Diplomarbeit / Diploma Thesis:

Rural Electrification: Acceptance of Pico Photovoltaic Systems in Ethiopia

Which conditions contribute to a sustainable integration of technical innovations into work and daily life in developing countries and implementation in the context of development cooperation?

Submitted by:

Hannah Müggenburg

Hölgesstraße 16
64283 Darmstadt
Germany

Phone: +49 -170-3860313
Email: Hannah_M@gmx.de
Examination no. 1333954

Supervisors:

Dipl.-Psych. Annika Tilmans, Prof. Dr. Petra Schweizer-Ries
(University of Saarland)

Prof. Dr. Reinhard Leichner (Technical University of Darmstadt)

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ)
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn

Technische Universität Darmstadt
Institut für Psychologie
Alexanderstraße 10
64283 Darmstadt

March, 2011

Acknowledgements

This thesis owes its existence to the help, support, and inspiration of many people.

I wish to express my gratitude to my supervisors, Prof. Dr. Reinhard Leichner, Prof. Dr. Petra Schweizer-Ries and particularly Dipl.-Psych. Annika Tilmanns, for being abundantly helpful and offering valuable support and guidance. My special thanks go to Annika Tillmans for managing the supervision at short notice and despite large distance.

I would like to thank Dr. Carsten Hellpap from GIZ in Eschborn and Joachim Gaube from GIZ in Ethiopia for giving me the opportunity to conduct a field study. I learned a lot and made many important and valuable experiences. My special thanks go to Tim Raabe from GIZ in Eschborn for his support throughout this study.

Special thanks go to Prof. Peter Adelmann, who initiated the field test in Ethiopia. I am grateful for the introduction to local conditions, people, cultural values and facilities and thus for helping me to manage a good start in Ethiopia. Thanks for providing straightforward support during the field test in spite of poor telephone connections.

Furthermore, I would like to thank Behailu Alemu and Lealem Bishaw for their great work and support. There could have been no better team! Thank you for your huge efforts. It would have been impossible to conduct the field test without you and your skills in conducting rural electrification. Thank you for giving me an insight into your culture and daily lives and for many nice memories.

I would also like to express my sincere thanks to Abeba for spending her sundays with me in the village for translation during the interviews. Thank you for your valuable advices and your generous hospitality. Your warm welcome made me feel very comfortable in Ethiopia and I gained valuable impressions. I am thankful that you divulge Ethiopian traditions to me.

I would also like to convey thanks to Shewa for her translations. Thanks for your great work, your kindness and open-minded nature.

Additionally, I would like to thank the habitants of Soleguraja providing me with helpful insights and sharing of their personal opinions and experience. Thank you for your patience, kindness and hospitality. Special thanks go to Sisay Deme for supporting all activities of the field test.

Furthermore, I am thankful for meeting with a warm reception from colleagues of Adama University, especially Andreas Schleicher, Anett Vogel, Birgit Simon, Dereje, Frank, Gerd and Manu Kreß, Mennin and her daughters, Girma, Gosa, Helmut, Klaus Boxnick, Sbhatleab, Sitotaw, Udo Weitekemper, Wolfgang Mitternacht and many more.

Lastly, and most importantly, I wish to thank my family, Volker, Maria, Martin and Eva Müggenburg for their continuous and unconditional support of all my undertakings. Without your emotional support and belief in my strength, this study would not have been possible in this way. I also wish to express my deep gratitude to Fabian Gengnagel for raising my spirit, for his understanding and unconditional support. Thank you for your help and strength in countless ways.

Contents

Abstract

In order to combat poverty and fight for the Millennium Development Goals through providing access to modern energy, it is necessary to analyze social acceptance of new forms of energy in order to implement them successfully. Nine different Pico Photovoltaic systems were tested during a field study in a non-electrified village in Ethiopia. Each lamp was tested for a week by one of 24 families. Qualitative interviews were conducted in order to explore technology change and its social impacts. With this measure is an alternating change of induction and deduction achieved to create insight. Qualitative Data (interviews, focus groups, participant observation) were supplemented by questionnaires about consumption of energy and pictograms about consumer's behavior. The most important results are: Apart from expected benefits in health, work, education and economy, people notice as well improvements in autonomy of children, flexibility, stress, security and family life. Negative aspects were found in social community and in the absence of possible activities. Quality of lamps is defined by respondents by brightness, duration and cone of light. Furthermore, people prefer white, bright light as well as a built-in switch. Systems considered best in European laboratory tests were evaluated poorly in Ethiopia. In the end people ordered 30 systems. Even non-participating people ordered systems. The buying decision was a collective one. Even though energy supply is the responsibility of women, men made the decision about the purchase of the lamps. Generally, people spent 24 Euros to 58 Euros.

Keywords: social acceptance; renewable energies; low-cost energy technology; development cooperation; diffusion of innovations; Pico Photovoltaic System

List of Figures

List of Tables

List of Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
BMZ	German Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
CO_2	Carbon Dioxide
ETB	Ethiopian Birr
GIZ	German International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GO	Governmental Organization
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
LED	Light-Emitting Diode
MDG	Millennium Development Goal
NGO	Non-Governmental Organization
PicoPV	Pico Photovoltaic
PPP	Public Private Partnership
UN	United Nations
W	Watt

I. INTRODUCTION

This diploma thesis presents results of a pilot project with Pico Photovoltaic systems on meeting the lighting needs of low income households in developing countries. This field study takes place in a small village near Adama, Ethiopia.

The first part is an overview of recent discourse about development cooperation and a classification of the present study. Furthermore, it explains the link between energy and development cooperation. Due to the newness of Pico Photovoltaic systems, a definition is given. Afterwards, a brief description of Ethiopia, where the field test takes place, is given as well as an explanation about chances of solar energy in Ethiopia. Furthermore, theoretical approaches and the need for further investigations are summarized.

1.1. Recent Discussion about Development Cooperation

In order to understand the background of this approach as well as its classification within recent development cooperation, the following section gives a brief overview of recent discussions of aspects of development approaches.

There has been much criticism of development cooperation in recent years (Seitz, 2010). A fierce controversy exist between different experts: Sachs argues for doubling the financial means to reduce poverty until 2015 in the context of the Millennium Development Goals. He sees poverty as a consequence of poverty traps or vicious circles[1] (Sachs, 2005). This refers to the theory of "Big Push", which states that only a massive impulse of simultaneous aid can trigger a tremendous change. (Rosenstein-Rodan, 1943). Other institutions, such as the Commission for Africa (Commission for Africa, 2005) and the International Bank for Reconstruction and Development of the World Bank Group (The International Bank for Reconstruction and Development / The World Bank, 2005) also support this idea of a Big Push. On the other hand, voices like Easterly demand a reduction in financial development aid and reconsideration of development cooperation in general (Easterly, 2005). Shikwati even suggests the abolition of development cooperation, because it "too often fills the pockets of dictators rather than the bellies of the starving" (Shikwati, 2002).

[1] For example: people, who do not have enough income, cannot save any money in order to release themselves from poverty.

In this debate most of the critics agree that development cannot be determined from the outside. Such measures are not effective, and can even harm. Even if the majority of development cooperation organizations support this point of view, so far "the existence of cultural mental programs[2] on either side has received lip services at best, and the only mental programs used in development planning have been those of the donors" (Hofstede, 2001, p. 438). Therefore, more attention should be paid to social structure, cultures and traditions of developing countries in order to implement sustainable projects, which are adopted by the people (Grill B. , 2007).

In this context a strategy to make development cooperation more effective was developed: 50 years of development cooperation show less impact than expected, which indicate, that governmental (GOs) and non-governmental organizations (NGOs) will not bring about the reduction of poverty, as well as problems in sections like education, energy, health, etc. on their own. The reduction of public finances limits the government and the institutions related to it. Therefore, only a general framework in issues of sustainable economic and social development can be established. For further operative tasks incremental support of the private sector is required. To ensure sustainability in terms of development cooperation it is necessary to use free market economy. In order to benefit from the overlap of interests of NGOs, GOs and the private sector, the Public Private Partnership (PPP) was developed. Its objective is to combine different measures of NGOs and/or GOs in cooperation with the private sector, which make a contribution to the ecological, economic and social development in partner countries (Schöpfer, 2004). Furthermore, it tries to fulfill the demands of diverse critics regarding the improvement of development cooperation.

The following section gives a brief explanation of the process of the present pilot study. Taking the above mentioned arguments into account, it is evident, that making Pico Photovoltaic systems available for free to every one of the remaining 1.5 milliard people without access to modern energy services, is economically impossible. The following section gives background information, about the reasons for selling PicoPV systems during the field study rather than giving them away for free. Giving goods for free seems to be the most reasonable solution at first glance. However, experiences in the past show, that this also has negative indirect impacts: for example food aid even

[2] "Mental programming" is described as the universal, collective and individual background of a person. It will be described in detail in the section on results.

increases poverty. Giving food for free ruins farmers. As a consequence they undertake only subsistence farming, gain no income and remain poor. Further on, this prevents healthy development of a job market (Seitz, 2010, p. 67). This example demonstrates that it is important to support partner countries to become independent. Additionally, Yunus (2007) underlines the importance of people's "self-reliance, pride and confidence" (pp. 137-140). Within his micro-lending program, a loan is never forgiven, in order to strengthen people's belief in their own abilities. Thus, even food aid after a natural disaster was paid back by borrowers (Yunus, 2007, p. 139).

A World Bank study (The World Bank, 1999) emphasizes as well the importance of confidence and independence. During the study, more than 60,000 people from 60 different countries were asked about their personal perspective of poverty. Statements of respondents show, that poverty is more than a lack of money. In the report poverty is summarized as being multidimensional: "Wellbeing is peace of mind; it is good health; it is belonging to a community; it is safety; it is freedom of choice and action; it is a dependable livelihood and a steady source of income; it is food" (The World Bank, 1999). Further statements by respondents included:

> "Poverty is like living in jail, living under bondage, waiting to be free" — Jamaica
>
> "Poverty is lack of freedom, enslaved by crushing daily burden, by depression and fear of what the future will bring." — Georgia
>
> "If you want to do something and have no power to do it, it is talauchi (poverty)." — Nigeria
>
> "For a poor person everything is terrible - illness, humiliation, shame. We are cripples; we are afraid of everything; we depend on everyone. No one needs us. We are like garbage that everyone wants to get rid of." — a blind woman from Tiraspol, Moldova
>
> "When one is poor, she has no say in public, she feels inferior. She has no food, so there is famine in her house; no clothing, and no progress in her family." — a woman from Uganda

Thus, poverty includes also a psychological dimension. It is important to take all these aspects into consideration and to support people in becoming more independent. Therefore, not only economic but also psychological rationales support the procedure of this field study in selling the PicoPV systems. In order to analyze the results of the present study regarding its aim of improving living conditions of people living in rural areas in developing countries (see chapter about chances of energy in development cooperation), it is important to keep in mind this perspective of low income households

themselves. In the end, the author deduces to what extent the outcomes of the present investigation are comparable with the perspectives of the low income households of the World Bank study.

Having considered all these issues, this field study aims to analyze individual needs and preferences of people living in Ethiopia, regarding electricity and its daily use, within the perspective of their own, Ethiopian culture. As 50 years of development cooperation have shown: it is not possible to make the people of developing countries follow ideas, developed only out of the cultural background of people from Western countries (Hofstede, 2001). Listening to the voices of people of developing countries is necessary in order to respond to their individual needs and daily habitations. Therefore, this thesis considers itself to be rather a bottom-up approach, than a top-down investigation.

