

2.10.1. Innovation diffusion and solar cooking

As defined by Rogers (2003) innovation is an idea, practice or object that is perceived as new for individuals or unit of adoption. Diffusion is the process which innovation is spread through communication channels over time and between members in a social system (Haider & Kreps, 2004). Based on the foregoing definition of innovation, solar cookers are here understood as an innovation as solar cookers are perceived as a new idea or object for the individuals and unit studied in thesis.

Rogers (2003) claim that innovations are always developed based on a recognized problem or a need, which motivates one to find a solution to the problem or the specific needs. The solar cookers were implemented in the Ajmer District as a result of local women complaining of the harmful affects caused by the use of firewood for cooking. To see how individuals and the society accept this innovation, the theory of innovation decision process is applied.

2.10.2. The innovation- decision process

One aim of the study is to identify factors that influence people's choice of using solar energy for cooking. Roger's model of Innovation Decision Process gives an understanding of how people make the decision to adopt a new innovation, such as solar cookers. According to Rogers (2003) individuals decide whether or not to adopt an innovation based on a series of choices and actions over time. Within this framework, an individual's decision about adopting an innovation is not a spontaneous decision, rather an ongoing process over time (Rogers, 2003).

The innovation decision process includes five main steps: knowledge, persuasion, decision, implementation and confirmation. Knowledge is developed when an individual learn about an innovation and get to know how it functions. Rogers (2003) categorize knowledge into three different groups: awareness-knowledge, how-to knowledge and principles- knowledge. The first category concerns the information about the existence of a certain innovation. For this study it means the information and campaigns demonstrated in the local context of the study, that makes people in the area aware of solar cookers. The second knowledge category includes the necessary information to understand and utilize the innovation. In the case of solar cookers, people need to learn how to use the applications in the right way. The final knowledge category presents the information about how an innovation works, in terms of physical laws. For example, in order to use a solar cooker correctly, one must understand that the cooker has to be directed toward the direct sun radiation (facing the sun) (Rogers, 2003). This type of information often reduces the uncertainty about the capacity of an innovation to solve an existing problem or serve a need.

Persuasion is the second stage of the innovation decision process and appears when an individual state a favorable or unfavorable attitude towards the innovation. For individuals who are potential adopters of solar cookers would for instance want to gain information about the positive health effects by using solar energy instead of fuelwood and time savings as they don't have to collect firewood anymore. This kind of information can constitute a positive attitude towards solar cookers. On the other hand, individuals can ask questions about how they can take advantage of the solar energy when they have to stay away from the household during daytime due to agricultural activities. A decision takes place when an individual or unit of adoption engage in activities that leads to the adoption or rejection of the innovation.

In the last two stages of the process the individuals and/or unit of adoption will seek to gain more information about the advantages or disadvantages of the innovation in order to evaluate whether the innovation should be adopted or rejected. In the stage of implementation the individual or unit of adoption actually utilize the innovation (the new idea is put into practice). In the confirmation state the individual or unit of adoption seek more information to use the innovation (adoption) or to reject the innovation. This also includes the active use of the innovation. As pointed out by Rogers (2003) an individual's decision to adopt an innovation and to actual use it is two different things. This means that even though one has decided to adopt a new technology, this does not mean that it is implemented. For instance; Ahmad (2001) study on users and non-users of solar cookers in an urban area in India show that several of the people who adopted the technology did not actually use it and rather stored somewhere. This brings up the point of assessing the needs and local context of the end-users of a technology. Haider and Kreps (2004, p. 4) enhance the importance to understand the innovation decision process in order to maximize the scope of diffusion and the rate of adoption of an innovation.

As Otte (2014a) points out in her article, the innovation decision model has received a lot of criticism, mainly questioning how measureable each stage of the decision process is. Rogers (2003) respond to the criticism by pointing out the intention of the model is to provide a simplified framework to understand human change when innovations are introduced. One can argue that the model is too abstract, but for the purpose of this study (to investigate factors that influence people's decision to use or not use solar cookers) the model is seen as a suitable theoretical framework to analyze why individual decide to or not to adapt to solar cooking technology in rural India.

2.10.3. Criticism of the innovation diffusion theory

The theory of innovation diffusion has been criticized for either focusing on the adoption perspective or the market infrastructure perspective instead of developing a complementary approach. The adoption perspective focuses on the characteristics of the individual while the market infra structure perspective emphasize the institutional context (McEachern & Hanson, 2008).

The innovation diffusion theory has also received critique regarding its pro- innovation bias, the implication in diffusion research that an innovation should be diffused and adopted by all members of a social system. It also implicate that innovation should be diffused more rapidly and that it should neither be re-invented nor rejected (Rogers, 2003). Moving forward I will review certain factors that is recognized as relevant for the use solar cooking technology.

2.11. Factors influencing the use of solar cooking technology

Both the innovation diffusion theory and appropriate technology approach identify certain conditions that must be in place before people decide to adopt and continue to use a technological artifact. According Troncoso, Castillo, Masera, and Merion (2007) an innovation is adopted by users if it represents an advantage and is more useful than the one it is substituting. It also needs to be compatible with local attitudes, values, beliefs and needs of the end-user. As well it must be easy to understand and implement, and potential benefits most be visible. This perspective focuses on the individual decision process.

This section will explain how predefined conditions may enable or limit the achievements of solar cooking technology. The variables considered as relevant for this case is divided into economic, cultural, social, political, technical and environmental factors. The variables reviewed in this thesis is a modified version of the framework presented by (Otte, 2014e).

Table 3: Variables relevant for solar cooking

Source: (Otte, 2014e)

Economic	Sociocultural	Political	Technical	Environmental
• Affordability • Local production • Job creating	• Food characteristics • Traditional cooking habits • Schedule of daily routine • Motivation • Existing power and gender relations	• Financing schemes • Dissemination strategies	• Satisfying performance • Easiness of use • Sensitivity to reparation • Information	• Availability and price of alternative fuels • Availability of suitable place • Levels of solar radiation • Levels of infrastructure

Economic variables

The cost of appropriate technology is an essential factor to the end-users. Gosh (1984) argue in his book *Appropriate Technology in Third World Development* that most of the appropriate technology that is developed is still too expensive for the people living in developing countries, even when cost of the technology is highly considered. In order to offer an appropriate technology that is helpful in meeting the needs of the end-users, the technology must be affordable (Wareham, 1997). This study is conducted in one of the poorest rural areas in India, leaving individuals with little or no financial means to obtain costly alternative energy sources. Local production of the technological artifact is seen as a mean to reduce the cost of the device in addition to creating employment opportunities.

Sociocultural variables

The local norms that constitute the way of living play an important role when it comes to successful implementation of solar cookers. The attributes of solar cooking technology must be compatible with the values and beliefs carried by potential users. Wareham (1997) strongly claims that solar cookers can only successfully be implemented in areas where the innovation is corresponding with the conventional way of cooking. When using solar cookers the daily meals must be prepared at the times during the day when there is solar radiation available. In some local contexts this may collide with the daily routines and schedule.

Political variables

Financial mechanisms to support the dissemination of the technological artifact is seen as important in order to reach out to more people.

Technical variables

In order for people to adopt and confirm the use of solar cookers the technical device must have a satisfying performance that meet the needs of the end-users. The artifact must be easy to use and the degree of sensitivity to reparation is important. In addition information is crucial in order to raise awareness about solar cookers and its potential benefits as an alternative to traditional cooking methods. Limited access to information about solar cookers may prevent the distribution of solar cookers.

Environmental variables

Access to and the price of alternative fuels are variables that will have an impact on whether people decide to use solar cookers or not. Availability of suitable area to place the solar cooker and levels of solar radiation is important.

The variables seen as relevant for solar cooking will together with the criteria for appropriate technology be used as a analytical tool to assess how suitable the solar cooking technology is in the local context of the study area and in what way these factors have an enabling or limiting factor on the achievements of solar cookers.

3. METHODOLOGY AND RESEARCH DESIGN

This chapter will elaborate on the methodological approach employed to study the impacts of the adoption of solar cookers in villages located in Ajmer district, India. The chapter will explain the overall research strategy employed to answer the established research questions, including methods of data collection and analysis, ontological and epistemological approaches and ethical considerations. In addition the quality of the research will be assessed and identify possible strengths and limitations (B. Berg & H. Lune, 2014).

The purpose of the thesis is to investigate the contribution of solar cooking technology in a selected rural area in India. The overall research questions have been explored by using a qualitative case study approach. The study examines the use of solar energy for cooking purposes among selected families and village communities in Ajmer district, India. The research questions of the thesis aim to understand the implications of adopting the technology of solar cookers.

Qualitative research methods can roughly be defined as the opposite of quantitative research methods, al though the distinctions between the two approaches can in some cases be perceived as more fluid. Where quantitative research is often referred to counts and measures of things aiming to generalize tendencies or test the causality of hypotheses, the qualitative approach seeks to understand social phenomena, social structures and human experiences. By using qualitative research methodology one intend to explore the *why* and *how* of a situation, not only *what, where* and *when* (Denzin & Lincoln, 1994). As the aim of the study is to investigate why people use solar cookers, and how it impact their lives and contributes to development, qualitative research methodology is seen as an appropriate approach to the study.

Qualitative research methodology includes a range of techniques. There are no strict rules of choosing one fixed method, but the choice of methodology should be coherent with the purpose of the study. In general qualitative research can be divided into three main groups f techniques: conducting interviews, participatory observation and text analysis. For the purpose of this study qualitative interviews and observation is the primary sources of data (B. Berg & H. Lune, 2014).

The choice of adopting qualitative research methods is grounded in both appropriate and convenient reasoning. Using qualitative research methods seemed appropriate to this study in order to gain a broad understanding of the context of the research questions and allowed essential insight into local practices and social processes. However, the potential value of the contribution of quantitative data to such study is not neglected either. The initial plan was to use mixed methods in order to collect quantitative data to collect adequate information about i.e. forest coverage that is relevant for the environmental dimension of sustainability. But due to language barriers and high level of illiteracy in the study are it was not possible to use proceed with the initial plan.

3.1. Ontological and epistemological considerations

Researchers who adopt a social science approach aim to discover tendencies in human behavior. Social science research includes different visions of how to understand and study social reality, often divided in two main approaches, *ontological* and *epistemological* considerations. Ontology is the philosophical study of the nature of reality and concern issues about beliefs of the world and the nature of reality, while epistemology concern questions of how we can study the world and what is regarded acceptable knowledge. Epistemology is in philosophy often referred to as "theory of knowledge" (Bryman, 2012).

Epistemology is concerned about how we know things and what can be regarded as acceptable knowledge in a discipline (Walliman, 2006). The critical debate around epistemology is whether or not the social world can be studied by the same principles as natural science. There are two main positions within epistemology: positivism, and constructivism. Qualitative research is associated with the constructivism positions and quantitative research largely support the positivism approach (Bryman, 2012; Walliman, 2006).

Positivists apply natural sciences to study the social reality. This is an objective approach that can test theories and establish scientific laws and seek causes and effects. Constructivists recognize the important role of subjective meanings in social actions and aim to affirm interpretations and meanings. All methodological approaches have a certain view of social

reality. This view will determine what can be accepted as legitimate knowledge. In this way ontology shapes epistemological positions (Bryman, 2012; Walliman, 2006).
Ontology is concerned about the theory of social entities and what there exists to be studied (Walliman, 2006). Qualitative and quantitative methodological approaches are recognized to have opposing ontological and epistemological positions. Qualitative research is commonly known to acknowledge constructionist ontological viewpoints. *Constructionism* accepts that there exist various local and specific realities. The perception of the social world is constructed by humans through social interaction, and is thus continuously under review. For that reason, a researcher might understand the social reality in a different way than the informants (Bryman, 2012).

Quantitative research applies objectivist ontology. *Objectivism* argues that the existence of the social world is external and independent of social actors. According to objectivism, the true nature of social phenomena can be discovered by researchers, and their interpretation will correspond with how other social actors interpret the nature of the phenomena (Bryman, 2012).

The outline of the ontological and epistemology perspectives made here is simplified and adapted to the means of the study. All positions within ontology and epistemology are not covered, but I decided to include those positions that are often referred to as the main oppositions of the two approaches. The main purpose of this section was to make a distinction between ontological and epistemological approaches and how qualitative and quantitative research methodology relate to these.

This study is based on qualitative research methodology and rests on a constructionist ontological approach. Meaning that I perceive the social world to be socially constructed and not independent of social entities. In addition I find the most appropriate way to study social constructed phenomena is through interpretivist epistemology that consider the complexities of social interaction. This approach recognizes that the knowledge constructed by a researcher is not neutral, but is built on the interpretations of the researcher. Thus the analysis of the findings of this study will be colored by my own perceptions of a socially constructed world. Potential subjectivity of the research is acknowledged and the research might be influenced by personal biases.

3.2. The case study approach

The qualitative case study approach is a tool for researchers to study phenomena within a certain context. There are mainly two directions one distinguish between in the case study approach, both based on constructionist ontology.

The selection of the type of case study design to conduct should be determined by the overall study purpose. R. Yin (2003) makes the following three categorizations of case studies: explanatory, exploratory or descriptive. Stake (1995) distinguishes between intrinsic, instrumental and collective case studies. According to R. Yin (2003) one should consider to use the case study approach if the study seeks to answer "how" and "why" questions, when one cannot manipulate the behavior of those involved in the study, when it is wanted to investigate contextual conditions of the phenomena and when the boundaries between context and phenomena is not clear.

This study employs a single, exploratory case study approach to meet the aim of the research. The purpose of explorative research is to explore a specific topic to elaborate the knowledge and understanding of the chosen field of study. This approach do not necessarily have accurately defined research problem, but allows the researcher to change direction along the study according to the findings (R. Yin, 2003).