In conclusion, this field study aims to overcome the problem of developing cooperation, which is characterized by Seitz as paralyzing creativity, self-responsibility and sustainability of engagement. He states, that partner countries are used to the fact that foreign countries are responsible for their development and initiative of one's own vanishes (Seitz, 2010).

1.2. Developing Cooperation – Chances of Access to Modern Energy Service

Energy, especially light is important for human beings: in every country, light stands for something positive, such as brightness or good. It is a symbol of development, life, consciousness and insight (Schachenmann). Brightness is regarded as one of the most important environmental factors: its function as a source of energy and information is a precondition for the existence and development of human beings. Many physiological processes and behaviors of the human body depend on light (Fisch, 2000). Particularly, regarding psychological factors light plays an important role in our life. Without light and brightness orientation in time and space is not possible. Light also promotes well-being: during seasons with only a small amount of sunlight, many people suffer from seasonal depressions. The fact that even whole branches of science conduct investigations to find out optimal ratios of light, again demonstrates the importance of light (Schachenmann). In short, a rise in brightness level results in an increase in physiological and mental performance (Fisch, 2000). Conversely, shortage of light causes illness. In conclusion, then, it is clear that health of human beings depends strongly on light on various dimensions.

Despite the importance of light, worldwide 1.5 billion people are without access to modern energy services (Roselund, 2010). That means every fourth human being is without access to electricity today (Reiche, Grüner, Attigah, Hellpap, & Brüderle, 2010). If people connected to unreliable energy supplies are also taken into consideration, this number even increases (Lighting Africa, 2010a). Thus, people have to rely on alternative energy sources, which have strong limitations in terms of quality. As described above this can have severe effects on human health (additional consequences for health are described below).

In order to achieve the Millennium Development Goals (MDGs)[3], access to modern energy services contributes a high direct and indirect influence. Figure 1 presents a strong link between energy consumption and Human Development.

Figure 1. Link between Energy Consumption and Human Development

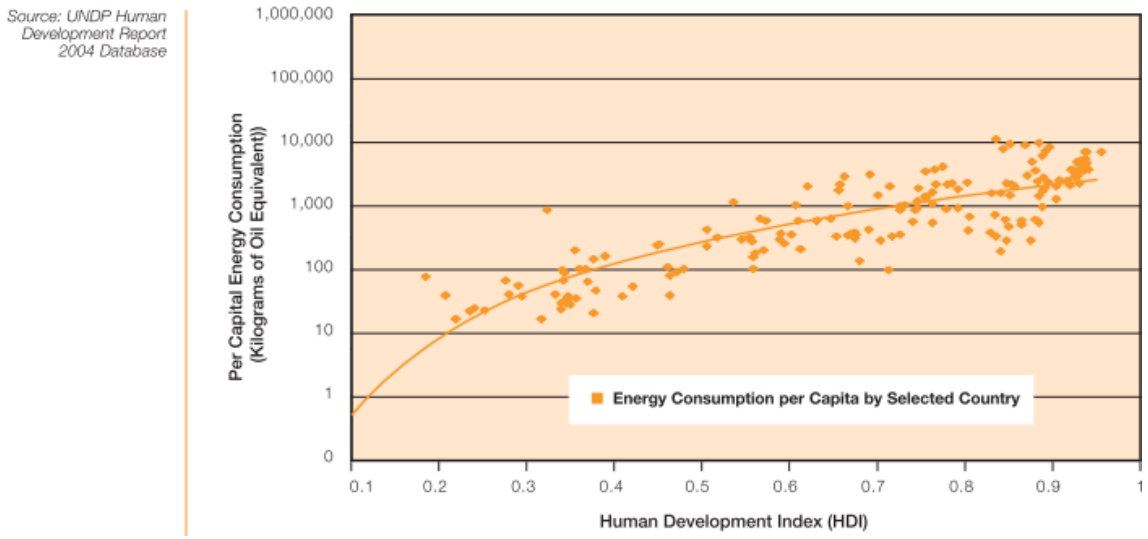

Figure 1. Energy Consumption Has a Strong Link with Human Development. Adapted from "The Energy Challenge for Achieving the Millennium Development Goals by the United Nations, 2005. Copyright 2005 by the United Nations.

As usual in correlation approaches, a causal connection in figure 1 cannot be assumed. Additionally, due to the fact that the Human Development Index takes into consideration only life expectancy at birth, education and per capita income the following section demonstrates additional benefits consequently to access to modern

[3] The MDGs were developed and agreed to by the United Nations and at least 23 international organizations for achievement by the year 2015. They include for example reducing extreme poverty, reducing child mortality rates, fighting disease epidemics such as AIDS, and developing a global partnership for development (United Nations, 2010).

energy services and how light induces improvements in the factors which form the Human Development Index. Figure 2 shows a brief summary of effects of energy on development.

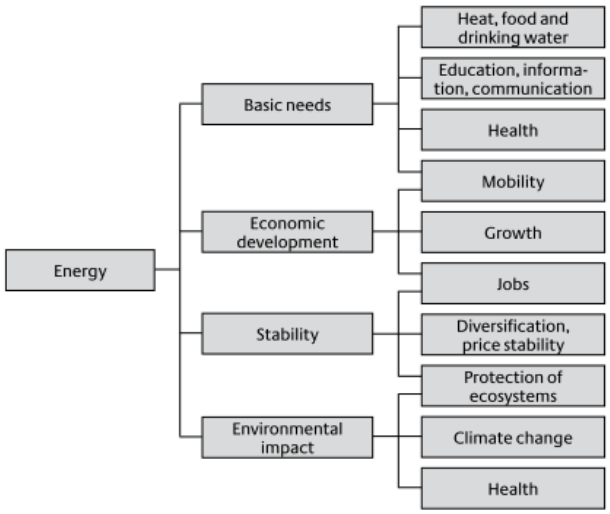

Figure 2. Importance of the Sector Energy. Adapted from: "Sustainable Energy for Development." by Federal Ministry for Economic Cooperation and Development, 2007. Copyright 2007 by Federal Ministry for Economic Cooperation and Development

Education. Increased illumination enables children to learn better. Furthermore, a radio for example can enable broader access to information and knowledge (Deutsche Gesellschaft für Internationale Zusamenarbeit, 2010a). Energy also provides a critical input to a host of social services, such as education, health care and communication (Bardouille, 2004). Lighting in schools helps retain teachers and enables access to educational media and communications in schools and at home. This increases the opportunities for education and allows distance learning. Therefore it contributes indirectly to MDG 2 (enable "Universal primary education")[4].

Environment. Apparently above all, especially renewable energy sources, such as hydro, solar or wind electrification have a direct input to MDG 7 of environmental sustainability (Goldemberg & Johansson, 2004).

Gender. Access to modern energy helps to reduce the burden on women, who collect and carry heavy amounts of firewood across long distances. Due to their responsibility for energy supply, in case of energy for lighting, women are freed from having to buy traditional energy sources in distant towns. This has an influence on the MDG 3 of "Gender equality and women's empowerment". At the same time, this creates time for

[3] For more examples refer to the World Energy Assessment – Overview: 2004 Update.

income generation, which relates to MDG 1 of "reducing poverty and hunger". Due to the fact, that women are responsible for housework, they suffer mainly from illnesses caused by traditional energy sources. This is why clean energy services are a significant benefit, especially for women.

Health. Access to a modern energy service has a direct positive impact on health by reducing air pollution. This contributes to MDG 4 of "reducing child mortality" and 5 of "improving maternal health". Furthermore, the risk of accidents due to traditional energy sources, such as fire, is decreased (Lighting Africa, 2010a). Because it enables health centers and hospitals to run refrigerators in order to cool medicaments and provide other health services (24 hours emergency service, mass-media communication, sterility of instruments, lighting during operations, etc.), access to modern energy services contributes even to MDG 6, "combat HIV/AIDS, malaria and other diseases" (Deutsche Gesellschaft für Internationale Zusamenarbeit, 2010a).

Since modern energy solutions can generate jobs and promote industry and transportation as well as commercial activities and micro-enterprises, they contribute to MDG 1, "eradicate extreme poverty and hunger" (United Nations, 2005).

Stability. In addition, renewable energy options in general help to prevent crises and conflicts over resources. This is based on the fact, that renewable energies make countries independent of limited energy sources, which have faced extreme price increases in recent years. Only in this way can they be independent of fluctuating prices on the global market, and therefore ensure that financial development cooperation has sustainable effects (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, 2010). Even if renewable energies are not implemented as the main energy source for the whole country, as in this study, in terms of stability it helps at least to make people more independent from fluctuating and continuously increasing oil prices.

Since studies show, that the highest monthly expenditures are for food and energy supply (Lighting Africa, 2008g), PicoPV systems can decrease monthly costs. Instead, money can be invested in basic needs, such as food, health and education.

Having considered all these issues, modern energy services, such as lighting, are strongly linked with the three pillar definition of sustainable development according to

the UN (UNESCO, 2007): economic, environmental and social development. Hence, making energy accessible for low-income households through PicoPV systems represents an approach with great potential.

1.3. Pico Photovoltaic Systems (PicoPV Systems)

While Solar Home Systems provide an energy performance of 20 to 100 Watt per hour (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2009b), PicoPV systems differ from Solar Home Systems primarily as follows: PicoPV systems consist of 3-4 components: 1. The lamp consists of light-emitting diodes (LED's), 2. They have a low voltage of 3.2 – 6V. 3. They have only small solar modules (1 W to 10 W, mostly 2-3), 4. Some of them have additional features like the facility for mobile charging or radio. A battery saves the energy, which was gained during day. To sum it up, photovoltaic off-grid systems can be differentiated mainly according their power dimension and the number of users (Mitja, A. Torra, C., Satue, D., Peters, C., Vallve, X.; Voseler, I. ,2003 cited in Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010) Figure 3 shows differentiations of solar systems.

The quality of the lamp differs in terms of the type of battery, robustness, quality and size of the solar module, additional features and the type of LED (Adelmann, 2010).

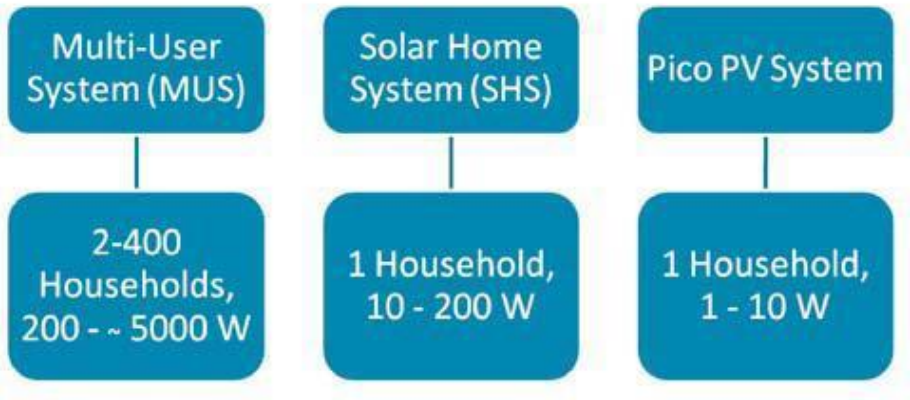

Figure 3. Off-grid PV technologies. Adapted from: "What difference can a PicoPV system make? Early findings on small Photovoltaic systems - an emerging low- cost energy technology for developing countries" by Gesellschaft für Technische Zusammenarbeit, 2010. Copyright 2010 by GTZ.