An explorative case study approach made it possible to investigate the influencing factors of the achievements of solar cooking technology and the local context of the study area where solar cooking technology was adopted. The study is not based on any predefined assumptions about the reality, but rather seek to understand and explore the relationship between technology, society and sustainable development. As the fieldwork was undertaken once during a particular time, this study is defined as a *cross-sectional* case study. For *Longitudinal* case studies the research is based on multiple visits to the field over a longer time period (Baxter, 2010). Thus, this study can only give information about the state of topic studied as it was during the fieldwork conducted in august/September 2014.

All research designs can be discussed regarding their strengths and weaknesses. The nature of the case study approach provide little basic for scientific generalization as the sample size of a case study is often small in number of subjects, and often involves one single case (R. Yin,

1994). This can also make it difficult to reach a generalizing conclusion (Tellis, 1997). Due to the small sampling size of the research methods it is argued that is difficult to establish reliability and generality. Also the approach is criticized for its lack of rigor, as there is a tendency for a researcher to have biased interpretation of the data (R. Yin, 1994).

The weaknesses mentioned here are all acknowledged as potential limiting factors of the research. However, the case study approach is employed in this thesis as it is seen as appropriate to gain knowledge and understanding for the social phenomena studied here. It is a valuable tool in order to access information necessary to explore the research questions. But there is by no mean an intention to generalize the findings. The risk of biased interpretation of the data will be considered when disseminating the findings.

3.3. Location/ setting of data collection

The data collection for this study was conducted mainly at Barefoot College, Tilonia Village and nearby villages in the semi-arid areas of Ajmer District, Rajasthan, India. The setting for the data collection was purposively selected based on already gained knowledge about the area and access to specific attributes in order to meet the purpose of the study.

Figure 2: Map of Rajasthan
Source

In order to gain knowledge about the impacts of using solar cooker technology and its added value beyond energy, data was collected both among solar cooker users, producers and households using conventional cooking methods.

3.4. Data collection methods

This study is based on two sources of data: primary and secondary data. The primary data compromises the data collection during the fieldwork in India, while the secondary data that is already produced by someone often for a different purpose, is used to develop a greater understanding of the sociocultural context of the study area and the research topic as well as establishing a theoretical framework for the study (Mikkelsen, 2005). All together the

research is based on data collected from 42 informants. Following is an explanation of the data collection methods applied.

3.4.1. Interviews

Interviews are meaningful way of collecting data when a researchers aim is to gain information about subjective perceptions and interpretations of the studied phenomena (B. Berg & H. Lune, 2014). According to Kvale (1996, p. 1) the intention of conducting qualitative interviews is to try to understand the subjective understanding and perception of the world. This reflect the purpose of this study which aim to describe and understand why people decide to use solar cookers or not in their experience and investigate the added value of solar cookers beyond energy. Interviews contributes to construct knowledge through interaction between the interviewer and the interview object (s) (B. L. Berg & H. Lune, 2014).

By performing qualitative interviews the researcher aim to obtain knowledge expressed in normal language instead of statistical quantification. One can distinguish between three main types of interviews: standardized interviews, semistandardized interviews and unstandardized interviews. The main difference between the different types of interviews is how rigid the structure of the interviews is. The standardized interviews follows a predetermined and standardized list of questions and the wording of the questions are asked in the exactly as they are written to all interview objects. This is a very formal structured interview where no additional questions may be added during the interview. Semistandardized interviews are based flexible structure and performance of the predetermined questions. In contrast to standardized interviews, the interviewer may add questions along the interviews, be flexible with wordings and make clarification during the interview. Unstandardized interviews include no list of prepared questions and the conversation is more or less based on the informant (B. Berg & H. Lune, 2014).

This study is based on semistandardized interviews conducted with both individuals and groups. All interviews were based on predetermined interview guides, but chosen interview method allows openness to add questions or change the form of the questions during the interviews. Using such an flexible structure of data collection allows the researcher to be open to new and unexpected phenomena (B. Berg & H. Lune, 2014).

The interviews with the individuals and groups producing and/or using solar cookers took place at different locations at Barefoot College, as well as interviews conducted with the institutional leader of the college. Interviews with individuals using conventional cooking methods were conducted in their respective households. The interview guides can be found in the Appendix.

3.4.2. Focus groups

Focus groups are type of group interview often including people who have particular experience or knowledge about the subject of the research (B. L. Berg & H. Lune, 2014). The intention of conducting focus group interviews was to reach out to more informants due to time limitation and also the considering the experience that the women spoke more freely in groups. This type of interview was conducted with the Women Barefoot Solar Engineers Society, Self-help-groups and employees from a local Crèche.

3.4.3. Observation

The purpose of doing observations during my fieldwork was to gain an understanding of what people *do*, and not only what the *say* they do (R. K. Yin, 2009). Of special interest was to get an overview of the whole cycle of the cooking practices in households. Direct observation and participating observation was also the only option to reach out to households using conventional methods as there were no access to interpreter or common language between me as a researcher and informants.

According to R. K. Yin (2009) observations can add new dimensions to understand a context or phenomena. By observing a phenomena one can also observe whether informants act differently than they say or intend to do (Walliman, 2006). The weaknesses of the observation method in addition to be time-consuming is that the documentation relies on memory and personal discipline of the researcher (Kawulich, 2005). This potential problem was countered by writing detailed field notes, with guidance of the predefined interview questions and indicators for each dimension of sustainable development and appropriate technology. When doing observations it is important to know what one want to look for. Thus an observation guide with predefined questions and indicators was prepared to use when observing the practices in each of the studied households (see appendix).

Observing behavior of people can increase the understanding of social and cultural context of the studied phenomena. And for this thesis it was important to obtain information about the division of domestic work and power relations in the households. Al though it was decided beforehand what I wanted to observe, the observation done was *uncontrolled* as I also put attention to others issues in order to not miss out on any information (Kearns, 2010).

One also makes a difference between participant and non-participant observation. *Participant observation* is mainly associated with ethnography, which involves research where the researcher spends long time in the society of study. A researcher applying an ethnographic study can fluently speak the language spoken in the society that is being studied. In situations where the researcher is only observing a social phenomena without participating in the setting is called non-participant observation (direct observation) (B. Berg & H. Lune, 2014; Walliman, 2006). Al though, some argues that it is difficult to make a distinction with the two approaches to observation. Kearns (2010) claim that even those researchers who intentionally only observe a social setting will alter the research setting. As I was only collecting data on and off over a period of two months, and I did not learn the local language spoken in the society I studied, this thesis is not based on ethnography. But it is difficult to say that I only conducted direct observation as I also participated in the daily activities of the households I stayed in and assisted the women solar engineers to construct solar cookers.

3.4.4. Secondary data

Secondary data is information collected by other people, often collected with other purposes. Secondary data is often used to help the researcher further into the research process, and not directly answer the research questions for the specific study (B. L. Berg & H. Lune, 2014).

The use of secondary data in form of academic literature and documentation has been necessary in order to make a theoretical framework of the thesis and to gain more information about the research topic, the geographical area where data was collected, sociocultural context, and further background information about the energy situation in India. Secondary data was used throughout to prepare the study, fieldwork and to analyze the data.

3.5. Sample strategies

Besides finding an appropriate study area it is necessary to decide on a sampling strategy for the data collection. Different qualitative sampling strategies may be used at different stages of the research, or for different research purposes. Qualitative research do not have the aim to produce a statistically representative sample, and is therefore using non-probability sampling (Bryman, 2012).

This research employs a purposive non-random sample strategy. Meaning that the number of people interviewed and observed is less important than the criteria used to select them. The characteristics of individuals are used to make a selection to make sure that the objectives of the studies can be reflected by the information given by the respondents (B. L. Berg & H. Lune, 2014; Walliman, 2006).

A purposive sampling strategy was used to access key stakeholders relevant for this study. Based on knowledge gained during the initial visit to Barefoot College subjects from Tilonia Village and surrounding villages was selected as samples. Such an approach was necessary to ensure that informants with the specific attributes necessary to assess were included in the sample. In addition, snowball sampling was applied to access further samples based on the recommendations by existing informants. When using snowball sampling one must consider certain weaknesses of such sampling strategy. The informants making recommendations for further samples might have their own agenda. This is a concern that is difficult to prevent, but I cannot identify any informant that I find harmful for the quality of the data used for this study (B. Berg & H. Lune, 2014; Bryman, 2012).

The data sample for this study includes three households using conventional cooking methods, representatives from Barefoot College the Women Barefoot Solar Cooker Engineering Society of Tilonia, Self-help- groups and a Crèche. Representatives from the Institute of Development Studies Jaipur and Barefoot College carried valuable knowledge about the area that could assist to identify interview objects and households to observe.

3.6. Assessing the quality of the data

Different criteria can be used to test the quality of research in social science. According to Collingridge and Grantt (2008) both quantitative and qualitative research have the intention to be valid and reliable. Validity in qualitative research refers to choosing the appropriate method to answer the research questions, and carry out a coherent, justifiable and rigorous methodological process. Such interpretation of validity is similar to how it is understood regards quantitative studies. The main concern for both qualitative and quantitative research is to produce legitimacy results (Kvale, 1996). The validity of the primary data used in this study will for instance be measured on how the interviews were conducted. Qualitative interviews are seen as valid when the interview investigates what is intended to be investigated (Kvale, 1996).

Reliability of a study is understood differently in quantitative research and qualitative research. Quantitative research seeks to measure how repeatable or consistent the research findings are. When repeated research leads to the same results as the initial study, the data of the research can be defined as reliable (Bryman, 2004; Walliman, 2006; R. K. Yin, 2003). Repeatability is not a measure of reliability when it comes to qualitative research. Instead, reliable qualitative research provides one with rich and meaningful description of a phenomena Collingridge and Grantt (2008). The aim is to produce consistent similarity in the research results. For that matter it is important to acknowledge that reliability accounts for all parts of the research process. Reliability is desirable in order to avoid subjectivity, however, (Kvale, 1996) enhance that an exclusive focus on reliability may prevent creativity and variation.

During fieldwork questions regarding the reliability and validity of the findings were raised. Initially the informants producing and/or using solar cookers were mainly providing information about the advantages of the solar cookers. There can be several reasons for this. First, the translator helping us with the interviews was acknowledged as a male authority at the institution the informants were connected to. This may have forced the women to only speak out the advantages. This was also proven when a second female translator who was not connected to Barefoot College, assisted us in the interview process. Than informants also provided further information about sociocultural context in their local community and power relations within their own households. Obstacles to large-scale implementation were also

mentioned in the second round of interviews. Second, entering a social context as an outsider might limit the information given by the informants. I experienced that more trust between the informants and me as a researcher was gained over time, and I believe that contributed to provide me with more information, also beyond the core concepts of interest of the thesis.

To enhance the validity and reliability of the research triangulation of theory and data was applied (Denzin & Lincoln, 1994). By applying interviews, observation and documentation I fell confident that the data reflects representative view of the field of study. Using theory triangulation to interpret the data and disseminate my conclusions and recommendations might help the reader to get a clearer orientation of my findings. To increase the trustworthiness of the study, all field reports from the interviews and observations were discussed and compared with both the translator and other representatives present during the conduction of data collection.

3.7. Limitations of the study

Different limitations can be identified for this study. First of all, the limited time for conducting fieldwork set certain boundaries when it comes to choice of methodology. Al though quantitative methods like questionnaires could provide the study with valid information, qualitative methods seemed more appropriate due to time limitations and the awareness of high level of illiteracy in the study area.

In addition, the findings of the study are context specific, and may not be used for generalization. Also, al though information is provided both by users and non- users of solar cookers, it should be considered that most of the information given by non-users are based on direct and participatory observation. Due to lack of infrastructure it was not possible to reach out to households using solar cookers as planned. However, solar cooking practices was observed at institutions and demonstrated by the producers. The number of informants may be questioned to be too few, but due to time limitations it was not possible to reach out to more informants during the time I was staying in the field.

3.8. Using translators

Conducting cross-linguistic interviews require the use of a translator. This may pursue some threats to the validity of the study. There is a possibility that the translator can influence the response one gets from the informants, intentionally or unintentionally. Questions may not be translated correctly, and the translator can possibly only translate parts of the response given into the language the interviewer understands. As pointed out by points out how power relations between the translator and the informant can influence the response given to the interview questions (Bryman, 2012).

During the fieldwork I experienced that more detailed and personal information was provided when we used a female translator that was not connected to Barefoot College. The initial male translator used to conduct interviews was perceived as an authority by many of the informants. This might have limited the response by the informants. Also, the female translator was trained in the field of study, which made it easier to communicate the purpose of the study and she also were able to explain the core concepts to the informants. Analyzing the information from the interviews, it seems that such attribute was beneficial in order to answer the research questions for this study.

Despite the potential drawbacks by using translators, it is important to mention the advantages of using one. As the initial male translator new the local setting he could give me important information about the sociocultural context, as well as easy that access to the society. As most of the informants did not speak of understand English it was necessary to use the translator to introduce me, and the purpose of the interaction. The translator was especially important for me to be able to access households in order to observe their cooking practices. Without the local translator and his trust to the local community, I would most likely not be able to live together with the local people in their homes. So overall, I will argue that in this study the use of translator do not reduce the trustworthiness of the research.

3.9. Ethical considerations

Ethical considerations must be made throughout the whole research process, and by some argued; ethics most be given even more awareness during fieldwork process.

Researchers are responsible to ensure that the informants are not harmed, privacy is maintained, and that informants have received an informed consent. The researcher is responsible to inform the participants of the study about the purpose of the research. The informants must also be aware of that they can always withdraw as informants.

All the informants of this study were given the information about whom I was and my purpose to interact with them. The translator gave the information orally in the local language, as most of the informants were not able to read. All informants were given confidentiality, but I asked for permission to use the name of the women organization producing solar cookers, as well as pictures taken during the fieldwork. The names of the individual informants are changed in the dissemination of the study. This permission was also confirmed by Barefoot College, which allowed me to use all the collected information as well as the pictures. However, it is difficult to ensure complete confidentiality when using a local translator. It is impossible to control whether the translator will share the information given during interviews with other members of the community. Both translators were informed about the necessity to keep the information confidential. I did not experience that this principle was broken during my fieldwork, but again this is difficult to ensure as the translator also speak a different language (Bryman, 2012; Kvale, 1996; Walliman, 2006).