Although prices for Photovoltaic solutions are falling, "the so called solar home systems (SHSs) – are not affordable for the vast majority of these users and this is not expected to change in the next decade." (Deutsche Gesellschaft für Internationale

Zusammenarbeit, 2010b, p. 4). PicoPV systems are more affordable and prices are expected to decrease (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b). Lighting Africa (2010a, p. 28) even forecasts a decline in costs of 40% by 2015. Increasing fuel prices further increase this price advantage. Thus, they can maintain a broader public. In conclusion, the Pico Photovoltaic (PicoPV) option seems to be an optimal solution.

1.4. Federal Democratic Republic of Ethiopia

Ethiopia is a land of 1,104,300sq km. With a population of 88,013,491 (Central Intelligence Agency), it is one of the most populous nations in Africa (Department for International Development). Within Ethiopia exist many ethnic groups with their own languages and dialects (Oromo 32.1%, Amara 30.1%, Tigraway 6.2%, Somalie 5.9%, Guragie 4.3%, Sidama 3.5%, Welaita 2.4%, other 15.4% (1994 census). Amharic is the official language, although the largest section of the population is Oromo. Overall about 84 different languages can be found in the country. The religions of the country are also varied. Most represented are Christians (Orthodox 50.6%, Protestant 10.2%) and Muslims (32.8%). Ethiopia is the only country in Africa which was not colonized, except of a brief Italian occupation from 1936-41 (Central Intelligence Agency).

In the Human Development Index (HDI) Ethiopia is placed at rank 157 out of 169. It is therefore one of the poorest countries in the world (United Nations Development Programme, 2010). The life expectancy at birth is 55.8 years (Central Intelligence Agency). Other problems are the high HIV/AIDS rate of 2.1%, the low literacy[5] rate of 42.7% and the proportion of population below the poverty line of 38.7%. Most of the people live in the countryside, urbanization is 17%. Thus, their main income is through agricultural work (85%), which often means subsistence farming. Ethiopia is a very young country: about 46.2% of the population is below the age of 14 (Central Intelligence Agency).

Today the political situation is ambiguous: even though the Ethiopian government claims to have accomplished democratic elections on 23 May, 2010, “in practice, Ethiopia’s citizens are unable to speak freely, organize political activities, and challenge their government’s policies -through peaceful protest, voting, or publishing their views - without fear of reprisal.” (Rawlence & Lefkow, 2010). The situation has deteriorated:

[5] Definition: age 15 and over and can read and write.

“Since the 2005 polls, the party has used its near-total control of local and district administrations to undermine opponents' livelihoods through withholding services such as agricultural inputs, micro-credit, and job opportunities” (Ethiopia: Repression Rising Ahead of May Elections, 2010). The political situation thus remains vulnerable.

The situation of women in Ethiopia is also somewhat difficult: Even though in theory the rights accorded them are relatively liberal, in practice, women have restricted opportunities in terms of education, ownership of land or financial income (Dejene, 2001). Today most of the women in Ethiopia are still circumcised, even though the government has tried to end this traditional rite (Dejene, 2001). Otherwise women are not accepted in their community. This also reinforces the spread of infection with AIDS (Füllkrug-Weitzel, 1999). Parents still decide whom their daughters should marry. Due to the fact that women marry and afterwards live with the family of the man, it is not considered worthwhile to invest in their education. Hence they are often used as hard workers for carrying heavy objects, like fire wood and water cans, across long distances (Beyene, 2008).

When reading this thesis, this background must be taken into consideration if one is to to understand the cultural situation of the people living in the village near Adama.

1.5. Prospects of Modern Energy in Ethiopia

The daily life of Ethiopians depends heavily on sunrise and sunset. The extent to which people adapt to the hours of brightness can be inferred for example from Ethiopian time measurement: sunrise is referred as zero and sunset as 12 o’clock. Given the absence of dramatic seasonal changes, sunset is about 6 p.m. by European time measurement. People in Ethiopia depend on daylight so much because only 1% of the rural population has the opportunity to use modern energy services (Entwicklungspolitik Online, 2009), which means about 66 million people are without access to electricity (Roselund, 2010). Despite the low electrification rate, Ethiopia has great potential for using solar energy: the national annual average irradiance is estimated to be 5.2 $kWh/m^2/day$ (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2009a). A target market analysis of Ethiopia (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2009a) shows that “the Ethiopian solar energy market is at its early stage of development” (p. 1), but the market of Solar Home Systems, for example, grows at an annual rate of 20%.

Recently, more than 94% of Ethiopian's energy consumption has been met through biomass fuels, such as wood, plant material or agricultural waste. Even though this is one of the renewable energy resources[6], if it is not used sustainably, it has severe effects on the environment and also for people. Consequences include massive deforestation, which in turn causes erosion and desertification (Deutsche Gesellschaft für Internationale Zusammenarbeit). As a consequence women and girls have to travel even larger distances with their heavy burdens to find and collect firewood. Other energy sources therefore need to be found.

In order to calculate the purchasing power of people living in Ethiopia, GIZ Ethiopia estimated current monthly expenses for traditional energy sources, such as kerosene, candles and batteries: low income households spend about 1.13 - 2.26 Euros[7] monthly on energy (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2008). A calculation of additional energy sources estimates monthly expenses of 4 Euros[8] for traditional energy supply.

In the case of rural Ethiopia, even though grid supplies generally represent an economical option for enabling electrification, in most rural areas it is too expensive to connect people because they are too far from the existing system (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b, p. 4). Off-grid electrification today offers the cheapest solution for most unconnected users in developing countries, who live more than 5 km from a small town. (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b). Consequently, off-grid solutions play a crucial part in making access to modern energy services possible for people living in rural areas.

6 because it emits only the same amount of CO^2, as the plants previously removed from the air.

7 17-24 ETB/monthly, calculated in June, 2008.

8 60 ETB/ monthly.

II. THEORETICAL CONSIDERATIONS

The next section is an overview of the theoretical background and recent research concerning innovations. First, the underlying perspective of this research is briefly explained. Afterwards, an environmental approach is introduced, followed by an overview of recent assumptions in innovation research. Finally, explanations for the questions being addressed by this research are documented.

2.1. Transactional Worldview

Current work is characterized by discussion of transactional approaches according to Altman et al. (Werner, Altman, & Brown, 1992; Altman, 1993; Werner, Brown, & Altman, 2002). Transactionalism emphasizes that environment and the perceiving individual are part of an integral way of process (Eckensberger, 2008). They are embedded into each other. Crucial assumptions are: 1. People and psychological processes are dependent on their physical and social environment. They cannot be separated. 2. Aspects of time and change are intrinsic to psychological phenomena. 3. A distinctive philosophy of science is assumed. This means (a) research should not focus on antecedent-consequent causation, but on "formal cause or the identification of patterns of relationship among variables linked to underlying principles" (Altman, 1993, p. 141). (b) Furthermore, the existence of only one reality is denied. Reality always consists of various individual perspectives. (c) Data from several observers and resources (triangulation; (Flick, 2008)) should be considered in order to understand the phenomenon as a whole. To summarize, the research process orientates on a holistic view. Although "transactional research is difficult to conduct" (Werner, Altman, & Brown, 1992, p. 300) and even Altman et al. "don't manage to capture all elements" (Werner, Altman, & Brown, 1992, p. 300), the present study aims to apply a holistic approach. Results are reviewed in the section entitled 'Discussion'.

2.2. An Environmental Psychology Approach

The socio-scientific examination of technology, as applied in this study, fits into the approach of environmental psychology. This discipline of psychology deals with environmental problems in various perspectives (mobility, energy, etc.). The mutual interactions of the individual and his or her environment are examined in detail. In environmental psychology technology and individuals are regarded as being not

independent, but influence each other (Jo Hatch & Cunliffe, 2006; Schweizer-Ries, 2008). In context of this social construction process is presented the environmental model according to Schweizer-Ries. But first, the concept of sustainability is applied to the context of energy.

2.2.1. Energy sustainability

The well-known definition of sustainable development, which consists of the three criteria of environmental, economic and social sustainability (UNESCO, 2007; Cervinka & Schmuck, 2010), was reworked in order to fulfill the demands of sustainability in terms of energy (Kleinhückelkotten, 2005; Schweizer-Ries, 2008). The concept of energy sustainability includes three different elements: consistency, efficiency and sufficiency. The following section briefly illustrates the individual elements.

1. Consistency. ***Acceptance and use of renewable energies:*** the objective of this strategy is to cover the amount of actual energy by the use of clean and renewable energies. The definition of these terms is aggregated by experts and will develop continuously with the invention of new techniques. Out of psychological perspectives arise two main issues: on the one hand a *construction of reality* that defines which energies are renewable. This can be seen as a social process of communication and definition by individual, community and public institutions. In terms of consistency a common vision of sustainable energy supply will be developed. On the other hand a *process of realization* is pursued. During this process technical, financial and social capacities are realized, which induce changes in behavior. Therefore, it can be referred to as a creation of new reality. Acceptance and use of renewable energies is also an objective in the present study. A new reality should also be constructed regarding the replacement of traditional energy sources, such as kerosene lamps. But in contrast to a construction of reality that defines which energies are renewable, a so-called leapfrogging process is initiated in this field study. This means that technological stages of development, which are prodigal, are skipped in order to implement a sustainable technology immediately (at least to the greatest possible extent) (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, 2004, p. 79).

2. Efficiency. ***Efficient acquaintance/use of energy***: The objective is the reduction of energy consumption by the use of efficient appliances, for example an energy-saving

lamp. The research field of psychology aims to understand the buying decision of consumers. Simultaneously, it is important to consider consumer behavior regarding these technologies (for example to turn off the standby function or to solve the problem of the so-called Rebound Effect[9]). In terms of *construction of reality* acceptance of the importance of reduction of energy consumption, as well as awareness of a solution should be established. Referring to the *process of realization*, singular (purchase of an appliance) and repeated behavior (habit of transportation to work) can be differentiated. Singular behavior can be explained by the classic works of Rogers about the diffusion of innovations (2003), which are referred to later in chapter 2.2.. Repeated behaviors should lead into automatic behavior. Since rural habitants in developing countries use electricity only when necessary anyway (due to small budgets and inconvenient energy sources), reduction of energy consumption was not a focus in the present study. Instead, it was concentrated on the process of realization in singular and repeated behaviors. In particular, the buying decision and consumer behavior were of keen interest.

3. Sufficiency. ***Reduction of energy consumption.*** In spite of the recent social development as a consumer society there is an effort to reduce the consumption of energy. Because of inappropriate levels of energy consumption, it is difficult to establish an awareness of this necessity. Quality of life and prosperity are always measured in terms of consumption. Thus, reduction of consumption is perceived as regression and loss. To achieve social awareness, a fundamental change in social values is necessary. This issue pertains also to an equitable and fair allocation of resources. It is not possible for the world population to consume as much energy as the Western nations currently do. The strategy of sufficiency was not a focus within the present study due to the fact that people of rural areas in Ethiopia already established an appropriate extent of energy consumption (or respectively have not yet changed it). If their traditional energy sources are completely replaced by solar lamps, this energy form might be sufficient to cover their actual demands. But clearly, values and measurements of quality of life and prosperity should be borne in mind. Since Western nations set an example of valuing prosperous lives, it is likely that other nations adopt these values.

In order to achieve sustainable development in terms of energy supply, these three strategies should be taken into account. Furthermore, acceptance of renewable energies

[9] It describes the phenomenon of increased energy consumption through the overuse of energy saving appliances in good faith/ clear conscience (Berkhout, Muskens, & Velthuijsen, 2000).

by users (see chapter 2.3.2. on acceptance) influences these strategies and therefore can change the energy culture (Schweizer-Ries, 2008). Holding a view equivalent to statements about development cooperation mentioned above, Luhmann (2008) states that a change of system can be initiated only within the system itself. Environment can trigger a change, but it depends on the system as to whether it implements the impulse. In order to evoke change, the existing social values and habits of the system should be the focus instead of the creation of an extern impulse.

In this thesis, the author focuses on the acceptance of renewable energies and the consumer decision. Therefore, strategies of consistency and efficiency according to Kleinhückelkotten (2005) and Schweizer-Ries (2008) are further examined in this study.

2.2.2. Simplified Environmental Model of Human Action

In order to give an impression of a possible study method aligned with the transactional worldview in the context of environmental psychology, the simplified environmental model according to Schweizer-Ries (2009) is presented in the following section. It shows how individuals and technology (as part of the environment) influence each other during technological development which can be transferred to this study. In the section on Discussion (5.1.4. Results in Comparison with Outcomes of other Studies) an approach to integrate results in this model is accomplished.

The simplified environmental model of human action according to Schweizer-Ries (2009) is a further development of the simplified model of human action according to Kaufmann-Hayoz and Gutscher (2001). The model posits that humanity always evolves continuously. Perceived possibilities and limitations are created by people themselves. Consequently, a changing environment lies also among the range of potential of human beings. This model is considered to be a systemic theoretical approach as described by Luhmann (2008). Luhmann's approach states that systems are always simultaneously part of superior systems and contain at the same time a number of different subsystems and categories. Borders between these systems are always subjective, perceived by the individual according to his or her objectives. The model provides three main elements: 1. *Environmental structures*, such as technologies, laws, incentives and infrastructures. 2. Perception and evaluation of *possibilities and limitations* of the individual's behavior in respect of external structures. 3. Concrete, energy relevant *human action* and its consequences for further perception of possibilities and limitation of behavior. Human

action is a result of interaction of the individual (target system) and his or her environment. Therefore, also technologies as environmental structures are socially constructed and shape behavior in turn (Jo Hatch & Cunliffe, 2006; Schweizer-Ries, 2008). Environment is determined by physical, economic and political conditions (Schweizer-Ries, 2009). Experiences determine behavior and perception of individuals. Hence, perception and evaluation are often habits, developed over many years. The individual's behavior is not always conscious. Regarding technological development, Figure 4 shows the environmental model of human action. It represents a circle of interdependent variables.

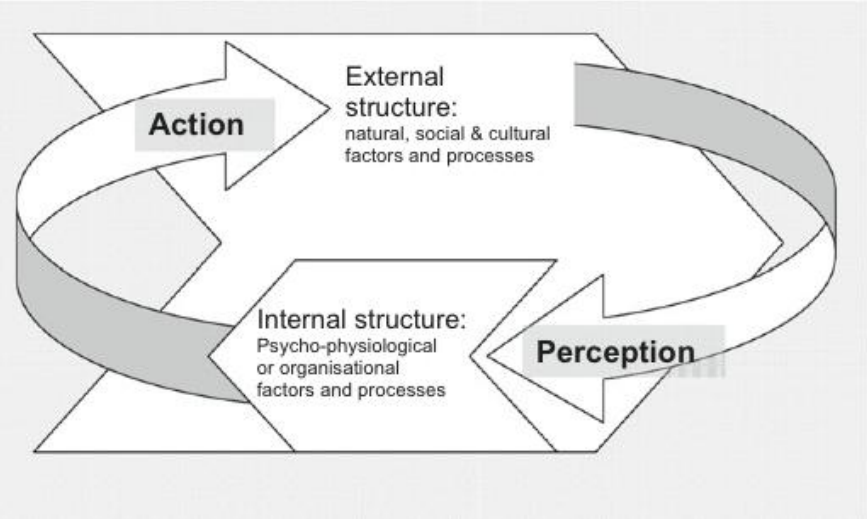

Figure 4. Simplified environmental model of human action. Source: Schweizer-Ries, 2008.

Measures of change consist of different dimensions: bids and prohibitions, infrastructure, financial incentives, technical solutions, institutional offers and social communication and construction processes, which influence perception and evaluation. Finally diffusion instruments have an effect on internal structure, too and can provoke a change in behavior.

To answer the question how change can be initiated, a closer look should be taken at the already mentioned instruments of diffusion, starting with the classic works of Rogers.

2.3. Theoretical Background of Innovation Acceptance

2.3.1. Definition of Innovations

"An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12).

Even though solar lamps were invented long ago, they are perceived by individuals in Ethiopia as new, and for this reason remain an innovation for them. In particular, the new Pico Photovoltaic (PicoPV) systems as a smaller alternative to the Solar Home Systems are a new invention, which has not yet spread across the country. In categorizing innovations, many authors rely on the perspective of consumers. Robertson (1971) for example classifies innovations through a comparison with existing products. He distinguishes between continuous, dynamically continuous and discontinuous innovations (Robertson, 1971, p. 7). In the context of Ethiopia, PicoPV systems can be classified according to Robertson as discontinuous innovations. They are classified as discontinuous because they are perceived as previously unknown products, rather than being an improvement or modification of an already known product (continuous and dynamically continuous innovation). PicoPV systems create new patterns of consumption due to the fact that monthly expenditures for energy supply are no longer necessary. Access to modern energy and electrical applications (mobile phone charger or radio) is also completely new.

Other well-known dimensions of innovations are postulated by Hirschman (1982). She differentiates between symbolic and technological innovations. Symbolic innovations imply a new social meaning, while technological innovations result in a change within a group of products. Concerning PicoPV systems, it remains to be seen how people will perceive the innovation, but its distinctiveness is expected to be high in both dimensions: as mentioned before, solar technology, especially PicoPV systems is not widespread in Ethiopia, therefore technological dimension is high. Due to improvements in daily life resulting from more hours of brightness, symbolic dimension should also be high. One of the objectives of this study is to investigate in underlying aspects of this dimension.

In terms of diffusion of innovations the research of Rogers is considered to be the classic point of orientation (Wiswede, 2007). Thus, the next section presents firstly a

definition of acceptance and secondly the most important aspects of Rogers' investigations.

2.3.2. Acceptance

For a long time, acceptance was not clearly defined. Generally, it was referred to as a positive attitude towards an idea or product (Wüstenhagen, Wosink, & Bürer, 2007). Acceptance optimally contributes to energy sustainability, as described above, and therefore a change of energy culture (Schweizer-Ries, 2008).

The following section refers to recent approaches which define the concept of acceptance more precisely.

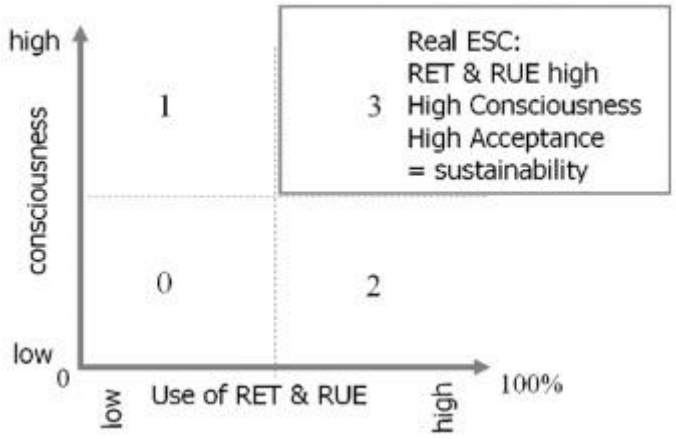

Figure 5. Social and technical dimensions of energy sustainable communities with renewable energy technology (RET) and rational use of energy (RUE). Source: Schweizer-Ries, 2008.

Technical development is described as being of two dimensions: while the x-axis of figure 5 represents the technical aspects, the y-axis shows the socio-psychological dimension of technical development. This social dimension is very important. It is described as environmental consciousness, which is broadly understood as consisting of environmental knowledge, experience, concern, value orientation regarding the environment, environmental relevant intentions and behavior (Spada, 1990; Schweizer-Ries, 2008). Concerning the present study, environmental consciousness might not be of first priority for users in developing countries, who frequently face threats to their livelihood in their daily lives. On the other hand, it is definitely of keen interest of countries and organizations which initiate projects like the present study.

Acceptance results from the social dimension of technical development and consists of the following dimensions: as described in figure 6, dimensions of acceptance are

valuation and action (Dethloff, 2004).

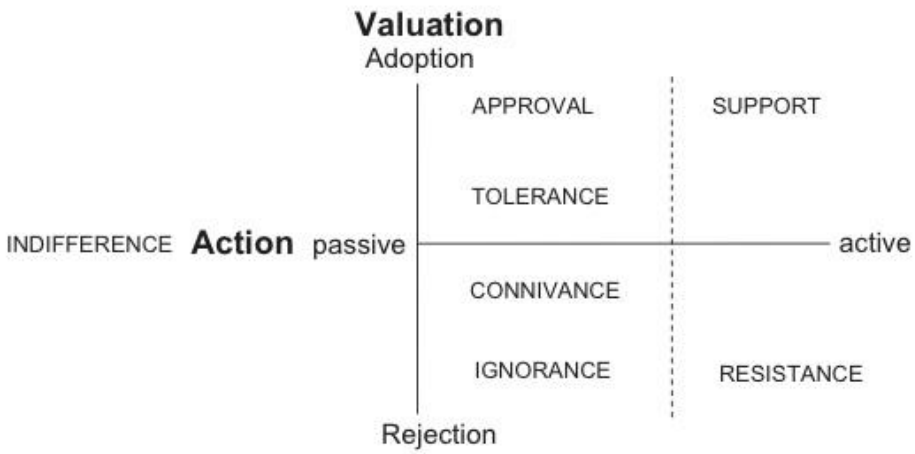

Figure 6. Two dimensions of Acceptance: Valuation and Action. According to Dethloff, 2004 (Schweizer-Ries, 2008).

Figure 6 emphasizes the importance of context. Valuation and action are always integrated in the social construction process, as already described in the Kaufmann-Hayoz model (2006). Furthermore, another differentiation between types of acceptance is demonstrated within this figure: passive and active acceptance. According to Schweizer-Ries (2008, p. 4131), active acceptance by decision makers (e.g. role models) is necessary in order to change the contextual framework and enhance citizens' actions in support of energy sustainability (which was defined in part 2.1.1.). A broader definition of acceptance comprises both active and passive acceptance, while the narrow definition includes only active acceptance (Schweizer-Ries, 2008, p. 4131). Within the present study, the narrow definition of acceptance is assumed. Thus, this study defines acceptance as being when an individual values the PicoPV systems highly and contributes actively to their use.

Regarding acceptance particularly of renewable energies, Wüstenhagen, Wosink and Bürer (2007) collected papers in order to investigate dimensions of social acceptance concerning renewable energies. As can be seen in figure 7, they found three dimensions: socio-political, community and market acceptance.

Socio-political acceptance is referred to as the most general level of social acceptance (Wüstenhagen, Wosink, & Bürer, 2007). It includes acceptance by key stakeholders and policy actors. This might involve for example the establishment of financial systems, which encourage investments and help in the making of collective decisions (Wüstenhagen, Wosink, & Bürer, 2007). *Community acceptance* includes specific

acceptance by local stakeholders, residents and local authorities. It consists as well of a time dimension due to the fact that acceptance changes during a project. The importance of sharing costs and benefits (distributional justice) and fairness during the decision process (procedural justice (Gross, 2007, pp. 2729-2731), as well as trust between the local community and investors is emphasized (Huijts, Midden, Meijnders, & L., 2007).