Payment and compensation to interview respondents came up as an ethical issue during the fieldwork. My initial decision was to not use any form for monetary incentives in order to be able to interview the respondents. On the other hand I was kind of forced into compensating the households for letting me stay with them. Children in the households were given small candy and the main translator helping me to facilitate the stay with the household later on ask directly for monetary compensation to give to the household. This was provided. When monetary incentives are involved in a research one must consider how such inducements affect the quality of the data. As the inducements took place after the data was collected, I will argue that this did not have an affect on the information provided unless the translator, without making me aware of it, gave promises of any sort of compensation before the interviews were conducted.

4. ENERGY IN INDIA

With a population of 1.2 billion people and hosting over 200 million households, India is the second most populated country in the world. According to numbers from 2011, India was the fourth largest energy consumer in the world, after China, the United States and Russia[10]. Even though the per-capita energy consumption is at a much lower level in India compared to developed countries, the energy demand more than doubled in the time period from 1990 to 2009. And the world's demand for energy is projected to increase by 50 per cent from now on towards 2030, where China and India alone stands for 45 per cent of the increase. This indicates that the country has a long way to come to ensure energy access for all. In terms of sustainability it will be important for the country to carefully select what type of fuels and technologies that should serve the households in the country with energy (IEA, 2012). As seen in the table below, still over 300 million people in India live without access to energy.

Table 4: Electricity access in 2012 - Regional aggregates

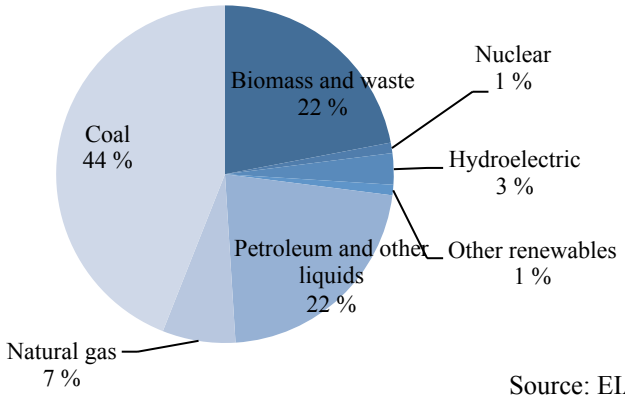
Region	Population without electricity (millions)	Electrification rate	Urban electrification rate	Rural electrification rate
Developing countries	1 283	76 %	91 %	64 %
Africa	*622*	*43 %*	*68 %*	*26 %*
North Africa	*1*	*99 %*	*100 %*	*99 %*
Sub-Saharan Africa	*621*	*32 %*	*59 %*	*16 %*
Developing Asia	*620*	*83 %*	*95 %*	*74 %*
China	*3*	*100 %*	*100 %*	*100 %*
India	***304***	***75 %***	***94 %***	***67 %***
Latin America	*23*	*95 %*	*99 %*	*82 %*
Middle East	*18*	*92 %*	*98 %*	*78 %*
Transition economies & OECD	1	100 %	100 %	100 %
WORLD	1 285	82 %	94 %	68 %
Source: IEA, World Energy Outlook 2014				

[10] http://www.eia.gov/countries/cab.cfm?fips=in (Access date: 19.10.14)

The primary energy consumption in India is currently dominated by coal and oil and natural gas production have increased over the past years. Future energy supply is predicted to continue to be hydrocarbons (EIA, 2014). The table below shows the distribution of sources of energy consumption.

[11]

Figure 3: Total energy consumption in India, 2012



Source: EIA (2014a)

Household energy consumption pattern in India stands for X of the total energy consumption in the country; where the majority of the household energy consumption is used for cooking and heating purposes. As the table below shows, still over 800 million people rely on traditional biomass for cooking.

[11] http://www.eia.gov/countries/cab.cfm?fips=in (Access date: 13.05.15)

Table 5: Population relying on traditional use of biomass for cooking in 2012

Region	Population relying on traditional use of biomass (millions)	Percentage of population relying on traditional use of biomass
Developing countries	2 679	49 %
Africa	*728*	*67 %*
Sub-Saharan Africa	*727*	*80 %*
North Africa	*1*	*1 %*
Developing Asia	*1 875*	*51 %*
China	*448*	*33 %*
India	***815***	***66 %***
Latin America	*68*	*15 %*
Brazil	*13*	*6 %*
Middle East	*8*	*4 %*
WORLD	2 679	38 %
Source: IEA, World Energy Outlook 2014		

Many households have to walk far to collect the fuelwood for cooking purposes, and due to deforestation many have to walk further now compared to five years back in time. According to the study of household energy consumption pattern in Rajasthan, India published by Laxmi, Parikh, Karmakar, and Dabrase (2003) households spend in average more than 3 hours per day on fuelwood collection. And even eighteen per cent of the households have to walk more than 3 km to collect the fuel. The remaining households walk a distance of 1-3 km in an average of fifteen times per month. The distribution of effort to collect fuelwood is presented in the table below:

Table 6: Type of effort to collect fuel-wood

		Districts			
		All	**Jodhpur**	**Kota**	**Sawai Madhopur**
Distance walked to collect firewood	Up to 1 km	29	34	39	20
	1-2 km	30	32	35	25
	2-3 km	23	20	17	29
	More than 3 km	18	12	9	26
Average time spent per trip (hours)		3.2	2.3	3.6	3.6
Average number of trips per household per month		15.6	18.4	8.3	16.5
Average time spent per month per household (person-hours)		49.9	42.3	29.9	59.4
Base: households always/mostly gathering firewood		1,483	527	292	664
Source: (Laxmi et al., 2003, p. 56)					

In both rural and urban areas Indian households use diverse fuel sources for cooking purposes- including electricity, firewood, kerosene, dung cakes and liquid petroleum gas (LPG). The difference is that 75 per cent of rural households depend on firewood to meet their cooking needs, compared to 22 per cent of urban households that uses firewood. Only 6 per cent of rural households use LPG for cooking and only 1 per cent of rural households are using either kerosene. Data for this study is collected in the state of Rajasthan where over 90 per cent of the households use firewood as their primary source for cooking (Woodbridge, Sharma, & Fuente, 2005).

4.1. Energy access and energy security in India

A rapid increasing demand for energy and growing concerns about economic and environmental consequences calls for an effective governance of the energy sector in India. The overall aim of energy security is to reduce a country's dependency on imported energy sources for its economic growth. Since 1985, India has increasing challenges of meeting the energy demand by domestic resources. Due to the population growth and high rate of people living without access to energy, the dependence on energy import is suspected to increase in the future. Among the strategies to meet the energy demand in India is diversification of energy supply sources, energy efficiency, development of renewable energy sources and sustainable development[12].

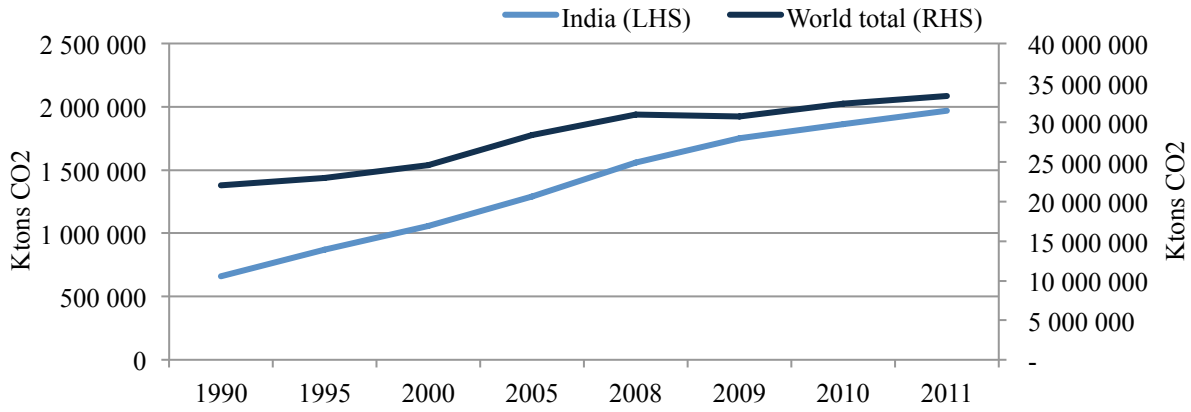
Access to modern energy services is traditionally closely correlated with development measures. The Intergovernmental Panel on Climate Change (IPCC) are among the actors that argue that providing access to energy to the poorest people in the society is essential in order to fulfill the goals of development (both referring to the Millennium Development goals and sustainable development). Industrialized societies have transformed their lives in correlation with increasingly consuming non-renewable energy sources. At the same time, in 2010, 20 percent of the world population lived without access to electricity. And 40 percent of the world population relies on traditional biomass like firewood, for cooking (Sathaye et al., 2011).

4.2. Energy and climate change

Every society needs energy services to meet basic human needs such as lightening, cooking, health services etc. Globally fossil fuels have dominated the energy supply, leading to a rapid increase in greenhouse gas emissions. Emissions resulting from energy supply have largely contributed to concentration of greenhouse gases in the atmosphere, causing global warming and climate change (IPCC, 2011). As seen from the graph below, India's CO2 emissions have increased rapidly since 1990.

[12] http://www.beeindia.in/energy_managers_auditors/documents/guide_books/1Ch1.pdf (Access date: 01.05.15)

Figure 4: CO2 emissions in India and World, 1990-2011



Source: European Commission, 2011

There are options for lowering the greenhouse gas emissions from the global energy system, while meeting the demand for energy the same time. Renewable energy sources have the potential to provide multiple benefits. In addition to mitigate climate change, renewable energy can promote social and economic development while providing energy supply and security. Furthermore, this will reduce the negative impacts unsustainable energy consumption can have on environment and people's health (IPCC, 2011).

Some renewable energy technologies can be implemented in decentralized areas, directly where the energy source is needed and used. In contrast to large grids that require advanced infrastructure to serve remote villages with electrification. Technologies using direct solar energy are examples of technology that can promote sustainable development. This thesis looks at the contribution of solar cooker technology in rural India beyond energy. Can solar cooker technology be a mechanism to achieve sustainable development at local level?

The increasing level of greenhouse gas emissions, lack of access to fuel and increasing fuel prices are some of the driving forces to utilize renewable energy sources. Among the clean energy sources available, solar energy is among the most promising source as it is clean, free and possible to access for everyone. Solar cookers are considered as one of the simplest and viable options in terms of utilizing solar energy. Solar cookers is suggested to be an alternative for clean and free energy source for rural areas in developing countries, which traditional rely on fuelwood (Sedighi & Zakariapour, 2014).

Beyond the negative environmental impact fossil fuel consumption have, dependence on traditional biomass for cooking results in multiple stressors and hinders for the users. The use of solid fuels is often time consuming limiting the time for education and income generating activities. People living in developing countries, especially in the rural part of the world lack access to alternatives to energy sources and if the alternative do exists, households often lack the economic capacity to purchase cleaner and more efficient fuel sources. And women and children who are mainly responsible for the cooking practices in the households are exposed to indoor air pollution that may cause negative impact on their health. This comes in addition to the physical pressure they carry when collecting the fuel source[13].

Deploying renewable energy sources have many valuable assets such as reduction in air pollution and related burden of diseases and future energy costs both for community and domestic purposes. The people, who already lack access to secure energy supply, are those who will benefit the most from a transition in energy supply.

If the fuelwood consumption continues in the same patterns, the energy use in India is not compatible with sustainable development. It is necessary to adopt an energy system that address current greenhouse gas emissions and transform today's energy supply towards a cleaner consumption pattern. In addition the country must proved energy supply to all those people without access to energy, mainly considering the rural part of India.

The associated harmful effects of using solid fuels for cooking underline the importance of finding new alternative and cleaner energy sources for domestic use. With an average of 300 sunny days in India, solar energy has the potential to improve the energy situation in the country. Using solar energy for cooking also has the potential to lift people out of poverty.

Access to modern cooking facilities, such as solar cookers, has the potential to allow households to have more productive hours, giving children more times for school, increase amount of time for income generating activities and improved health. This will potentially lead to sustainable development at the local level. As a clean energy source, solar cookers have no emission of gases to the atmosphere and will not have any negative impact on the health of the users or the atmosphere. And by using the direct solar energy, there will be less

[13] http://www.who.int/indoorair/impacts/en/ (Access date: 18.03.15)

pressure on local natural resources. One other important feature about the mechanism of solar cooking technology is that it involves the potential empowerment of women. Women are seen as necessary actors in sustainable development. Teaching women how to use solar cookers will potentially result in social and economic empowerment of the women themselves and their families.

The geographical location of India and the level of solar radiation are perceived as very suitable for using solar energy technology, especially in decentralized areas where it is difficult to access with other forms of modern energy sources that require extensive infrastructure. As the majority of traditional biomass is used for cooking and heating purposes in rural households in India, solar cookers is seen as an adequate mechanism to meet all dimensions of sustainable development. By replacing firewood with solar cookers, women and children have more time for education and income-generating activities, women and children do not have to carry burdens associated with the use of firewood, and due to less emissions and less use of natural resources, there will be less negative impact on the environment. This will contribute to mitigate climate change as well.

The next chapter will present solar cooking technology as a solution to meet current and future energy need in India.

5. SOLAR COOKING IN INDIA

Since the industrialization, the ability to harness and utilize different forms of energy has improved the living conditions of billions of people. Historically we can see that economic development have been strongly correlated to the increase of energy use. Increasing energy consumption has been closely tied to the rising level of prosperity and economic opportunity in many parts of the world (Ahuja & Tatsutani, 2009). But the world is now facing a global energy crisis that is putting lives and our environment at risk. At the same time as the world is facing the consequences of climate change caused by continuous greenhouse gas emissions, still 1.8 billion people live without access to any form of energy source. The global dependency on fossil fuels is pushing the carrying capacity of the environment and climate system, as well as putting great socioeconomic burdens on especially the poorest and rural population of the world. To meet the standards of sustainability it is necessary to speed up the global transition to clean, low-carbon energy systems (Ahuja & Tatsutani, 2009).