Figure 7. The triangle of social acceptance of renewable energy innovation. Source: Wüstenhagen, Wosink and Bürer (2007).

Market acceptance concerns adoption by consumers, investors and intra-firms (Wüstenhagen, Wosink, & Bürer, 2007). Rogers' investigations (2003) explore consumer adoption in detail. His work is presented in the next section (2.2.3. Model of Innovation-Decision Process).

In this pilot study, acceptance is defined as support according to Dethloff (see figure 6). Hence, the objective is to explore *active acceptance*, which is constituted as buying a PicoPV system.

In general, the following behavioral considerations seem to enhance acceptance (Wiswede, 2007): high expectation of reward, especially a high reward of great certainty in the near future, on the other hand, low expectation of punishment is also beneficial, particularly perception of low risk and low effort in acquiring the innovation. A high level of attention to highly observable and distinctive features of the innovation also help to increase adoption. Effects of model and identification play also a big role, especially through relevant attachment figure, agents of diffusion and opinion leaders. High perceived compatibility, mainly high consistence with existing cognitive

structures and cultural (and sub-cultural) virtues, norms and life styles should not be ignored in the process of acceptance (Wiswede, 2007). This last point refers to the theory of cognitive dissonance: according to Festinger the existence of dissonance, which he defines as "the existence of non-fitting relations among cognitions […] (such) as any knowledge, opinion or belief about the environment, oneself or about one's behavior" (Festinger, 1957, p. 3), is very uncomfortable for the individual. Therefore, individuals try to reduce it and to avoid situations which will evoke or increase dissonance (Festinger, 1957). Hence, the degree to which an innovation fits onto the cognitive map of consumers defines its grade of cognitive dissonance. Innovations should cause only little dissonance or provide an easy and/or incentive possibility of dissonance reduction (Wiswede, 2007).

2.3.3. Diffusion of Innovations

Diffusion of an innovation is the next step after acceptance by an individual. Diffusion of innovations is defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system." (Rogers, 2003, p. 5).

When it comes to the diffusion of innovations, the social system plays a large role. Gatignon and Robertson (1985) summarize three important elements which have a significant influence on the process: (1) actual norms and values. The innovation can be accepted only when it does not hurt any cultural values or beliefs. There is huge social pressure. (2) System Evolution. Due to the fact that values and norms are not constant, it is important to pay attention to the development of social norms and values as well. Rogers (2003) referred to the differences between a modern and a traditional society. He claims that a traditional society is not as open to new innovations as a modern one. Furthermore, the traditional society maintains its habits and traditional usual actions. (3) System Homogeneity. Within social systems which are very heterogeneous, the speed of diffusion decreases, according to Gatignon and Robertson (1985, p. 858). This is caused by the lower degree of contact between individuals.

Social influence is especially effective if the product is very noticeable, if there is a lack of objective evaluation of a product, very high complexity and high prices (Dethloff, 2004).

Within society are some socio demographic characteristics which have an influence on

the acceptance of innovations: for example skepticism surrounding technology can be found more often among elderly people in Germany (Jaufmann, 1999 cited in Dethloff, 2004). Women show also more skepticism and they react in an ambivalent way to technology. Furthermore, they calculate more. Population groups with a higher educational level are often more open minded regarding technical developments (Dethloff, 2004).

According to Rogers there are two different kinds of communication channels, which are defined as "the mean by which messages get from one individual to another" (Rogers, 2003, p. 18): mass media channels, which include radio, television and newspaper, and interpersonal channels, which can be described as a face-to-face exchange of information between individuals. In addition, he suggests a new type of communication channel, which has developed in recent years because of the spread of the internet: interactive communication channels. In order to inform people about new innovations and create a state of awareness as per Rogers' model, communication through mass media is fastest and most effective according to Rogers. Although mass media can reach a very large audience, this channel is able to change only weakly held attitudes towards the innovation. Changing strongly held attitudes is the advantage of interpersonal channels, especially in persuading an individual to adopt an innovation.

2.3.4. Model of Innovation-Decision Process

Rogers (2003) states that the innovation process comprises five different steps, which follow each other sequentially: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. These stages are presented in figure 8.

In the first stage, *knowledge*, the individual gets to know about the existence of the innovation. Further on, he or she will seek more information about it, through such questions as "what is the innovation?", "how does it work?" and "why does it work?". According to Rogers three types of knowledge exist: (1) awareness-knowledge, which is the knowledge about the existence of the innovation and (2) how-to-knowledge, which is knowledge about how to use the innovation in an adequate manner. In the opinion of Rogers this is an essential variable in the process of adoption. The individual should have some knowledge before the trial of the innovation.

For complex innovations this type of knowledge becomes even more critical (Sahin, 2006). The third kind of knowledge is referred to as (3) principles-knowledge. In this

stage the individual learns how and why the innovation works. An innovation might be adopted without this knowledge, but a continuous misuse of it may cause a later rejection of the innovation (Sahin, 2006).

Figure 8. Model of Innovation- Decision Process according to Rogers

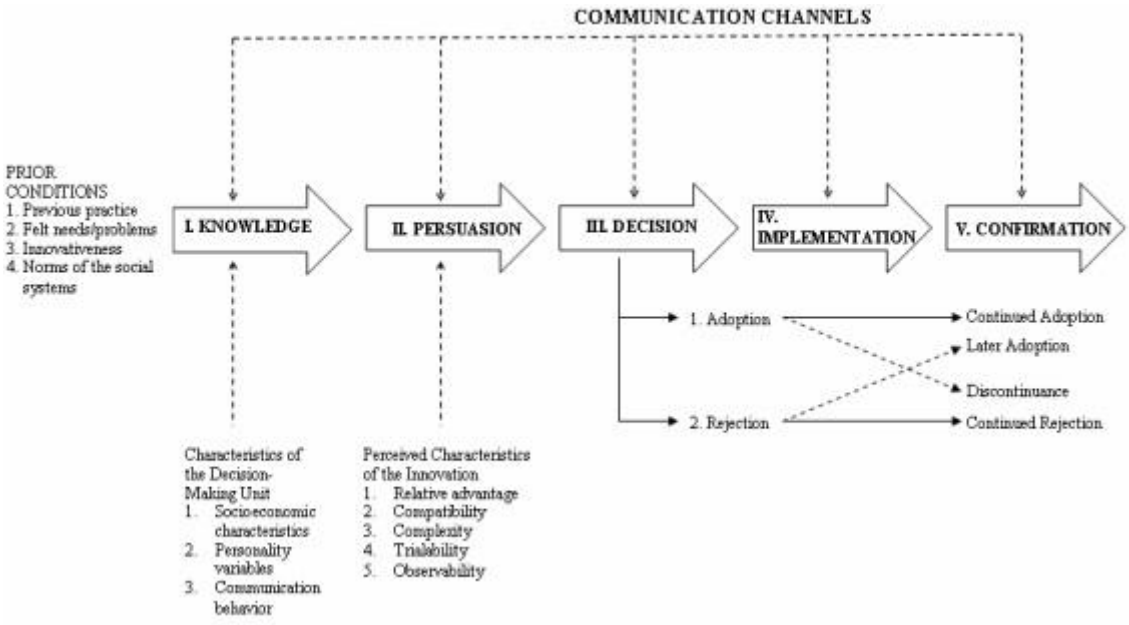

Figure 8. A Model of Five Stages in the Innovation-Decision Process. Adapted from: Diffusion of Innovations by Everett M. Rogers. Copyright 2003 by The Free Press.

Even if an individual has all kinds of knowledge, it does not mean automatically that he or she will adopt the innovation. As described above in section on acceptance, the adoption process is also influenced by the individual's attitudes.

At this point it is logical to refer to the theory of reasoned action by Ajzen and Fishbein (1975 & 1980), represented in figure 9. This theory was developed in order to predict and explain the behavior of humans in certain situations, such as the decision whether to adopt an innovation or not, as described in Rogers' stage of persuasion. The theory states, that the *behavioral* intention of a person depends on the person's intention to perform a given behavior. Intentions consist of motivational factors, such as effort or strength of will to perform a certain behavior. Intentions in turn are influenced by the individuals' attitude towards the behavior and his or her subjective norms. The term "attitude towards a behavior" can be explained with the help of value-expectation theories[10]. On one hand it is determined by the expectation of the probability of achieving certain consequences through one's actions. On the other hand the evaluation

[10] Wert-Erwartungs-Theorien

of these consequences contributes to the attitude. Subjective norms are influenced by opinions or claims of behavior of important persons and the motivation to follow them. In other words it can be described also as perceived social pressure. This theory was revised later because it does not consider processes, which are incompletely volitional. Ajzen added in his Theory of Planned Behavior the new component of perceived behavioral control. This component is composed of the perception of behavioral control (subjective opinion of the person) and the actual control (Ajzen, Ellen, & Madden, 1992). It describes the perceived ease or difficulty of performing a behavior and includes as well as in past experiences obstructions and the experience and information of friends and acquaintances. The importance of this added component is said to increase as volitional control over the behavior declines. Ajzen states as a general rule that "the more favorable the attitude and subjective norm with respect to a behavior, and the greater the perceived behavioral control, the stronger should be an individual's intention to perform the behavior under consideration." (1991, p. 188). Apart from that general rule, the importance of each component is expected to vary across situations and behaviors. Empirical investigations show a strong correlation between the two components, intentions and perceived behavioral control, and behavioral performance.

Figure 9. Theory of Planned Behavior according to Ajzen

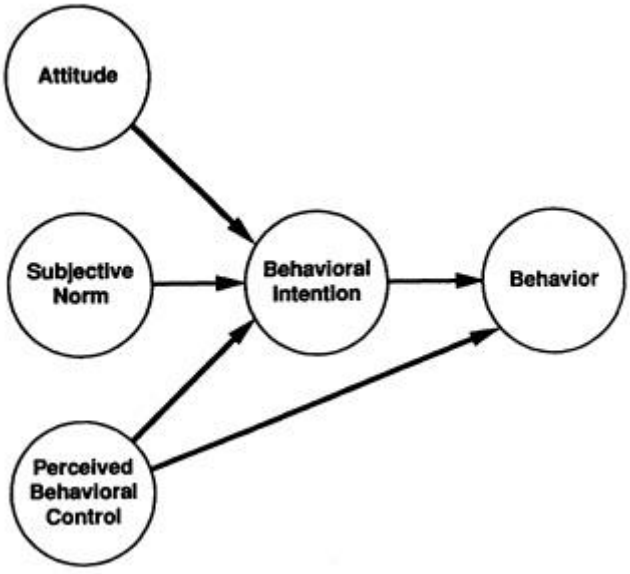

Figure 9. Theory of Planned Behavior. Adapted from: A Comparison of the Theory of Planned Behavior and Theory of Reasoned Action by T., Madden, P. Ellen, I. Ajzen, 1992. Behavior is predicted by intention, attitude, subjective norm and perceived behavioral control.

Both of the models refer to the human as homo economicus, who wants to maximize his benefit. But it is generally known that human beings are rational only in a very limited way (for example (Kahneman & Tversky, 1979)).

To return to the innovation-decision process according to Rogers, the second step of innovation process is called *Persuasion*. In comparison to the cognitive action in the stage of knowledge, the following stage of persuasion is more affected by emotional or affective components. In this stage the person's attitude toward the innovation is formed. In particular, experiences and opinions of close peers influence the individual's opinion now. During the following stage of *Decision* the individual decides, whether to use the innovation (adoption) or not (rejection). According to Rogers (2003) individuals want to try the innovation before they decide whether to accept it. Hence, the possibility of trial is an important factor in the decision process, as it enables the person to evaluate the innovation's usefulness in his or her personal environment. The *Implementation* stage occurs, when the individual finally puts the innovation into practice. This is the first time the process of acceptance leaves the mental, cognitive state and the individual starts to act. Finally the *Confirmation* stage takes place, in which the individual searches for support for his or her decision. Even if the decision at this stage can be reversed again as a consequence of conflicting information, the individual searches mainly for information that support his decision.
In the present study the stages of knowledge, persuasion and decision according to Rogers (2003) are of particular interest.