The increasing demand for energy and the focus on sustainable energy consumption patterns have emerged the interest for improving household energy patterns. To meet the challenge of lack of energy access and inefficient use of fossil fuels, the Indian government have increased the effort on implementing improved cooking stoves and improved access to energy in order to end the energy poverty circle (Woodbridge et al., 2005).

The global interest in alternative sources for cooking has increased due to the global perception of the potential for delivering triple dividends: improved health, improved conditions in the local environment and reduced emissions of black carbon (Lewis & Pattanayak, 2012). Several international development actors like The World Bank (2011) enhance that the value chain around cook stoves present an opportunity to promote sustainable development. Studies done on improved cooking stoves show that it can have far-reaching impact on the health and socioeconomic status of rural households (Kanagawa & Nakata, 2007). The recognized efficiency of improved cooking stoves has contributed to further interest in solar cookers. The sun carries the potential to provide clean energy for the poorest people in developing countries. Being a universal energy source makes solar energy unique (Wentzel & Pouris, 2007). Solar energy can be a suitable technology especially for developing countries who are facing a double energy challenge in order to both provide energy access and security in a sustainable way (Ahuja & Tatsutani, 2009).

The concept of solar cooking is not new and can be found many places all over the world. Actually, the construction of the first documented solar oven was made in 1767 by the Swiss physics called Nicholas de Saussure[14]. Augustin Mouchot published the first book about solar energy called *Solar Energy and its Industrial Applications* that was published in 1869. Later on Mouchot constructed solar cookers for soldiers in Africa. During the second World War the interest in solar energy rises as a result of fuel shortages which again occurred during the oil crisis in the 1970 (Wentzel & Pouris, 2007). Throughout the 20th century the solar cooking technology has been improved and applied in various part of the world. But for a long time solar cookers have been enhanced as the 'solution looking for a problem'. According to studies done on the implementation of solar cookers in South Africa there has been a lack of focus on the need of end-users. To ensure successful implementation and continuous use of solar cookers, the end-users needs must be addressed and the technology itself most be appropriate for the local context (Wentzel & Pouris, 2007).

Despite the recognized triple-win outcome of improved cooking applications, progress in achieving large-scale adoption and use have been remarkably slow (Kanagawa & Nakata, 2007). Al though solar energy is largely available in India; the harnessing of the energy has not reached out on a large scale. Several challenges have hampered the progress in doing so. Short-term access to solar energy can be uncertain, and the degree of solar radiation that can be used directly for cooking may vary on a daily basis due to local weather predictions and seasons. Geographical location, weather conditions and land availability are among the factors that will impact the applicability of solar energy (Johansson, Crmick, Neij, & Turkenburg, 2004).

One recognized obstacle for the use of solar cooking technology is lack of sociocultural acceptance of the technology. This can be rooted in the lack of knowledge of how to use the application or people believe that the equipment cannot be used to actually cook food. Through her casework Otte (2014a) elaborate on the importance of cultural understand of cooking in Burkina Faso and India. In both countries Scheffler reflectors were installed to be used in institutions like bakeries and steam kitchens. Through the cases from the two countries, Otte (2014a) argue that cultural factors can enhance and limit the implementation

[14] http://energyinformative.org/the-history-of-solar-energy-timeline/ (Access date: 13.04.15)

of solar cookers. The main argument is that solar cookers are successfully implemented when they support the local cultural context. By doing so, the end-user of the solar cookers will move away from the perception of solar cookers being a foreign technology, and rather being an integrated part of the local community. Culture can be understood as shared values and norms that can define behavior in a society. Culture can also be invisible, and not even recognized by the people affected about the character of common values and norms (Steers, Meyer, & Sanchez-Runde, 2008). This invisible aspect of culture can be an obstacle to the implementation of solar cookers, if it is not recognized and carefully considered before the process starts.

An other argument put forward by Wentzel and Pouris (2007) says that the implementation of solar cookers has failed due to the technological driven approach of it. Meaning that the needs of the end-users are not considered when choosing the technology to be implemented in a specific area. Successful continuous use of solar cookers requires broad understanding of local culture, habits and needs. This must come first, not the selection of type of technology to implement.

Based on the case studies in Burkina Faso and India, Otte (2014a) identifies several cultural factors that may prohibit use of solar cookers. People seem to be skeptical towards the functionality of solar cookers as the technology prepare food without visible fire, as well as the food has to be prepared outside. This may collide with traditional habits. As the food has to be cooked outside during daylight, the use of the technology may collide with other daily routines. The characteristics of the food cooked using solar energy may also influence how well the solar cookers are accepted.

Keeping in mind bot the potential benefits and obstacles of implementing solar cooking technology in developing countries, the thesis will proceed with assessing solar cooking practices in the Ajmer district in a rural part of India.

6. ASSESSING SOLAR COOKING PRACTICES IN AJMER DISTRICT

This chapter will investigate the solar cooking project established at Barefoot Colleges, the use of parabolic solar cookers in the local area and look at the role of the Women Barefoot Solar Engineers Society (WBSES). The information used is based on the interviews conducted with the female solar engineers and the users of solar cookers and additional information provided by employees at Barefoot College. Further on when analyzing the impact solar cookers have beyond energy, the thesis will also consider information provided by individuals using traditional biomass for cooking. This is considered to broaden the understanding of the solar cooking technology can contribute to improve the livelihoods of people living in Ajmer District, India.

Predefined factors that are perceived to have an influence on solar cooking practices is used to assess the achievements of the solar cooking technology. These factors were defined under the theoretical framework in chapter 2.

6.1. Barefoot College and the parabolic solar cookers

For over 40 years Barefoot College have provided solutions for rural communities with the aim to promote self-efficient and sustainable societies. Barefoot College is located in a rural part of India, in the state of Rajasthan. The whole state include a population of 68 million people and according to numbers published by UNDP in 2011, at least 28 million people in the state live in poverty[15]. And over 90 per cent of the people living in the rural part of the state depend on firewood for cooking (Woodbridge et al., 2005).

The implementation of parabolic solar cookers is one of the solutions offered to meet the local needs for energy. This solution emerged after rural women in the local community approached the head of Barefoot College to complain about the physical burdens they carry as a result of using firewood for cooking. They concerns were taken seriously and the women were invited to be trained to construct solar cookers themselves[16].

[15] http://www.in.undp.org/content/dam/india/docs/rajasthan_factsheet.pdf (Access date 11.05.15)
[16] http://www.barefootcollege.org/ (Access date: 13.04.15)

The vision of Barefoot College is to adopt the Ghandian ideas of lifestyle and lift the rural people out of poverty by mainly applying rural traditional knowledge and skills to build self-efficient and sustainable societies. The Barefoot College strategy to promote development is to demystify sophisticated technology and transfer the access, control, management and ownership to rural men and women, who most are illiterate[17].

Barefoot College recognize women as important agents of sustainable change in local communities, therefore, empowerment of women is one of the main objectives of all the solutions provided. Do to sociocultural norms and beliefs in the local context it has been difficult to reach out to women and train them in areas that are dominated by men. Since 1972 Barefoot College have trained women practical skills that are needed in the local community, such as midwives, dentists, school teachers and parabolic solar cooker engineers.

The WBSES in Tilonia, Rajasthan, India, was established in November 2003. The first woman solar engineer at Barefoot College was trained by the German engineer Wolfgang Scheffler to construct Scheffler reflectors to implement in the local community. Barefoot College continued to train more women to become solar engineers by using standardized measures as shown by Scheffler himself. Today, six women work as solar engineers at Barefoot College, using their skills of accuracy and metal craft to build parabolic solar cookers on order. It takes the women approximately 20 days to produce one cooker, and so far one hundred people (including eighty women) have been trained to use the parabolic solar cookers[18].

The illiterate and semi-literate women who are a part of the solar engineer association are independently fabricating, installing and maintaining parabolic solar cookers to be applied in rural areas[19]. The target group is poor women, and solar engineers want to listen to their needs and help them to improve their livelihood. The society has the following seven goals and aims:

1) Give women a better chance in life- more opportunities and more freedom

[17] http://www.barefootcollege.org/barefoot-approach/ /Access date: 13.04.15)
[18] http://www.barefootcollege.org/solutions/solar-solutions/parabolic-solar-cooker/ (Access date: 13.04.15)
[19] http://www.barefootcollege.org/solutions/solar-solutions/parabolic-solar-cooker/ (Access date: 13.04.15)

2) Making a woman's life a little easier by removing some of the burden of collecting firewood or other types of fuels
3) Breaking the cultural barrier and traditional thinking of what a woman's role should be in society
4) Improve health for all household members (particularly women and children who spent more time cooking)
5) Improve the environment by reducing fuel consumption
6) To be role-models for all women and show them what is possible to achieve
7) Give more power to the impoverished women (widows, physically challenged, poor women) by creating employment for them and making them more self-dependent

These goals will be used later on in the discussion to evaluate to what extend they have been achieved in order to promote sustainable development.

6.1.2. Challenges the society is facing

According to the information provided through interviews with the woman solar engineers they are faced with challenges in order to implement the solar cookers in their local community. Some of the obstacles mentioned are now overcome, but it is worth mentioning to illustrate sociocultural barriers that must be considered when introducing rural communities with new technological devices.

In order to construct the solar cookers they rely on local materials. In the beginning when the women went alone to the market to buy supplies for their work of constructing solar cookers they were met with a lot of resistance. People were not willing to sell this type of equipment to women. But the women solar engineers were persistent, and kept their essence. They overcome the obstacle by going back to the market again, and again, until people got use to them. In this way the WBSES has contributed to challenge traditional gender stereotypes in the local community.

The woman solar engineers were also faced with resistance from their own families. Several of the women I spoke to explained that before they came to Barefoot College they were not even allowed to leave the house without permission, and most of them had to cover their faces with veil (Purdah tradition in India). Their families were hesitant to let these women do

this type of work, that was not only 'not suitable for women' but it was not traditional work for these families. And they did not like they fact that they would be working with men (this was also something the women themselves were not comfortable with in the beginning). But when attending the training at Barefoot College relatives of the women were invited to overview the practical skills the women learned. In this way families approved the activities the solar engineers were performing. Now the women feel full support from their husbands as well. Picture 6 and 7 are included to illustrate how women now perform skills that are traditionally accepted as man-work.

Picture 1: Constructing solar ccokers 1
Source: Linn-Cathrin Juell, 2014

Picture 2: Constructing solar ccokers 2
Source: Linn-Cathrin Juell, 2014

The solar cooking technology is also a very unknown product in the local marked, and many people are very skeptical when being introduced to it. At times the women need to work hard at convincing people of the positive perks that comes with its use. The WBSES spend a lot of time to travel out to remote villages to demonstrate the use of the solar cookers and to explain the benefits of using it. In the discourse of technology adaptation and transition management it is known that traditional methods of doing things are often more accepted than new technology introduced to a society. The uptake of technology depends on whether the potential user perceives that the technology will add value to their lives. This attribute must be informed and demonstrated in order to increase the adoption rate of the technology. In this sense the WBSES plays a very important role. It gains trust among the end-users that rural women themselves go around to advocate for solar cookers.

6.2. Practical attributes of the parabolic solar cookers

The WBSES who produce the parabolic solar cookers are all trained at Barefoot College. It takes twenty days to finalize one solar cooker by using standard measurements (Figure 7 and

8) that are found in the workshop. The solar cooker consists of one solid frame and cooking box (Figure 9) made of material made at the local hardware shop and the reflector frame (Figure 10) of is made of six solid pieces (122 cm x 120 cm x 63 cm) where the mirrors are attached with wires. Behind the reflector a geological clock system (Figure 11) is attached so the parabolic frame can rotate following the sun. The pictures below identify each functional part of the cooker.

Figure 7: Standard measurements
Source: Linn-Cathrin Juell, 2014

Figure 8: Standard measurements
Source: Linn-Cathrin Juell, 2014

Figure 9: Cokking box
Source: Linn-Cathrin Juell, 2014

Figure 10: Parabolic reflector frame
Source: Linn-Cathrin Juell, 2014

The solar cookers are constructed to be user friendly and easy to operate. Only one adjustment needs to be done in the morning so the spring and clock system attached to the solar cooker will track the sun all day and rotate the cooker every 3.23-minute[20]. The solar radiation is reflected on mirrors directed towards a cooking pot, and allows the food to be cooked quickly.

Figure 11: Geological clock system
Source: Linn-Cathrin Juell, 2014

This technology works well in areas that have abundant sunlight, like Rajasthan, India. All forms of cooking like frying, boiling and steaming is possible on solar cookers. Measurements done during the fieldwork showed that 1-liter of water could be boiled in 10 minutes.

6.3. Achievements of solar cooking technology in Tilonia Village

The local production of solar cookers at Barefoot College has multiple purposes. By training rural women to become solar engineers the aim is to empower the women both socially and economically. Furthermore, the people living in Tilonia Village and nearby villages highly rely on traditional biomass for cooking. By demystifying advanced technology and producing solar cookers locally, the aim is to provide the local community with sustainable energy. The overall vision of this is that such a local mechanism can contribute to sustainable development.

So far, the Women Barefoot Solar Engineers Society has trained close to one hundred people to use and adopt the solar cookers and seventy solar cookers are being operated in nearby villages. By using hardware from local shops, the production of solar cookers is benefitting non-users as well. Local production of the solar cookers is also an important factor in order to gain trust to the technology and make it affordable to the end-user.

Especially the female users are appreciating the solar cooking technology in Tilonia Village. During the interviews the female users of the solar cookers sad that they are now

[20] http://www.barefootcollege.org/solutions/solar-solutions/parabolic-solar-cooker/ (Access date: 13.04.15)

experiencing less smoke-related health issues, enjoy the taste of solar cooked food, and have increased appetite as they get less gastro issues when eating solar cooked food. When using the solar cookers women and children now spend less time on cooking activities and have more time for education and income-generating activities. The information gathered through the fieldwork indicates that in several level the women feel empowered after starting using solar cookers. The cafeteria at Barefoot College is also using an institutional parabolic solar cooker. When speaking to the people consuming the food there they all expressed a big satisfaction regarding the taste of the food.

The WBSES continue the work to spread the implementation of solar cookers in nearby villages. Going to villages, the women demonstrate how the solar cookers work and explain the potential benefits of using one. Still most rural people give most trust to traditional cooking methods, and doubt the fact that such a thing as parabolic solar cookers can actually be used to cook food. This is also a matter of sociocultural norms. The traditional role of women in rural India is constrained to domestic purposes, including collecting firewood and cook food for the whole household. To convince rural women and their husband that it is effective and beneficial for the household that the women spend less time on cooking purposes is rather difficult. But the women solar engineers are doing a remarkable job in changing these traditional beliefs. Also, that they as women themselves are distributing their experiences of using solar cookers is making the difference. Me as and outsider, western woman, or a male person would probably not achieve the same outcomes due to the local sociocultural context. The picture below illustrates how the women demonstrated the use of the solar cooker.

The women solar engineers trained workers at a local Crèche (daycare for children) run by Barefoot College to use the solar cooker. According to information given during an interview with the employees at the Crèche, the institution has received great benefits by using the solar cooker. As the solar cookers is cooking the food automatically, the employees now pay less time to actively cook meals for the children, and can focus mainly on activities together with the children. The cooking process itself also take less time. When using traditional Chula's for cooking it takes up to one hour to cook one meal in addition to the money spent on fuels and the time it takes to collect firewood. As well, when using firewood for cooking, the employees need to be more careful and aware to avoid that children will heart themselves on the fire. The workers have also observed a change in their own and the children's health after

starting using the solar cooker. Previously the children had health issues associated with indoor air pollution, like running nose, teary eyes and cough. This is now improved.

All the seven goals established by the WBSES are met to a certain extend. Rural women are given more opportunities and more freedom by using the solar cooking technology (1). Be replacing the consumption of firewood with solar energy, the life of women and their children is easier (2). The WBSES have proved that it is possible to challenge and change traditional thinking of women's role in society (3). Also the women experience less health issues when utilizing solar energy instead of cooking with traditional Chula's (4). The reduced consumption of firewood has positive impact on the environment (5). Furthermore the WBSES act as role models for other rural women and help them to be empowered by engaging in SHG or other activities (6). By reaching out to the most vulnerable people in the society, the WBSES has improved the livelihoods of several impoverished women (7). The next section will identify the factors that influence these kinds of achievements.

6.4. Factors that influence the achievements of solar cookers in Tilonia Village

This section will identify how the predefined dimensions as defined in chapter 2 have influenced the achievements of the solar cooker project in Ajmer District. Certain criteria and conditions must be in place in order to successfully implement solar cookers. So far, the WBSES has achieved a lot regarding their work of producing and implementing the technology. But some obstacles must be overcome. Following is explanation of the identified factors that is evaluated to have an enabling or limiting influence on the achievements of solar cookers.

6.4.1. Economic variables

Economic costs of buying a solar cooker seem to be one of the major obstacles for the implementation of the solar cooking technology. Most of the people living in rural India are relatively poor and cannot afford to buy a parabolic solar cooker for 15, 000 INR (approximately 250 $). For the ones with stronger financial capacity it might be possible to go together with more families and buy a solar cooker for community purposes. To counter the financial issue in long term, the Women Barefoot Solar Engineer Society should consider establishing an installment payment system, so potential users do not have to pay the entire cost at once. Additionally, cooperating with the state might make it possible to organize a

subsidy arrangement as well. However, unfortunately neither of these options was further discussed with the interview objects.

6.4.2. Sociocultural variables

Sociocultural norms and beliefs may influence the implementation of solar cooking technology. Traditionally the role of Indian women in rural areas is to take care of their family and cook food in traditional ways. Changing such norms and habits it's not easy. In general traditional ways of doing things are more accepted and it takes time to make people adopt new technology. For instance, if some people in the village tell something bad about solar cooking, people trust this, and it is really difficult to change this view. Regarding the characteristics of the food it still exists perception that 'solar cooked food is not well cooked'. Al though this barrier is overcome in Tilonia Village where the Women Barefoot Solar Engineers are based. By telling their friends and neighbors that solar cooked is tastier and leave you with less gastro problems, people are now more and more accepting solar cooked food.

In order to implement the solar cooking technology at large-scale it is necessary to distribute information about the existence of the product. By experience it seems that there is more knowledge about the solar cooking project outside of India. During my fieldwork I spoke to two Indian students who explained that they had searched for a long time in order to find a place to observe this specific technology. This was surprising information to get when being aware of how well-known Barefoot College is internationally. The founder of the institution, Banker Roy, is famous for his TED talks and speeches at international conferences.

The limited knowledge about the solar cooking technology at local and national level may be due to the limited capacity of the Women Barefoot Solar Engineers Society. The time capacity of the women restricts how far they can reach out with the information. Employing more people to simply advocate for adopting technology may improve this. Al though infrastructure may offer additional problems. The infrastructure in rural areas of India is rather poor, and in order to demonstrate the function of the solar cookers in practice, it is necessary to transport the solar cooker by car. It is close to impossible to convince people with little or no awareness about solar cooking to adopt the technology without actually seeing the functionings with their own eyes.

6.4.3. Political variables

Political variables were predefined as financial mechanisms and disseminations strategies. The solar cooking project in this study is established and monitored by Barefoot College and the WBSES. At the time the fieldwork was conducted, there were no external actors involved in the project. Neither was there any financial scheme to support the production of the solar cookers or subsidies to potential users. This is perceived as factors that limit the range of adoption of the technology, as most people in the area could not afford to buy the device. Collaboration with the government could potentially contribute to large-scale implementation and further development of the solar cookers. However, according to the informants interviewed at Barefoot College, this is not a desirable solution.

6.4.4. Technical variables

One other obstacle to the implementation of solar cookers is that it is weather dependent. The local sun conditions in Rajasthan is very suitable to use solar cookers as there is close to 300 sunny days per year. But the fact that the solar cooking technology can only be used during daylight is an obstacle for the achievements of solar cooking. Most of the rural people in India rely on livelihoods that require work away from the home during the day, making it difficult to use the solar cooker. In some areas this problem was solved by introducing community cooking, or by employing grandmothers or household members without work to cook food for the family. And other improvement to overcome this problem is to use phase changing material that can store the heat from the sun radiation, making it possible for households to cook food after daylight. The Women Barefoot Solar Engineers Society is currently working on a solution for this the University of Haryana.

Successful adoption of a technology requires awareness of the importance and efficiency of the technology. The WBSES is doing a good job by demonstrating the use and benefits of adopting solar cookers by traveling around to nearby villages. But still it is necessary to overcome the sociocultural perception about solar cooking not being useful. In many areas people still believe that the cookers actually do not work. By training more women to become solar engineers and continue the work of demonstrating and explaining the use of the solar cookers, I believe that this obstacle can be overcome.

6.4.5. Environmental variables

Reaching Tilonia Village is rather easy by car, but accessing other villages nearby or in more outskirt areas is almost impossible due to poor infrastructure and periods of flooding that damage the roads. This makes it difficult to reach the poorest of the poor who have little social and economic capacity to improve their livelihoods. In addition, solar cooker technology do not need extensive infrastructure like large grid infrastructures that promote electrification.

Table 7: Overview of factors influencing the achievements of parabolic solar cookers

	Advantages	Disadvantages
Economic variables Affordability Local production Job creating	• The local production of the parabolic solar cookers creates job opportunities for rural women. • The solar cookers are suitable for community cooking (several households can buy one together)	• Too costly to buy No installment payment No subsidiary option
Sociocultural variables Food characteristics Traditional cooking habits Schedule of daily routine Existing power and gender relations	• Solar cooked food is by users perceived as tasty and more healthy Local production	• Difficult to overcome sociocultural barriers in some areas
Political variables Financing schemes Dissemination strategies	• Solar cookers are well known in Tilonia village The role of WBSES	• Difficult to reach out to people outside Tilonia • Illiteracy
Technical variables Satisfying performance Easiness to use Sensitivity to reparation Sustainability	• The solar cooker can be build on the spot	• Difficult to reach areas outside Tilonia village
Environmental variables Availability and price of alternative fuels Levels of solar radiation Levels of infrastructure	• Easy to use Improve taste of food Improved health Improvement regarding phase changing material	• Difficult to use during rain season Depend on direct sun light

The table above summarize in what way the factors influence the solar cooking technology process in Ajmer District. Before looking at how these factors also influence individual's decisions of adopting the technology or not, I will look at how appropriate the solar cooking technology is regarding the sociocultural context of the study area.

6.5. The appropriateness of solar cooking technology in Ajmer District

Five criteria adopted and reconstructed from the framework of Wicklein (1998) will be used to assess the appropriateness of the solar cooking technology in Tilonia Village. The aim is to evaluate how well the demystified technology is adapted to the sociocultural conditions of the area and if it serves the needs of the people and society. The degree of the occurrence of the criteria will conclude whether the solar cookers are appropriate or not.

(1) System- independence

This criterion refers to the ability of the technology device to be operated with few or no additional appliances. Assessing the solar cooking practices in Tilonia Village, I observed that the technology itself is more or less system- independent. No additional devices are needed to support the function of the technology, except form access to solar radiation. The dependence on direct solar energy is a constraining factor as it limits when the solar cooker can be used. Also, as the solar cookers are locally produces, spare parts are easily available.

(2) Individual technology vs. collective technology

This criterion is a matter of assessing the sociocultural context of the area where the technology is implemented for it to be appropriate. In the context of solar cookers it seems like the technology is planned to be suitable both for individual and collective operation. However, during the fieldwork it was observed that the cooker was mainly used collectively. This also reflects the nature of the local culture where cooking habits are shared among several households.

(3) Cost of technology

In order for the technology to be useful for rural people the device must be affordable. At current stage the solar cookers are too expensive for most people in the area. It is therefore recommended that either substitution from the government or installment payment be offered to the potential users. In addition the Women Barefoot Solar Engineers Society is also producing larger solar cookers that can be used by institutions or community cooking. This might be more appropriate for the users.

(4) Risk factor

All technologies have the risk of success or failure. Therefore it is important to assess both internal and external risks that may reduce the appropriateness of the technology device. I argue that sociocultural acceptance of the technology is the biggest internal risk while the dependence of direct solar energy is the major external risk factor. The internal risk is minimized by the fact that local people produce and introduce the technology. The Women Barefoot Solar Engineers dedicate much of their time to travel to local communities to demonstrate the function of solar cookers and its impacts beyond energy. Often the women engineers experience resistance towards the solar cookers, and more traditional cooking practices is more accepted. Therefore it is crucial that local people is communicating the attributes of the technology to potential users. By developing a suitable phase changing material the intention is to reduce the risk of dependence on direct solar radiation to operate the technology. The phase changing material will make it possible for the users to obtain the traditional habits of cooking. Al though it was observed that many solar cooker users were willing to reschedule their days in order to use the technology.

(5) Evolutionary capacity of technology

The ability to improve the technology will increase the appropriateness of the device. The Women Barefoot Solar Engineers Society is perceived to be a dynamic institution that is aiming to offer the best suitable solutions for their local community. This is experienced when they are adapting the size of the device to be more appropriate for institutional/community cooking and the development of the phase changing material. I believe these improvements of the technology will serve more needs and solve further problems.

(6) Purpose of technology

This criterion measures whether the technology device can serve several purposes. The achievements of the use of solar cookers in Tilonia Village indicate that the technology device have several impacts beyond energy. Improved health, increased mobility of women and increased income are some achievements recognized beyond energy.

By identifying the degree of occurrence of the six criteria we are able to indicate the appropriateness of solar cookers. There is a high occurrence of several of the criteria, but the cost of the technology and dependence on direct solar energy is reducing the level of appropriateness of solar cookers. Measures are taken to improve these drawbacks, which will most likely result in an appropriate technology. Until these improvements are assessed in practice, they cannot be evaluated to actually improve the appropriateness of the technology.

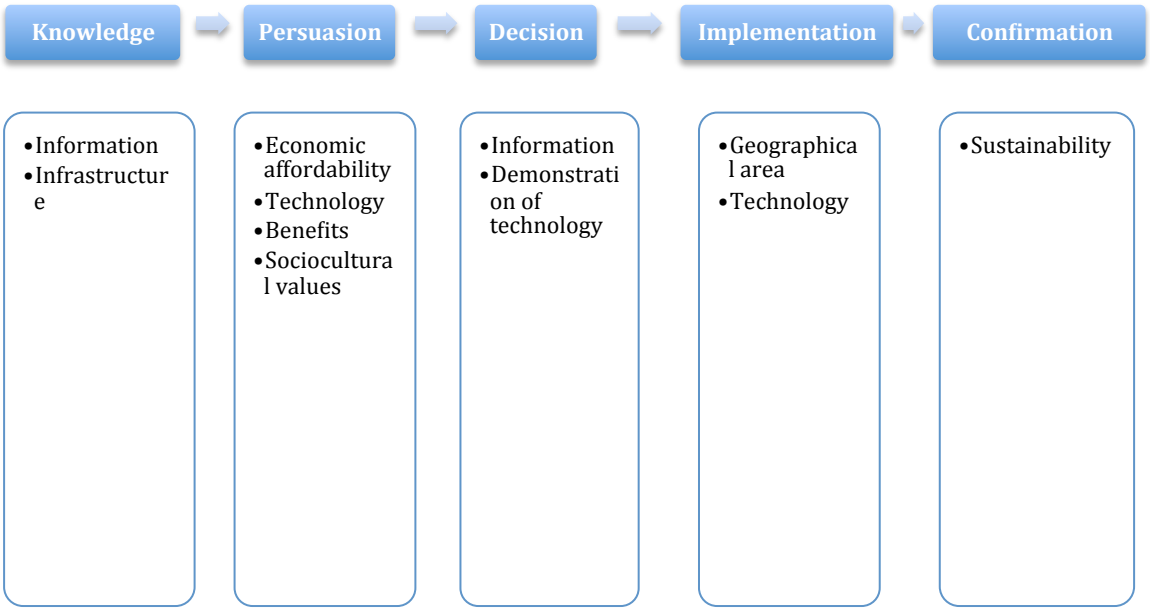
Even though that it is well argued that appropriate technologies are suitable for rural populations it is often experienced that traditional methods of doing things are more locally accepted than new technology. This is a sociocultural barrier that must be overcome in order to achieve a successful adoption of appropriate technology.