A valuable approach which combines the mentioned Innovation-Decision Model of Rogers and the Theory of Reasoned Action according to Ajzen is the technology acceptance model. It describes acceptance of technical innovations in organizations. Davis et al. (Davis, Bagozzi, & Warshaw, 1989) concluded with the help of empirical data that only two of the former five characteristics of innovation remain: relative advantage, which is referred to as *perceived usefulness*, and complexity, which is called *perceived ease of use* in this model. Perceived usefulness is referred to as "the extent to which people believe that the technology will help them perform their job better" (Davis, 1989, cited in: Straub, Keil & Brenner, 1997). Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, cited in: Straub, Keil & Brenner, 1997). They evaluate two

alternatives: a direct impact of perceived usefulness in behavior intention and an indirect influence with the help of the variable of attitude. They have shown that perceived attitude has a greater influence and is therefore a better predictor of acceptance than perceived ease of use. This result was proven in different studies as well as with empirical research using the model of diffusion of innovation. However, application of the model in different countries has shown that the model "may not predict technology use across all cultures" (Straub, Keil, & Brenner, 1997, p. 1).

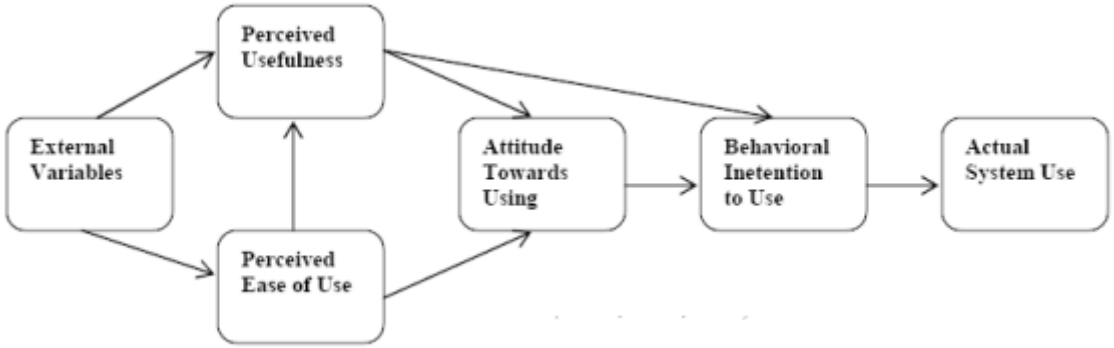

Figure 10. Technology Acceptance Model. Compiled from: Dethloff, 2004.

Even if it is a valuable approach to combine various investigations, the technology acceptance model can hardly be replicated in practice, especially outside a work context (Theuerling, 2010).

The previous section explained first different definitions of acceptance. Afterwards theoretical considerations about elements which influence the decision to adopt or reject an innovation were presented. The next section gives an explanation of characteristics of innovations which support the acceptance process described above.

2.3.5. Characteristics of Innovations

Rogers' empirical studies (2003) show that the acceptance of an innovation depends on the following characteristics of the innovation: (1) relative advantage, which he defines as "the degree to which an innovation is perceived as being better than the idea it supersedes." (Rogers, 2003, p. 229). Elements of the relative advantage are for example perceived advantages in terms of social status and economic factors. Another important characteristic in the motivation process of accepting an innovation is (2) compatibility, which he presents as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters"

(Rogers, 2003, p. 240). This also depends on cultural background, virtues and social values into account. According to Rogers (2003) (3) complexity describes the level of difficulty in using and understanding the innovation. The fourth element of (4) trialability he refers to as "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2003, p. 258). The last factor, Rogers states, is (5) observability, which is defined as the likelihood of others perceiving the benefits of an innovation. In this context, social networks, such as family members, friends or neighbors, as well as peer-to-peer-networks play an important role. Peer discussion of a new idea and the visibility of its results is an important indicator of the later diffusion process.

The more an individual perceives a relative advantage, compatibility and trialability by using the product, the more he or she will be likely to accept and adopt the innovation (Schulz, 1974, p. 2 cited in Wiswede, 2007, p.302).

Regarding the particular diffusion of energy-saving innovations, Darley and Beniger (1981, cited in (Wortmann, 2010) developed the following elements out of Rogers' diffusion theory (Rogers, 2003): capital costs, perceived savings, certainty of savings, compatibility of innovations with values, attitudes and lifestyle of target groups, possibility of trial, dissatisfaction with the existing situation, and the effort and skills necessary for installing the innovation. Völlink, Meertens and Midden (2002) found that concerning energy conservation technologies, not all characteristics assumed by Rogers and Darley and Beniger are equally relevant. They emphasized the importance of perceived compatibility with values as a general adoption factor. Furthermore, they showed that perceived relative advantage is the first criterion which determines whether the adoption process goes on or the adoption is rejected. Only if perceived relative advantage is high is the evaluation process continued. They assume that each innovation technology has its own characteristics, which influence the adoption process. In order not to adjust characteristics for each innovation technology anew, they suggest exploring perceived positive and negative outcomes through, for example, focus group discussions (Völlink, Meertens, & Midden, 2002). This was accomplished within this pilot study.

Another theory about the way in which an innovation's characteristics influence perception and evaluation thereof, is that of Raju (1980). On the basis on Berlyne's theory of activation, Raju developed a theory which explains the optimal arousal

potential of an innovation. He posits two components: a novelty component that consists of positive characteristics, such as novelty and value of surprise, and the so-called conflict component, which represents mainly negative characteristics, such as uncertainty, ambiguity or incongruity. According to Raju the optimal arousal level the consumer should reach to adopt an innovation is an additive combination of the two components.

Similar to the theory of Berlyne, this theory suggests that the stimulus, in this case the innovation, should be perceived as new, and therefore provoke activation potential, but it should not be perceived as too new or attached with conflicts. The relation is again represented as an inverted "U". On the other hand it remains undeclared, which attribution causes which type of conflict. Personal dispositions, for example in exposure to conflict, also remain unconsidered (Wiswede, 2007).

Figure 11. The Optimal Arousal Potential

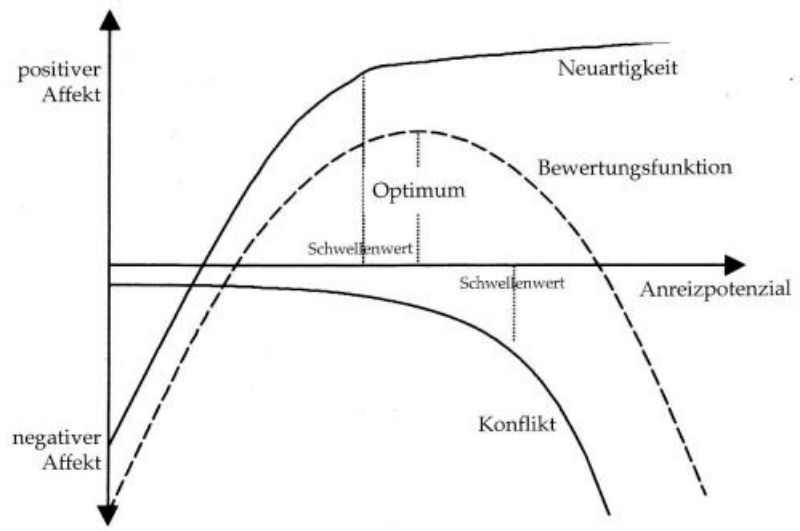

Figure 11. Integrative approach of the optimal arousal potential Adapted from Raju, 1981. *Einführung in die Wirtschaftspsychologie* by G. Wiswede, 2007. Evaluation is estimated as a function of novelty and conflict component. This link is an inverted "U" following Berlyne's theory of arousal.

In this context Kaplan (1999) claims that diffusion literature has recently focused on the issue of knowledge and innovation characteristics, but has failed to pay adequate attention to experience as a determinant of adopter persuasion and to the concept of familiarity with the innovation of the adopter. He therefore establishes a revised conceptual model of the variables that contribute to the innovation diffusion process: 1) *Context*. The variable of context contains three subcategories: environment,

organization and person. This is equal to Rogers work. 2) *Motivation.* Motivational factors may be economic variables (as a context factor in motivation), incentives, autonomy (freedom from electricity providers), salience (the degree of local merit). Kaplan (1999) states that motivation is necessary, but not sufficient to create interest. The third variable he developed is 3) *Technical knowledge*. Kaplan refers to it as "objective knowledge, information that can be acquired from books, conferences, and technical information retrieval (Kaplan, 1999, p. 471)". This is the main distinction between Rogers and Kaplan. Whereas knowledge as Rogers sees it can be influenced by past experiences, Kaplan adds a distinct variable of experience and familiarity, which are the two remaining variables: The fourth variable of (4) *experience* is a multifaceted concept, which is summarized in table 1.

Components of experience

Type of experience	Description	Example
Exposure	Degree/amount of stimulus encounters	Nielson TV ratings
Direct	Actual hands-on activity	Investment, experimentation
Vicarious	Indirect connection to stimulus	Stories, networking, cues
Innovativeness	Inherent capacity to innovate	Past direct experience

Table 1. Components of experience according to Kaplan. Source: Kaplan (1999).

"Clearly, expertise is more than the result of book-learning" (Perkins and Rao, 1990 according to Kaplan, 1999, p.471), therefore Kaplan states this component as a distinct concept. Another important concept is (5) *familiarity*, which he refers to as "the cognitive state resulting from experience: a degree of close acquaintance. To be familiar suggests a level of comfort, a closer association with something than would arise from technical, objective knowledge alone (e.g. Whittlesea, 1993). It requires exposure to, and experience with, the object (Kaplan, 1999, p. 472)." According to Kaplan, familiarity also increases confidence in one's abilities, and helps to organize the mental structure of the innovation in a less complex and better organized way.

To illustrate the concept of familiarity he uses the example of usage of computers, into which most of the users have no technical insight, but still gain a feeling of familiarity through the daily use of this technology.

Figure 12. New innovation decision conceptual framework

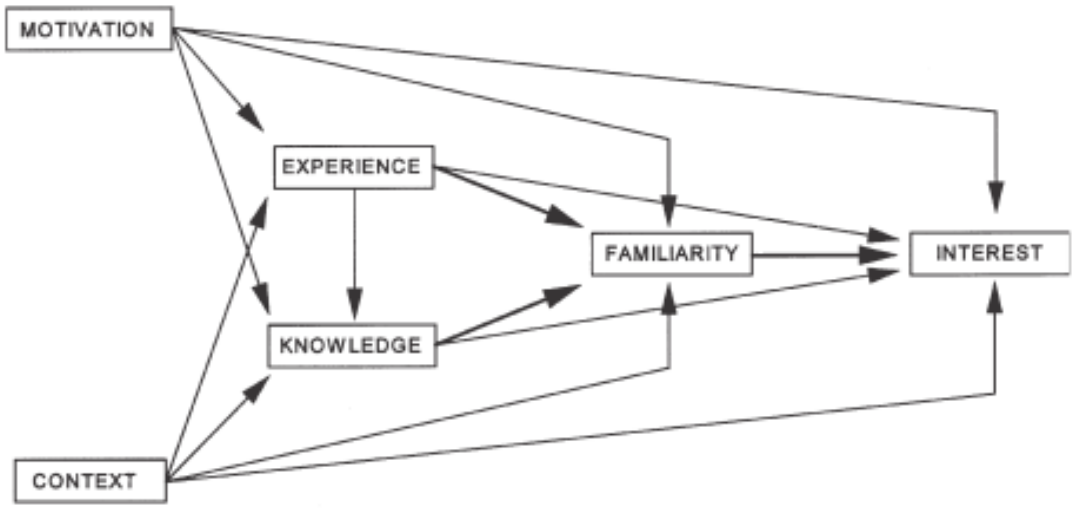

Figure 12. A new innovation decision conceptual framework Adapted from: From passive to active about solar electricity: innovation decision process and photovoltaic interest generation by Kaplan, 1999.