When looking at the overview (Table 1) of the criteria of appropriate technology we can see that the solar cooking technology meets all of the criteria except the criterion of affordability. For the solar cookers to be adopted at a larger scale an affordable solutions must be offered to the rural community.

6.6. Factors influencing the solar cooking decision process

This section will look at how the decision-process regarding adopting solar cooking technology is influenced by the factors mentioned above. The framework of the diffusion decision-making process is used to analyze this. This model (presented in chapter 2) assumes that the different factors influence the innovation decision process at the following five different stages: (1) Knowledge, (2) Persuasion, (3) Decision, (4) Implementation, and (5) Confirmation. The figure below illustrate at what stage of the decision-process the different factors occur:

Figure 12: Factors influencing the solar cooking decision



Source: Adapted model from Rogers (2003)

6.6.1. Knowledge

At this first stage of the decision process, information and infrastructure are seen as influencing factors. According to Rogers (2003) the knowledge stage is defined as the time space where individuals or other decision- making units are being aware of and understand the existence of an innovation. Three types of knowledge have been defined as relevant for innovation- decision processes; a) awareness-knowledge, b) how-to knowledge and c) principles knowledge.

In this case of adopting solar cooking technology one can see that the knowledge about the parabolic solar cookers was well distributed within Tilonia Village where the woman solar engineers had established their social network. However, it was more difficult to transfer the information about solar cooking technology outside of this social network. And people in general outside this network new little about the solar cooker initiative either. Students visiting from University of Haryana confirmed this, who for a long time had search for such a project to try out their phase change material innovation. According to these students there is

little awareness of the project in India in general, al though Barefoot College initiatives are well known internationally.

From this we can conclude that where the women solar engineers can access and inform people over time to gain trust, the information transition is more successful.

6.6.2. Persuasion

In the second stage economic affordability, technological benefits and sociocultural values can influence whether people decide to adopt solar cookers or nor. At this stage second stage of the innovation- decision process individuals form their favorable or unfavorable attitude towards the innovation (Rogers, 2003). Lack of economic affordability and the belief that solar cookers cannot be used for cooking, or cook different food than they are used to (sociocultural values) were the most limiting factors promoting an unfavorable attitude towards the solar cooking technology among the non-users that was observed and interviewed. Despite this, the woman solar engineers demonstrated that over time they were able to change such attitude by going back to the people and explaining and illustrating the beneficiaries of the solar cookers.

6.6.3. Decision

The third stage of the innovation-decision process is where individuals make a choice whether to adopt or reject an innovation (Rogers, 2003). Also here information is important. The woman solar engineers actively approached potential users of the solar cookers by informing and demonstrating the functioning of the innovation. In this way potential users can see how and if the technology works, and next decide if they want to start using it or not. If necessary the women solar engineers provided further information for the ones asking for it.

6.6.4. Implementation

In this case, implementation takes place when the solar cookers are effectively used. Even though if a household do have access to a solar cooker, it is not implemented before it is actually in use (Rogers, 2003). For this the geographical area and the performance of the technology are crucial factors. Areas where the information for this study was collected it

was observed that the solar cookers were well implemented. It was not recognized any cases where the equipment was just stored somewhere without being used.

6.6.5. Confirmation

In the confirmation stage individuals seek additional information to confirm the decision already made. Here the sustainability of the technology is an influencing factor. This is an important stage to ensure the continuous use of the innovation and to ensure that the adopted technology will sustain (Rogers, 2003). In this case it means that those who decide to purchase solar cookers need to have access to the producers and monitoring institutions of the technology. What is relevant here is that all the solar cooker users observed during the study have easily access to the woman solar engineers in case they needed further information, reparation or maintenance. This will help the decision units to not doubt their decision.

The aim of this chapter was to investigate how certain factors influence the function of solar cooking technology in Ajmer District. The study shows that the success of the solar cooking project in this case is influenced by the predefined factors and by the degree of appropriateness of the solar cooking technology. Furthermore the study indicates that individuals base their decision on whether to uptake the technology on the same criteria as assumed beforehand.

One of the objectives of the study was to explore the link between energy, technology and development and investigate the impacts of solar cooking technology beyond energy. The next chapter will apply the Capability Approach in order to assess the impact solar cookers have on people's lives and the four dimensions of sustainable development.

7. MEASURING SOLAR COOKERS' IMPACT ON DEVELOPMENT

"I believe the solar cookers are making a change" (Informant A)

This chapter will explore in what way the implementation of solar cookers have an impact on the life of rural people in Ajmer District, India. The Capability Approach defined by Amartya Sen and a set of capabilities is used to evaluate if the adoption of solar cooking technology leads to development.

7.1. Capability approach in the context of solar cooking

According to the capability approach, expansion of valuable, individual human capabilities is a central aim of development interventions. The rationality behind this is that an expansion in human capabilities is empowering a person to be an agent that can make choices and undertake actions that can improve ones livelihood. This perspective on development allows one to make a connection between technology choice and engineer design. Especially engineer design can impact what kind of capabilities a technical artifact contributes to (Oosterlaken, Grimshaw, & Janssen, 2012; Robeyns, 2005).

As presented in this thesis, the majority of people living in rural areas of India rely on carbon-based fuels for cooking. Consumption of modern energy is low in poor households both due to high expenses and lack of access to modern energy sources. It is also states that in these areas mainly women and their children carry the burden of using carbon-based fuels. Collecting firewood and burning of firewood can cause harmful health effects and is time consuming. According to capability approach theory, people who are dependent on energy sources of high expenditure and physical burden (like firewood in rural India), will limit the freedom of people to live the life they want to and do what they want to. Applying the capability approach to this case imply that a successful development project is not a pure matter of providing access to a specific resource. The capability approach assess whether the adoption of solar cookers have expanded valuable human capabilities (Oosterlaken et al., 2012). What are people able to do and be now compared to the time before they were

involved in the solar cooking project? As identified in chapter 2, there are three conversion factors that may influence the decision of using solar cooking technology social, personal and environmental factors.

7.1.2. Social conversion factors

Sociocultural norms and values and other peoples' opinions can influence ones attitude towards solar cooking technology. Established traditional gender roles can also play an important role of the conversion the characteristics of solar cookers to the wanted functioning. Especially the latter factor was noticeable in this study. The female solar engineers explained how resistant their husbands and families were regarding them being trained to become solar engineers. However, now when the families can see the attributes of the training and use of solar cookers, they are satisfied with the outcome. There also existed the perception that traditional food like chapatti could not be cooked by the solar technology. These are few examples illustrating how established sociocultural norms and values can influence the conversion of the characteristics of a solar cooker into a functioning.

"Before joining Barefoot College, I was not allowed by my husband to socialize outside the household, interact with other men or go for paid work. Now my husband has changed his mentality and I fell empowered and free to do what I want" (Informant B)

"We go to monthly meetings in local communities with pamphlets and attend local fair and conferences to demonstrate the use of the solar cooker. Especially we inform women about health. And we demonstrate how to cook some meals so the women can be sure that the cooker is working" (Informant C)

"We welcome all people who want to stop by and see our work" (Informant D)

7.1.3. Personal conversion factors

Personal conversion factors are attributes like sex, skills or disability that may influence how a person is able to convert the characteristics of a good into a functioning (Robeyns, 2005). For this case, this means in what way participants can take advantage of the potential benefits of solar cookers.

All the users of solar cookers visited during this fieldwork were trained in how to use the equipment and how to easily maintain it. The woman solar engineers trained the users themselves, normally for the duration of one day. In order to make the participants to actually confirm and implement the technology this seems like a prerequisite, otherwise the risk for just storing away the equipment is increasing. When learning the skills to operate the solar cooker, the users will be able to achieve the characteristics of the good (solar cooker).

"We have all faced resistance. Solar cookers are an unknown product and communities are skeptical when solar cookers are introduced. We need to convince people of the benefits of using solar cookers" (Informant E)

"Some are afraid the solar cookers won't work, so we give them a guarantee; we give them our mobile phone numbers so they can call if they need repairs" (Informant C)

"People are afraid that it might break; we guarantee that we will come back and repair it" (Informant D)

"We just have to show them how it works. Again and again. And explain"(Informant F)

7.1.4. Environmental conversion factors

The use of solar cookers requires certain conditions such as sun radiation and free space area to place the cookers. This study have already pointed out that one of the drawbacks that limit the use of solar cookers is that people are unable to stay at home during daytime to cook meals. But community cooking and the implementation of phase changing materials can counter this problem. The decreasing access to firewood sources and rising prices are also factors that motivate rural people to find alternative fuel sources for cooking.

The environmental factors mentioned above can be considered to contribute or limit the characteristics of solar cookers to achieve a functioning.

"Even though some people are skeptical, people stand in line to buy solar cookers during periods of resource scarcity. Some even try to bribe the solar cooker engineers to get a solar cooker faster" (Informant B)

7.2. The capability set

After identifying the conversion factors that can contribute to or limit the achievements of solar cooking technology, I now aim to explore how solar cooking enables people to live the lives they want to live by investigating the potential expansion of a set of capabilities assumed to be relevant for solar cooking. The capability set I have chosen identifies six dimensions that are assumed to have an influence on people's freedom. Sen sees development as freedom and explores the relationship between freedom and development by recognizing freedom as constitutive of development and instrumental to it. Moreover he enhances the need to focus on capabilities or substantive human freedoms that encompasses both processes and opportunities (Sen, 1999). Increasing people' choices (capabilities) can only be put to use if economic circumstances, political conditions and the social environment allows it. Human development is a matter of people's choices and the outcome of the choices that it offers them (UNESCO, 2008).

The interviews conducted for this study provided insight in whether these dimensions were expanded through the use of solar cookers. After presenting the capability set an analysis follows to identify how the interviews provided data regarding an expansion of this set of capabilities. The capability set include the following six dimensions:

Table 8: Capability set for solar cooking

Capability	Assumption	Findings
Time savings	Women save time when not collecting fuelwood	✓
	Solar cooking take less time	✓
Health	Improved health due to less indoor air pollution	✓
Income	Increased income and monetary savings	✓
Political participation	Increased political participation	✓
Education	More time and money for education	✓
Social relations	More time to attend organized activities	✓

7.2.1. Time autonomy

All the solar cooker users interviewed in this study informed that after they started to use solar cookers they now have more time to use for other needs. In the case of the Crèche the workers were able to devote their time to organize activities together with the children, rather than cooking meals. In other households the women had more time to treat their own personal needs, join organized activities and get involved in income generating activities. Furthermore this led to increased interest to enroll children in educational programmes.

"The solar cooker cooks automatically, so I don't have to watch over it while it cookers and can use that time instead with the children" (Informant G)

"I have raised awareness now. I want my children to go to school and study. I want them to become solar engineers" (Informant F)

"I save money now so my children can go to school" (Informant B)

"Now I go to SHG meetings. I did not have time to do that before" (Informant C)

7.2.2. Physical health

No medical tests of the informants were performed, but based on the information provided, women and children who previously were affected by smoke caused by cooking practices; now feel that their health has improved. All the respondents informed that they have less cough, running nose and teary eyes. One informant added that she has less gastro issues when she eats solar cooked food and that her appetite has increased.

"Solar cookers are good. I don't couch anymore. Not my children either. The solar cooked food is more healthy and I have less gastro problems now. I fell hungry now" (Informant F)

"The solar cooker is safer and better for the children. They don't get burned and they don't cough anymore" (Informant H)

7.2.3. Income generating activities

Less time spent on cooking practices allow people to work in the labor marked. In the local context where the study is conducted, traditionally women are expected to stay home and take care of domestic activities. However, the use of solar cookers has empowered women to get more time and increased freedom to join income-generating activities. In addition users of solar cookers are able to save more money during the year, as they don't have to pay for firewood. When the women received financial control they mainly spent the money to cover education and health expenses. These statements are all in accordance to the information provided through interviews. No measures have been taken to control this.

"Before my family could not borrow money. Now we can" (Shenaz)

"I always prayed that I would get work. Even though I only earn under INR 5000 a month, the feeling of having my own money makes me feel empowered. I feel happy with my life and I feel achievement" (Shenaz)

"Many men now depend on women; women earn, and men take the money and eat" (Guman)

7.2.4. Social relations

The Barefoot College and the Women Barefoot Solar Engineer Society play particularly important roles in building and strengthening social relations. Both by distributing information and by establishing organized groups like SHG. In this way women expressed that they feel more free and empowered. And by having the support from other women, more women dared to raise their voice both within their own families and the community.

"Before joining Barefoot College, I was not allowed by my husband to socialize outside the household, interact with other men or go for paid work. Now my husband has changed his mentality and I fell empowered and free to do what I want" (Informant A)

"Now I attend SHG meetings and I feel support. I am stronger now" (Informant F)

By going through the expansion of each of seven dimensions, I will conclude that the solar cooking technology has improved the lives of specially women and their children. By going through a process of being trained to either construct or use solar cookers, women increased their social value and mobility. The time savings coming with use of solar cookers gave women opportunities to take part in other organized activities, often this included educational programmes, SHG, community councils and so on. By receiving their own income, women are economical empowered and have increased freedom to do their own priorities. This underlines how important education and knowledge is to promote development.