The last variable is a dependent variable, called interest, which is influenced by the others mentioned above. It can be equated with the second stage, persuasion, in the theory of Rogers. Figure 12 explains the correlations and interdependences of the different variables according to the theory of Kaplan.

To summarize, in the previous chapters acceptance was defined. In this study it is referred to as positive valuation and active contribution. Furthermore, stages of the acceptance process as well as the impact of characteristics of the innovation characteristics were described. The present study can be located in the persuasion and decision stage according to Rogers. Various theoretical models have been developed to explain and predict behavior in the context of acceptance of innovative technology. These theoretical investigations give valuable hints as to which factors should be the focus during the present study. Investigations by Ajzen, Kaplan, Raju and Rogers are of further interest and provided the basis for the interview guideline (see chapter 3, Methods).

Even though there is deep interest in the acceptance of innovations, concerning acceptance of PicoPV systems in developing countries there is a lack of investigations regarding practice and theory. The following two chapters examine the need for further investigations in these two areas.

2.4. Need for further *theoretical* investigations

Given this context, there is a gap between implementation of technology in industrial and developing countries. This is not only caused by cultural differences, but also by different needs and saturation of products and inventions. For example, there are no experiences, whether adoption is independent from prestige/status effects or whether especially poor people attach high value to their social environment because of a feeling of inferiority. Furthermore, innovation in Western countries includes innovations for prestige and fun, while an innovation in developing countries is perhaps evaluated on very different dimensions, such as essential improvement in daily life.

Moreover, there is a lack of data concerning dimensions in developing countries, which contribute to the decision of adopting or rejecting an innovation. Only 30% of diffusion studies were conducted in developing countries (Rogers, 2003). These studies were realized for example in the context of agriculture and family planning. The few existing approaches which try to explore essential factors in implementing technologies are accused of being subjective, because of too concrete questions and related problems of social desirability (Nieuwenhout, de Villers, Mate, & Aguilera, 2004)

As explained before (in the chapter on Acceptance of Renewable Energy Projects), various experiences of development cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2007) show that even extremely beneficial innovations do not diffuse on their own (Rogers, 2003). Often the fitting of approaches in Western development cooperation to cultural values of developing countries is neglected. Incompatibility with cultural values leads to problems in terms of social acceptance. Therefore, investigations into social acceptance are essential. Hofstede supports this opinion: he claims that until now only few investigations have taken a close look at the "mutual relationship between culture and technological change" (Hofstede, 2001, p. 438). Furthermore, he describes people of the partner countries as cultural experts, who describe application of innovations to technical experts from Western countries.

Due to the newness of PicoPV systems, only few statistics exist concerning their acceptance. Furthermore, up to now there has been no attempt to combine practical values and theoretical considerations in regard to the topic of acceptance of PicoPV systems in rural electrification.

2.5. Need for further practical investigations

The need for a research into this topic was realized due to former experience in the field of renewable energies[11] and their social acceptance: due to the fact that renewable energies are generally positively evaluated (Eurobarometer, 2003; BPA, 2003; Simon and Wüstenhagen, 2006 cited in Wüstenhagen et al., 2007; Gross, 2007), the issue of social acceptance is often neglected (Wüstenhagen, Wosink, & Bürer, 2007). However, moving from general support to concrete actions, a huge gap appears. Furthermore, huge differences were found between implementation rates in different countries, which cannot be explained only by differences in resources (Toke et al., 2008 cited in: Wüstenhagen, Wosink & Bürer, 2007). Schweizer-Ries (2004) also draw the conclusion that in rural electrification, especially in development cooperation, mainly technical aspects are still the focus (p. 28). To summarize, lack of acceptance is a common barrier when implementing renewable energy projects.

Due to a lack of studies about Pico Photovoltaic systems, the following section refers to examples of former renewable energy projects and their difficulties of implementation. They are partially comparable and should explain the need for further investigations in this sector.

Early investigations with *solar cookers* already identified a lack of social acceptance as a problem, which impeded implementation of renewable energy techniques (Deutsche Gesellschaft für Internationale Zusammenarbeit, 1999). Comparing the results of solar cooker projects in different countries, such as China, India and South Africa, it has to be acknowledged, "that decades of efforts have not helped solar cookers to achieve a breakthrough" (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2007, p. 3). According to the observations of GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2007) there is a lack of projects which encourage the use of the technology and not only its purchase. This lack of social acceptance is caused by an incompatibility with cultural values:

> "In many cases solar cookers cannot be integrated into families' everyday working and domestic lives without further complication. Moreover they call for changes in behavior, which it is difficult to persuade people to adopt as long as there are

[11] which can be referred to as innovations in this context. To this category belong along with solar energy wind and water energy, geothermal energy and biomass fuels.

> alternatives that are more convenient or closer to users' traditions." (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2007, p. 19).

In the case of *Solar Home Systems*, which provide similar features to PicoPV systems, experience has already been gained through various projects. An analysis of the current status of solar rural electrification in developing countries concludes that "satisfied users are essential for successful solar rural electrification" (Nieuwenhout, de Villers, Mate, & Aguilera, 2004, p. 29). However, problems also exist in developing a sustainable PV market (International Energy Agency, 2003). The International Energy Agency found amongst others the following reasons: "lack of clear ownership of the technology, lack of maintenance and the ultimate failure of the PV system with consequent rejection of the technology" (International Energy Agency, 2003, p. 1).

In contrast to the Not-In-My-Back-Yard Syndrome which affects the large infrastructure facilities of other renewable energy sources, implementation of micro-generation technologies, such as PicoPV systems is confronted with the following obstacles: willingness to install the technology at home, capital investments and behavioral changes (Sauter & Watson, 2007). Social acceptance of *micro-generation technologies*[12], such as PicoPV systems, is not well explored, compared to that of large renewable energy projects (Sauter & Watson, 2007). Additionally, due to the newness of PicoPV systems, only early findings exist about their performance in field tests and acceptance by users (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b).

This review of literature supports the importance of social acceptance as a relevant factor. Rogers already mentioned this issue in his early works: he concluded that even innovations which are extremely beneficial, such as life-saving innovations, do not diffuse on their own. Indeed, their acceptance can take a long time (Rogers, 2003).

In conclusion, it is essential to investigate social acceptance in order to implement renewable energy projects successfully and sustainably.

Taking all these issues into consideration, it is of further interest to find preliminary answers to the following questions in order to make development cooperation more effective and sustainable:

---

[12] Micro-generation technologies are defined as energy generation technologies, which are installed in individual households (Sauter & Watson, 2007).

How do people in developing countries resolve whether to use a technical innovation? Which dimensions of evaluation are important for users? To what extent does the cultural background have an impact on the innovation-decision process?

III. METHOD

In order to explore the questions mentioned above, Ethiopia was chosen location for this field study. Research into acceptance of PicoPV systems here is worthwhile, because Ethiopia has a low electrification rate[13] and a great potential to use solar energy[14].

Given the lack of systematic research about acceptance of PicoPV systems (see chapter two) this thesis is based on qualitative social data research, whose objective is to analyze subjective and social perspectives in a new field of research. The target is therefore not to verify an established model or theory but instead to discover new relations (Flick, 2004). On this account no explicit hypotheses are to be verified as in quantitative research. Whereas in quantitative research the sequential steps of conception, method and empiric can be measured in a fixed and independent order, in qualitative research they overlap and are interdependent (Flick, 2004).

Problem-focused interviews according to Witzel are the mode of collection. This method was chosen in order both to be open to the perspectives of participants and to set the topic in advance. With the help of this kind of interview, participants are stimulated to think about their actual condition and their cognitive perception and tell about their actions and changes that occurred on behalf in the new situation.

3.1. Problem-focused interview according to Witzel

The research method is based on qualitative interviews, more precisely the problem focused interview according to Witzel (2000). This is a theory generating method. Similar to the "Grounded Theory" developed by Glaser and Strauss (Glaser & Strauss, 1998) it is an alternating change of induction and deduction to create insight. With this measure it is possible to overcome the tension between following specific theoretical guidelines and openness (Witzel, 2000). There are three principal assumptions:

1. Focusing on the problem means in this context orientating discussion around a socially relevant question. With this kind of interview a theory can be generated while at the same time communication is focused on a specific issue. Although there was no appropriate literature or theory regarding diffusion of innovations in least developed

[13] Only 1% of the rural population has the opportunity of using modern energy services (Beyene, 2008).

[14] national annual average irradiance is estimated to be 5.2 kWh/m2/day (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2009a)

countries (especially, regarding PicoPV systems in Ethiopia), topics of particular interest are included in the interview, as described in section on theory. Cultural background in Ethiopia differs very much from in the West. Therefore, it is important to gain new perspectives on the cultural background of the people by using open questions. At the same time a few issues were of particular interest. The issue of making electricity available for low-income households in developing countries in order to contribute to the reduction of poverty as one of the Millennium Development Goals is socially relevant, as shown above. As described above, social acceptance plays a large role in development cooperation. Even if it does not affect Western people directly, they will have to face the consequences of migration from least developing countries, for example because of the effects of climate change (Warner, Ehrhart, de Sherbinin, Adamo, & Chai-Onn, 2009), as well as increasing conflicts over resources and a strong dependence on them. Consequences include, further destruction of already fragile eco systems (Messner, 2010). Global problems such as climate-related migration and displacement "can be successfully addressed only if they are seen as global processes rather than local crises" (Warner, Ehrhart, de Sherbinin, Adamo, & Chai-Onn, 2009, p. 4). Therefore this is a global issue and a highly relevant social topic for research.

2. Relevance Based. This describes the flexibility of the method. It is possible to combine different kind of data collection, such as qualitative interviews, observation, group discussion, etc. in order to fulfill different requirements of the field study. Because many interpersonal interactions happened in between the interviews and during the rotation of the different lamp types, participant observations were also part of data collection.

3. Orientation on process. There is a stepwise collection and verifying of data, which is a slow and reflexive process during collection of the data (Witzel, 2000).