According to the theoretical framework presented in chapter 2, an increase of the defined capabilities is equal to development. The interviews conducted give information that show that women have increased time autonomy, improved health, developed stronger social relations, take part in political activities, take part in income-generating activities, have raised their and their children's level of education and knowledge. All of this is argued to improve the lives of the people studied.

8. DOES SOLAR COOKING TECHNOLOGY CONTRIBUTE TO SUSTAINABLE DEVELOPMENT?

The intention of this chapter is to give an overview of the findings of the research regarding sustainable development. The information provided through interviews and observation is categorized under the four dimensions of sustainability to give an overview of in what ways the implementation of solar cookers contribute to each dimension of sustainable development. Necessarily some of the findings already mentioned above will be repeated in this assessment.

Sustainable development refers to *"development which meets the needs of the present without compromising the ability of future generations to meet their own needs."*[21]. This includes economic growth, social inclusion and environmental protection. In addition this thesis has included the dimension of empowerment as women are recognized as important and necessary actors to include when enhancing sustainable development.

This study explores the link between energy, technology and development. By doing so, the intention is to investigate whether solar cooking technology can meet the need of a cleaner energy source for cooking while socially and economically empower the rural people in the Ajmer District of India. The findings of the study will be categorized in the following dimensions to provide an overview of in what way the implementation and adoption of solar cookers contributes to sustainable development.

8.1. Impact on the social dimension

According to the women solar engineers and female users of solar cookers, they have perceived several changes in the social dimension of their lives. Several of the women who were interviewed participated in Self-Help Groups (SHG) and expressed that trough the training in using solar cookers they are now more aware of the importance of education, and do also want their children to go to school, even college. And more importantly, the female users of solar cookers are now aware of that also girls can and should attend school. The raised awareness of importance of education was among others expressed in this way:

[21] http://www.un-documents.net/our-common-future.pdf (Access date: 10.05.15, p. 41)

"I want to reduce women's health issues" (Informant B)

'I want my children to study as much as they want, no matter if they are boy or girl' (Informant F)

'I want to send my daughters to college to be solar engineers' (Informant I)

The interview objects underlined that when using solar cooking technology they and children have less smoked-related issues, and the solar cooked food is more nutrition and better for the stomach. Furthermore, replacing the chulha with clean energy, they have achieved increased safety in their households as there is less risk for the children and others to burn them self on the fire or any other damages when collecting firewood. And when not depending on firewood for cooking households are more self-reliant over energy needs as there is equal access to the sun (depending on equal access to solar appliance). Additionally, they have more time for other activities.

Solar cooking requires the users to be taught how to use and maintain the equipment. One important factor that makes the adoption of solar cooking successful in this case is the important role of the WBSES. The women solar engineers are trained to produce, use and repair the solar cookers. More than that, the way they as women talk about solar cooking they make more people adopt the technology. Alongside the implementation process of producing solar cookers, the women solar engineers have raised their own education status and raised awareness about the importance of education in general. By doing so, rural women have increased their status in the local community.

The rural women who are trained to become solar engineers have crossed many sociocultural barriers and improved their socioeconomic status and role within their family and the local community by doing work recognized as "male-work". The woman solar engineers are now speaking out load, using their traditional and conventional knowledge to spread awareness, skills and knowledge in their local community. This is a large contribution towards sustainable development. Allowing women to take part in education programs and income-generating activities is beneficiary for the whole household and local community, as it is seen that women make different social and economic priorities.

"Now that I earn my own money I can save money to support my daughter to go to college. Even my husband can ask me to borrow money"(Informant F)

"My husband don't pay for my children" (Informant A)

8.2. Impact on the economic dimension

Adopting solar cooking technology ace economically empowered women and their families in ways that improve their quality of life. By using solar energy for cooking, households spend less money on buying firewood or LPG and women have more time to take part in income-generating activities. This again, opens up the opportunities for household members to take part in education programs and organized social groups such as SHG. The women in households prioritize to use saved money to cover other family needs like school, school material and health services, all of which are prerequisites for economic development. The information gathered for this study does not include interviews with men, so it is impossible to conclude whether men make different priorities. But based on information made by the female users and women solar engineers, their husbands or other male relatives first prioritize to cover their own needs. As one interview object said it: 'my husband drink up all the money'.

8.3. Impact on the empowerment dimension

When talking about the empowerment dimension of development in this study, it is referring to how adopting the solar cooking technology has socially and economically empowered the female users of solar cookers. The experienced benefits of using solar cookers are grouped under four categories; access to and control of financial resources, improved self-image, increased mobility and challenge of gender stereotypes.

"I always prayed that I would get work. Even though I only earn under INR 5000 a month, the feeling of having my own money makes me feel empowered. I feel happy with my life and I feel achievement" (Informant F)

"I got new skills and capabilities after the training" (Informant A)

"We feel empowered and proud and want to ensure that more women will feel the same" (Informant J)

"I want to give women more opportunities and break the cycle of traditional thinking"(Informant B)

"I want to give employment to women in rural areas" (Informant J)

As the citation above shows, one of the women solar engineers points out that she feels an achievement by earning her own money. Having access to and control over financial resources gives her opportunity to make her own priorities, save money and even get a bank loan as financial security. This increases the opportunities of women and their families and improves their socioeconomic status.

The women also expressed that they felt more respected after generating their own income, giving them a new position within the domestic power relations. Now they take more part in decision-making processes and the labor division in the household is divided between the men and women in the household. The increased mobility of women is illustrated by citing some of the women solar cookers:

'Before I was only at home looking after the children and making chapatti. But now I am out working and earning money' (Informant F).

'Before my husband treated me as inferior because I wasn't working; now he respects me' (Informant E)

Some of the women solar engineers and the female users of solar cookers also attended organized groups. The attendance in groups like community councils and SHG increased after being trained to use solar cookers. From being almost hidden members of the community the solar women become more visible after attending the process of learning how to use the solar cooking technology. Including women in decision-making processes is

necessary to achieve sustainable development. And by letting women speak their mind and being trained to perform skills needed in the community, the women are challenging the traditional ideas of gender roles, promoting change towards a more equal society.

8.4. Impact on the environmental dimension

The solar cooker uses reported improvement regarding health issues caused by indoor air pollution. Both women and children who are most exposed to the smoke coming from cooking with firewood seemed to have no or little smoke-related health issues. Women users also experienced less gastro issues and increased appetite when eating solar cooked food. This indicate that the use of solar cooking technology put less pressure on natural resources and reduce the level of emission of black carbon to the atmosphere. This has the potential to be a significant contribution to reduction in deforestation and soil erosion. Compared to the information provided by non-users (households using firewood and/or other sources for cooking) this can give a more strong indication to confirm the environmental benefits from using solar cooking technology. Those using firewood for cooking have to walk further to collect firewood today, compared to five years back in time. This indicates that the local forest coverage is decreasing, enhancing the need to reduce the pressure on local resources. Further quantitative measures regarding previous and current forest coverage and soil quality could confirm this.

One other recognized feature of the use of the solar cookers was the significant role in water pasteurization. The users of solar cookers boiled the water they used for cooking and drinking to a larger extend compared to the households using firewood for cooking. The difference here can be due to one of more of the following explanations: the lack of awareness regarding bacteria in the water, or due to time consumption (it takes time to collect firewood to boil water) or limited access to resources for cooking.

The result of the study shows that solar cooking technology has impact beyond energy. Al though the data is not able to evaluate and measure all aspects and indicators of sustainable development, the study indicates that taking part in the solar cooking process has impact on the social, economic, environmental dimensions of life. The most significant impact I was able to observe was the empowerment effect the technology of solar cooking has on the rural women's life. In this sense I strongly believe that Barefoot College as an institution plays a

crucial role. Barefoot College is a strong educational institution, but also acts a safety net for the rural community by offering social, economic and technical support. I believe this is essential to include when evaluating the appropriateness of the solar cooking technology. However, I will with confident argue that being a part of the solar cooker technology has an impact on people's lives. What is difficult to measure is if this is due to the technology itself. One can argue that being a part of an institution or an educational program will impact one's life. But it is interesting to observe to what extend a local produced technology can have multiple benefits beyond its technical function.

Table 9: Factors promoting the use of solar cookers

Social:	Economic:	Environmental:	Empowerment
• Improved health • Time savings	• Job creation • Increased income • Monetary savings on fuels	• Reduced consumption of firewood • Reduced emissions	• Access to and control of financial resources • Increased mobility • Improved self-image • Gender stereotype challenged

9. CONCLUSION AND RECOMMENDATIONS

The purpose of the study was to analyze the implementation of solar cookers in Ajmer District, India, concerning how the technology impact people's lives and it's potential to contribute to sustainable development. The objectives of the study aimed to identify what factors that determine the success or failures of solar cookers, why people choose to use solar cookers and how the use of solar cookers impact people's live. Further the thesis discusses the appropriateness of the solar cooking technology and how the technology fulfills the potential to meet all dimensions of sustainability.

9.1. Investigating the added value of solar cookers beyond energy

When investigating the impact of solar cooking technology it is easy to conclude that the technology have added value beyond energy to the people adopting the technology in Ajmer District in India. The women who are involved in the WBSES inform that they feel socially and economically empowered. Both the production of solar cookers and the use of it challenge traditional gender stereotypes. The women who work as solar engineers have been trained to perform skills that traditionally is recognized as man-work and the use of solar energy instead of firewood result in time savings that women and children can employ to other activities like education, SHG and income generating activities. By using clean energy for cooking people also experience improved health, as they are not exposed to the same amount of indoor-air pollution. And of course, the use of solar energy reduces emissions of black carbon and reduces pressure on local natural resources.

These achievements can contribute to meet all dimensions of sustainability. But I question if the same results could be reached outside the institution of Barefoot College. Barefoot College has embraced its vision of an equal and sustainable society across the local communities nearby. I believe that this has an impact on the results achieved. During my fieldwork I gained a perception that most of the benefits depend on the contributions made by the WBSES. The women solar engineers are given the opportunity to be trained and take part in income generating activities. This is challenging the traditional sociocultural norms that for a long time have out limit to the socioeconomic development of rural women. In this way the WBSES act as important actors of change, that also influences the success of the implementation of solar cookers in India.

Despite the recognized success of using solar cookers, some limiting factors have been identified during the study. The strongest factor that limits large-scale implementation of solar cookers is economic affordability. Currently the technology is too expensive for most of the potential users, and is therefore not adopted. Furthermore, the performance of the technology device is not ideal when it comes to the schedule of daily routines. Most of the potential users depend on livelihoods that are located away from the households. This makes it difficult to utilize the solar energy during daytime. Some of the resistance met towards the new technology is grounded in sociocultural values and traditional habits of cooking.

9.2. Investigating solar cookers potential to promote sustainable development

When evaluating to what degree solar cookers can promote sustainable development certain criteria is used to measure the appropriateness of the solar cooking technology applied and the capability approach is used to investigate how solar cookers impact people's lives. Based on this, the thesis discuss if the achievements of using solar cookers also meet all dimensions of sustainability.

As seen from the analysis above solar cooking technology brings development through expanding the capabilities defined in the capability set. This includes time savings, improved health conditions, increased income, increased mobility of women, increased awareness about the importance of education and increase in political participation. However, the benefits of using solar cookers are limited to those who can afford it. According to the criteria for appropriate technology, the technology itself meets the standards of sustainability. For solar cooking technology to act as a mechanism for sustainability, the criterion of economic affordability must be fulfilled.

9.3. The link between energy, technology and development

Historically access to energy has been an important driver of development in industrialized countries and emerging economies. Current global pattern of energy consumption is putting our environment at risk and stagnating development of rural part of the world. Technology has the potential to improve the livelihoods of people by providing clean energy resources. The assessment of the use of solar cookers in rural India shows that replacing carbon-based

biomass as cooking fuel with solar energy, people experience to be socially and economically empowered and the environment is protected.

It is difficult to argue that the technology itself does really 'free' people, but with the support and contributions of Barefoot College, solar cooking technology expand the freedom of people and make them socially and economically empowered. I argue that the achievements and impact of adopting solar cooking technology depend on existing practices, power relations, the appropriateness of technology and supportive systems. This reflects the need to adopt a social understanding of technology. For instance, the institutions of, and the social relations created through Barefoot College, the WBSES and SHG is recognized as crucial factors to achieve technological and social change in the communities assessed in this study. This study proves that social conditions influence people's choice of implementation and adoption of technology.

The appropriate technology approach suggests that development should be a process that starts with the realities of the communities targeted for development. The idea is to provide developing countries through using scientific experience of developed countries to help the people living in poverty. The aim is to meet the needs of the end-users by implementing useful technologies that are appropriate for the local conditions. By adding the sustainability dimensions to this as well, appropriate technology also considers environmental protection. A relevant question here would be, for how long is a technology appropriate?

I will argue that appropriate technology is not capable to cover a permanent technological gap between rich and poor countries, but is valuable at an intermediate stage. Development is a process that is happening over time. A technology device itself does not have the property to achieve development alone. Development starts with people and how their involvement in education, organization and discipline. One must understand that technology is not social and political neutral. Rather its appropriateness depends on the surrounding social, cultural and political organization. Long-term sustainable development implies larger structural changes that can also contribute to counter the imbalances of class and economic growth at national and international level. Solar cookers as intermediate or appropriate technology should not be perceived as an acceptance of the current situation of the people living in the Ajmer district of India. Rather it should be seen as a way towards challenging the divisions in the world and change the pattern towards sustainable development for all.

Appropriate technology has in many cases served desirable results. But this should not lead us to just accept the conditions poor people live in and determine the potential for development. According to my findings of the study I will argue that the implementation of solar cookers in Ajmer district will not have any further impact when it comes to address the imbalances of class and economy at national or international level. But I believe solar cookers as intermediate technology brings out positive outcomes in terms of social and economic development and environmental protection at local level. Here it is important to enhance that the result of the adoption of solar cooking technology is also context specific, meaning that the impact solar cookers have on people's lives in Ajmer district India, may not be the same in any other area.

Statistics over households' energy sources in rural India presented in the above suggests that there is a large potential for implementing solar cookers outside the Ajmer District. It is beyond the scope of this thesis to conclude whether or not to implement solar cookers on a large scale. Nevertheless, there is a need for reorganizing energy production so it will benefit rural people. And structural changes must take place in order to promote development at a larger scale. Future work should aim to generalize conclusions from this work and advise where solar cookers should be implemented.

Appropriate technology strategies can be implemented systematically in state policies, and will therefore reach out to a larger amount of people. This can be an important step on the way to lift people out of poverty and advance technology. By employing a social understanding to technology and the means of energy, I will argue on the basis of this study that solar cooking technology have the potential to successfully be implemented as a mechanism to promote sustainable development in local areas, at an intermediate stage.

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Appendix 1

QUESTIONNAIRE ON COOKING METHODS IN RURAL INDIA

INTERVIEWEE DETAILS			
Name of interviewee		**State name**	
Village Name		**Date of interview**	
District name		**Agro-zone**	

DEMOGRAPHIC CHARACTERISTICS

Name	Relation to interview object	Age	Sex	Education (years)	Occupation*	Income (month/Rs.)
(Interviewee)	NA					

** Agriculture = 1; Agricultural Labour and Daily wage = 2; Rent from land = 3; Self Employment = 4; Services (include jobs in Government offices, factories, private companies) = 5; Unemployed = 6; Student = 7; Housewife = 8*

SOCIO-ECONOMIC CHARACTERISTICS		
Economic status	1. APL card	
	2. BPL card	
	3. Antiyodaya card	
Social status	1. SC	
	2. ST	
	3. OBC	
	4. GEN	
Does the HH own land?	Yes	
	No	
If yes, then specify land size (in acres)		
If yes, who owns the land?	Household	
	Head of household	
	Husband	
	Wife	
What do you use the land for?	1. Agriculture (rice cultivation/vegetable)	
	2. Orchard	
	3. Given on lease	
	4. Barren land and cattle grazing	
	5. Self-enterprises (rice mill, etc.)	
	6. Others (specify	
What kind and number of livestock does the family have?	None	0
	Cows	
	Buffaloes	
	Fowls	
	Goats	
	Others	
Any household members working away from home?	Yes	
	No	
If yes, how many family members are working away from home?		
How many months do they work away from home?		
Do they send any money home?	Yes	No
If yes, how much do they send home?		(Rs./month)

DETAILS ON HOUSEHOLD INCOME, EXPENDITURE AND SOCIAL SCHEME BENEFITS			
Household Income in the last month	Rs.		
Average household expenditure per month	Rs. 400-1000		
	Rs. 1000-1500		
	Rs. 1500-3000		
	Rs. 3000-6000		
	Rs. 6000-12000		
	More than Rs. 12000		
What does the hh spend their monthly income on?	**Expenditures:**		**Decision-making:**
	Food	Rs.	Husbands/wife/others
	Health	Rs.	Husband/wife/others
	Education	Rs.	Husband/wife/others
	Fuel	Rs.	Husband/wife/others
	Agriculture (relevant?)	Rs.	Husband/wife/others
	Self-enterprise (relevant?)	Rs.	Husband/wife/others
	Depth payments	Rs.	Husband/wife/others
	Household savings	Rs.	Husband/wife/others
	Others (specify)	Rs.	Husband/wife/others
For women solar users			
Do you have your own bank account?	Yes	No	
Do you save your money?	Yes	No	
If yes, what do you plan to do with the money you save (specify)?			
For the household			
Household credit	Do you have a bank account?	Yes	No
	Have you taken a loan for any of the listed purposes in the past 5 years?	1. Other domestic purposes (specify)	
		2. Education	
		3. Health	
		4. Marriage/Death/birth/others	
		5. Livelihood activity	
	Who decides if the hh takes a loan?	Husband/wife/others	
	Who provided the loan?	1. Moneylender	
		2. SHG	
		3. Bank	
		4. Relatives/friends	

ENERGY SUPPLY FOR COOKING		
What is the main fuel source used for cooking?		
Who decides what type of cooking fuel you use?	Husband/wife/other	
Are you satisfied with the supply of fuel for cooking?	(1) Yes	(2) No
What alternative fuel sources do you have for cooking? Specify.		

Energy related activities	How much time is spent on cooking per day during summer months?	_____ hours	
	How much time is spent on cooking per day during winter months?	_____hours	
	Do you stock fuel for use during the monsoon and winters?	Yes What type:	No
	Which months do you go to collect fuel sources for stocking?		
	During these months, how much extra time per week do you spend on collecting additional fuel?		

Fuel Type	**Quantity per month (in units)**		**Nearest Source of availability and distance (km)**	**Who goes to collect?**	**Who decides who collects the fuel?**	**Do they use any form of vehicle to collect fuel (specify)**
	From market	**From natural environment**				
Firewood and chips (kg/Rs.)	_____kg/month _____Rs./month	_____kg/month				
Dung Cake (kg/Rs.)	_____kg/month _____Rs./month	_____kg/month				

Electricity (kWh/Rs.)	_____unit/month _____Rs./month					
LPG (kg/Rs.)	_____kg/month _____Rs./month					
Kerosene-PDS(litre/Rs.)	_____litres/month _____Rs./month					
Kerosene - market (litre/Rs.)	_____litres/month _____Rs./month					
Coke and Coal (kg/Rs.)	_____kg/month _____Rs./month	_____kg/month				
Charcoal (kg/Rs.)	_____kg/month _____Rs./month	_____kg/month				
Gobar Gas						
Other fuel (specify)	_____/month _____Rs./month	_____/month				

Is there change in the following over the past 5-10 years?		
Cooking fuel	(1) Yes	(2) No
Cooking stove	(1) Yes	(2) No

Traditional	**Reasons for change in cooking fuel used over time**	**Reasons for change in cooking stove used over time**
Expensive/cheaper		
Health benefits		
Provided free		
Income constraints		
Awareness Program		
Awareness Program		
More efficient		
Change in family size		

Solar	**Reasons for change in cooking fuel used over time**	**Reasons for change in cooking stove used over time**
Expensive/cheaper		
Health benefits		
Provided free		
Income constraints		
Awareness Program		

Awareness Program		
More efficient		
Change in family size		
On whose initiative did you install the solar cook stove?	Individual (specify)	Government/NGO Support
Who made the final decision to buy the solar cooker?	Husband/wife/other	
Did you take part in deciding to buy a solar cooker?	Yes (specify what argument(s) made for or against)	No

DAILY ACTIVITES				
Please describe your daily routine from when you wake up	**What:**		**Alone/others (specify)**	**Time/hours:**
Activity 1				
Activity 2				
Activity 3				
Activity 4				
Activity 5				
Activity 6				
Do you send your children to Anganwandi?	Yes	No		

WOMEN'S ECONOMIC ACTIVITY		
Are you employed?	Yes	No
If yes, how many hours per day do you work?	(hours/day)	
How many full working days are spent in a month?	(days/month)	
How many months per year do you work?	(months/year)	
MGNREGA		

Do you have a MGNREGA job card?	Yes	No
What type of work?		
Total number of workings days		(per year)
Have you received the wages?	Yes	No

SELF-HELP GROUPS		
Are you a member of any SHG group?	Yes	No
When did you join?		
Why did you decide to join?		
What made it possible for you to join?		
What kind of activities are you involved in in the SHG?	1. Self-employment activities	
	2. Saving and credit facility	
	3. Both the above	
	4. Others (specify)	
How many hours per day do you spend on SHG activities?	(hours/day)	

TRADITONAL COOKING PATTERN		
Primary fuel source for cooking		
Type of stove used in hh	Traditional Chulha	
	Kerosene stove	
	Improved Chulha	
	Gas stove	
	Solar stove	
Who decides on the type of stove used?	Husband/wife/other	
List all the appliances and utensils you use for cooking		
Describe on an average day, how you go about your cooking? - *how many times cook per day* - *at what time of day* - *what food cooked* - *how long it takes*		
What cooking fuel do you use during summer months?		
What cooking fuel do you use during winter months?		
What cooking fuel do you use during monsoon months?		
Has the household heard about solar energy?	Yes	No
Is the household willing to switch to a new cooking method?	Yes	No
What do you think is the benefits of using solar cookers?		

INDOOR AIR POLLUTION	
Do you experience smoke while cooking?	Yes
	No
Do you experience any of the listed issues when cooking?	Coughing
	Breathing problems
	Teary eyes
Who are most affected by any of the listed issues while cooking?	Women
	Children
	Men

SOLAR STOVE USERS		
When did you install the solar stove?		
Who decides on the type of stove used?	Husband/wife/other	
Costs for operating, maintaining etc.		
How much did it cost to buy the solar cooker?	Rs.	
Did you borrow money to buy the solar cooker?	Yes From where: Private Bank	No
Did you pay in installment?		
How much per installment?		
Does the solar cooker need to be maintained?	Yes	No
Who maintains it?		
What are the options for complaining? How fast do they come?		
What maintenance problems have you come across?		
What is the maintenance cost?	Rs.	
Use of solar stove		
How much time did you spend on cooking activities before the solar cooker?	hours/day	
How much time do you spend on cooking since you started to use the solar cooker?	hours/day	
If less time is pent on cooking now, how do you use the extra time?		

Have you reduced the consumption of any other fuels such as firewood or kerosene after using solar energy? If yes, specify which fuels and how much reduction.		
Has your expenditure on fuels reduced beginning to use solar energy? If yes, then how much has been saved per month?	Rs. _____/month	
If the hh has extra money, what is it used on?		
Is it necessary to use other fuel sources in addition to solar energy for cooking?	Yes	No
If yes, specify sources		
Cooking pattern		
Who decides on the type of stove used?	Husband/wife/other	
List all the appliances and utensils you use for cooking		
Describe on an average day, how you go about your cooking? *Compared to before solar cooker:* *- how many times cook per day (more/less)* *- at what time of day (different?)* *- what food cooked (different?)* *- how long it takes (more(less)*		
What cooking fuel do you use during summer months?		
What cooking fuel do you use during winter months?		
What cooking fuel do you use during monsoon months?		

Benefits/disadvantages		
Do the households experience any of the listed benefit after using solar stoves?	Fuel savings	
	Smoke removal	
	Faster cooking	
	Reduced time for cooking activities	
What is perceived to be most beneficial after implementing the solar stove?		
Are there any disadvantages of using a solar cooker?	Lack of sun	
	Difficult to use	
	Undesirable flavor of food	
	Changed food habits	
	Others	
Are the members in your household happy with the solar cooker?	Yes (specify)	No (specify)

Appendix II

INTERVIEW GUIDE

Empowerment impact

1. To women solar engineers (Individual interviews):

- What is your age?
- Are you married?
- Do you have children, if so how many children do you have?
- How old are your children?
-
- How many people live in your household, and what is your relation to them?
- What kind of work do you do
- How much time do you spend on your work every day?
- What are your daily responsibilities? (could you perhaps describe a normal day in your life)
- Are your children in school, if so at what time of the day are they attending school?
- What are the sources of income?
- How much money do the household earn per month/annually?
- What do you use your salary on? What are the priorities? How much do they spend for each priority (health, education, food, social functions etc.)?
- Who make the decisions about money spending?
-
- What does your husband and/ or others living in your household do for work (their livelihood)? (move to household characteristics)
- From where did you got the information about solar engineering?
- Why did you want to become a solar engineer?
- What do you think are positives and negatives of your work? [or something like that, with the aim of getting info on whether these women feel they are or want to or think they're role is to empower women? Relates to importance of a women's organization implementing solar oven use by ensuring these ovens are available to women in the community (as we assume)]
- How does your husband and/or other members of your household feel about you working?
- Who make the decisions in the households?
- What does empowerment' mean to you? Do you yourself feel more empowered after you started working as a solar engineer?

2. To women solar engineers (Group Interviews):

- Simplify questions
- Since becoming a solar cooker engineer, has your life changed in any way? [Looking for info on alternative livelihood, increased income, impact on household especially children through more money for education/better education, more respect from household/community members, etc.] *should we write separate questions relating to these aspects?
- What do you think are positives and negatives of your work? [or something like that, with the aim of getting info on whether these women feel they are or

want to or think they're role is to empower women? Relates to importance of a women's organization implementing solar oven use by ensuring these ovens are available to women in the community (as we assume)]

- Have you installed a solar stove in a household before? If so, did you experience any resistance from the people living in that household? If yes, from whom? Why do you think they resisted?
-

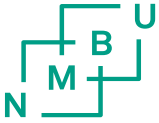
3. To rural women with solar ovens:

- What is your age?
- Are you married?
- Do you have children, if so how many children do you have?
- How many people live in your household, and what is your relation to them?
- What are your daily responsibilities? (could you perhaps describe a normal day in your life)
- How old are your children? Do your children go to school? If so, at what time of the day are they attending school?
- When was your solar stove installed? What were your first impressions of it/What did you think of it at first?
- Do you use your solar oven? How often and what for? If not, why? (follow-up questions)
- Are you involved in any groups in your community [e.g. women's self-help groups, development projects]? If so, which ones and when did you start becoming involved? Why did you decide to become involved?

*Ask questions about:
- price of cooker
- household size [how much food needs to be cooked]
- sunny space available?
- cooking techniques [if any foods difficult to cook using solar stove]
-cooking schedule [if the solar stove requires them to cook at different times of the day]

4. To Barefoot College representatives

- Is the aim of BC's solar projects (e.g. WBCSES) to increase women's empowerment? What impact does BC expect this will have on development in the local community/in India in general?



Norwegian University
of Life Sciences

Postboks 5003
NO-1432 Ås, Norway
+47 67 23 00 00
www.nmbu.no