Instruments of the problem focused interview are: 1. Short questionnaire. With the help of this questionnaire socio-demographic information was collected about participants. In order to prevent a question-answer-scheme and interruption of the conversation the author decided to ask these questions at the end of the interview 2. Interview guideline. This was mainly used as an aid to the memory of the interviewer. Simultaneously it ensured the comparability of the different conversations. This interview guideline contains eight main topics: usability, daily use, quality, expectations, satisfaction, effects and familiarity. These topics are derived out of theoretical considerations mainly

of Ajzen, Kaplan and Rogers as described in chapter 1. Furthermore, GIZ contributes further ideas about topics of interview guideline, gained through experiences in projects (for example GIZ, 2007), which are worth of further examinations. Main topics were the users' evaluation of the PicoPV systems and their experience in daily life according to the assumed characteristics of innovation, which play an important part in the decision process. The aim was to understand the decision process of the users in deciding whether to buy a PicoPV system (=active acceptance) or not (passive acceptance or rejection). The interview guideline was also helpful in ensuring that every topic was covered in the conversation. 3. Recording (Transcription). Recording helps the interviewing person to follow the conversation, because he or she does not have to take notes during the whole conversation. At the same time the interviewer is able to observe gestures and specific conditions of the situation. All interviews for this thesis were recorded and transcribed completely. This step contains the first elements of analysis. 4. Postscriptum, also referred to as a protocol of context, contains special events, conversations, thoughts, noticeable problems shortly before or after the interview as well as the first ideas of analysis (Witzel, 2000). The author kept a research diary to collect all information about happenings and observations.

Interviews are conducted until there are no new insights within the conversation. This is known as theoretical saturation.

3.2. Instrument of Analysis

Qualitative content analysis according to Mayring (2003) is the method used to analyze the data. The main part of the analysis is qualitative. This can be supplemented by quantitative analysis, such as analysis of frequency. In the following section the method is described in detail. This is designed to ensure inter-subjective understanding and control of method, which is a criterion of qualitative research according to Mayring. Grounded theory is another method that can be used to analyze available data. The author decided not to use this method due to the fact that participants are often neither very well educated nor used to being interviewed. Therefore answers turned out not to be very long or detailed. Additionally, interviews had to be translated. As a consequence of these two facts, it is not possible to attach value to analysis of every single word within the interviews. Furthermore, the author does not want to generate

completely new theory but to rely on existing literature. This is reasoned in order to achieve a more feasible approach by integration in former experiences.

In order to make the present study inter-subjectively comprehensible (a criterion of quality), a detailed documentation of the procedure is presented in the following section.

3.2.1. Procedure of qualitative content analysis

1. Selection of basic raw material

Selection of material

The basic population is the village Grajja Mariam near Adama (Nazareth) in Ethiopia. It consists of approximate 220 households. 24 families participated in the pilot project with the solar lamps. The population of this thesis consists of 18 qualitative problem focused interviews according to Witzel (2000). This was supplemented by observations during visits in the village during day and night. In addition, short questionnaires about the consumption of energy were administered, as well as two focus groups at the end of the field study.

Analysis of originate situation[15]

This diploma thesis contains statements of 18 families about their use of the solar lamps, the quality thereof and the changes that resulted. The members of the village had not had any modern energy access before. The village is located about 10 km from a city. Jobs are mainly around the village (agriculture). The villagers belong to the Oromic culture, which is the majority ethnic group in Ethiopia (while the Amharic culture is dominant). Most of the people in the village are not able to read or write. Participation in the pilot project and the interviews was voluntary. The interviews took place at the participants' homes.

The team consisted furthermore of two Ethiopian technical students, whose task it was to make up contact with the village and ensure technical support, and a translator, who was able to speak Amharic, Oromifa and English. The special emotional, cognitive background of action was the author with her German cultural background as a foreign, white woman in a patriarchal community.

[15] Analyse der Entstehungssituation

Formal characteristics of material

The interviews were recorded and afterwards transliterated in digital form. The questionnaires were filled in like a short interview. The group discussion took place with voluntary participants of the field study and was treated like the interviews: they were also recorded and transcribed.

2. Question of analysis[16]

Direction of analysis

The present research concerns acceptance of innovations. The interviews should motivate the participants to think and report on their actual feelings, their cognitive state and their previous actions and changes caused by the new situation of access to modern energy services. According to the content analytic communication model the direction of analysis is to make statements about the emotional, cognitive and actual background of the text.

Theoretical guided differentiation of question[17]

This thesis concentrates on the acceptance and diffusion of an innovation, the PicoPV systems. The interviewees made statements about their use of the lamps, quality and usability characteristics. The theoretical background was presented in the theoretical part of this paper.

3. Procedure of analysis[18]

The strength of this procedure of analysis is described by Mayring (2003) in following previously fixed steps of analysis. These separate steps make it inter-subjectively comprehensible and verifiable. This makes it possible in turn to convey it to other subjects and to transform it into a scientific approach.

16 Fragestellung der Analyse
(Mayring, Qualitative Inhaltsanalyse. Grundlagen und Techniken., 2003).

17 Theoriegeleitete Differenzierung der Fragestellung
(Mayring, Qualitative Inhaltsanalyse. Grundlagen und Techniken., 2003).

18 Ablaufmodell der Analyse
(Mayring, Qualitative Inhaltsanalyse. Grundlagen und Techniken., 2003).

Definition of technique of analysis

Content analysis according to Mayring (2003) is chosen as method of analysis. It is a form of analysis, which generates a method of text analysis, which is systemic and inter-subjectively comprehensible. Mayring (2003) describes the different steps of content analysis as follows: First, the text passage of interpretation is defined. This represents the unit of analysis. During the second step it is reviewed whether the interpretation was satisfying. Translation of a text or passage of text is also part of step two. Subsequently further material for explanation is chosen (step 3). Step 4 contains a differentiation of narrow and broad explication. Narrow explication allows only material taken from the underlying text itself. Statements which are linked to the interpretative text are collected. Furthermore, it is verified whether similar issues exist within the text material. During broad explication material going beyond the text is considered, such as information about the author and condition of origin. In addition theoretical preconception or the background understanding of the interpreter can be consulted. A formulation has to be found to explain relevant passages within the following step (step 5). This is achieved by summarizing the collected material. Finally the last step (step 6) verifies whether a reasonable explication has been attained.

4. Definition of units of analysis

The smallest units of analysis in this thesis are single words. This is the ‘encoding unit’, which is defined as the smallest text component that can be summarized as one category. On the other hand ‘context unit’ is defined as the largest text component that can be summarized in one category. In this case a whole section of text can be subsumed in one category, because most of the people explained their concerns with a lot of repetitions.

5. Analysis / evaluation by means of categories

The objective of qualitative content analysis is to establish a system of categories that explains the basic population. While interpreting the basic material, the process of analysis is repeated in various loops. Therefore, categories are developed in a reciprocal relationship between theory and concrete material. During the first step the author analyzed the material according to inductive category formation, which is called open coding (Strauss & Corbin, 1996). First codes of important passages in the sense of the

theoretical question were developed. After analyzing about 10-50% of the given material, the codes were revised (Mayring, 2003). The acquired codes were summarized in concepts, which were organized in a network (mind map).

Within the next step the developed concepts were subsumed in categories. While concepts are the description of an event or a phenomenon, categories are classifications of concepts in an abstract way (Strauss & Corbin, 1996). For a better overview the author integrated the categories in the scheme as well.

During the last stage of analysis these categories were verified with another inspection of the interviews and furthermore an examination of the transcribed focus groups. Even though the categories should merely be verified at this stage, new codes, concepts or even categories were added to the scheme if necessary. The author aimed to organize the material on an abstract level at all times during this process. Through this procedure the analysis was confirmed. To meet the quality criteria of scientific research the interpretation of the author organized in a network was discussed with a qualitative research group. In this way inter-subjective comprehension was ensured. Further criteria of quality are reviewed in the chapter on discussion.

Results are presented in the corresponding part of this thesis.

3.3. Sample and Acquirement of data

The field study took place from May until August 2010 in a small village near Adama. 24 families tested the lamps during the field test. All of them live in a village, called Soleguraja, near Adama (Nazareth).

3.3.1. Description of Sample

The village is located about 10-15 kilometers from Adama. Due to the huge amount of construction occurring everywhere in Ethiopia, including Adama, it is conceivable that it will belong to the city in the distant future. At the moment, however, access to the village is possible only by travelling off-road for some distance. The distance to the village was overcome by the use of a Bajaj (three-wheel open mini-taxi), horse or car which was difficult due to the rainy season and poor conditions of the car.

The village in total contains about 220 households. Their habitants had only limited experience with electricity in the city nearby. The village itself was not electrified. All

participating families named the man as head of the household. Interviewees were heads of the household, spouses or children. Family size varies from only two people up to 15 family members. It is defined as number of people who live on the same compound. Most families also include a larger number of people, who need to be taken care of. Compounds consist mostly of two (36%) to three houses (55%) made of cow dung. People often own more than one house, because the kitchen is separated. All people in the sample are farmers. 36% have an additional job as a trader. In terms of education, adult persons report about having visited at least some of primary (55%) or secondary school (46%)[19]. Nevertheless few adults were able to read and write. None of them has an additional education. Because they are farmers, their monthly income is calculated for one year. Afterwards it was converted in an estimated monthly income. 27% have an estimated monthly income of 12 Euros to 29,90 Euros (201-500 ETB) and 27% 29,96 Euros to 59,80 Euros (501-1000 ETB).[20] This sum has to be distributed among the whole family, often consisting of a large number of people. Income is calculated without monthly expenditures for food and energy. These values are only a rough estimate due to the non-regularity of income. Furthermore, the question of income was regarded as personal question and was only answered in private. Distortions in both directions might be possible due to the fact that people either wanted to present themselves in a certain way in front of the foreign, white author or wanted to keep their real income secret[21]. Electrical goods possessed by the people include radios (55%), tapes (46%) or a mobile phone (82%). Even though there is no network in the village, people use the mobile phone outside the town to contact friends or family members (in order to find each other for example) or for work purposes. It was explained to the author that a mobile phone resembles a symbol of status and the life-style of city habitants. Therefore, people would spend a lot of money on a mobile phone, even if there is no network in their village or they are not able to use all the different functions of the mobile (for example operations like releasing free space by deleting data).

The occupation of the head of the household is attending school (18%), domestic work (18%), agricultural work (91%) or commerce (27%). The occupation of the spouse is

19 Anomalies are caused by rounding up or down.

20 1,00 ETB = 0,06 Euro; 1,00 Euro = 16,70 ETB in June 2010.

21 Habitants of the village developed something like a tax system. Every family pays according to its income in a common cash box. Expenditures are decided together.

agriculture (55%) and staying at home in order to take care of the children and doing domestic jobs (27%). Additionally, she is responsible for the energy supply.

Asked about the three most important things to improve in their households, respondents stated: light (91%), furniture (36%), increased size of dwelling / home (27%), improved toilet facilities (18%)[22].

Interviewees use the following sources of energy in their household: wood (100%), charcoal (91%), batteries (82%), kerosene (55%), gas (45%) and candles (27%). Car batteries or other fuels are not used. Charcoal is mainly used for making coffee (in a traditional coffee ceremony) and for cooking soups or boiling milk. Wood is used for lighting and cooking purposes in the kitchen. Batteries are mainly used for torches and radios. Kerosene and candles are most important for lighting purposes. Wood and charcoal are mainly collected freely. In 73% of families this is task of the spouse, in 18% of cases children are responsible for collection. Batteries, kerosene, candles and gas must be bought in the city. The average consumption of kerosene is 1 liter per week, of batteries 3.5 pieces per week and of gas 0.5 liters per week. 63% described kerosene as their major energy source. 46% named grid as their preferred type of lighting.

3.3.2. Description of data acquirement

Half of the families of the sample were introduced to the study during a special event to present the PicoPV systems for the first time. People who were interested in participating in the field study attended this meeting. The other half of the sample was composed by chance after additional PicoPV systems were delivered. The families tested each of the nine types of lamp for one week (including the weekend). Each Sunday the lamps were rotated. This day was chosen because the field test took place during harvest time. Therefore villagers did not have much time to participate in the field test, because they had to work on their fields. Only on Sunday did they have enough free time to rotate the solar systems. This event often lasted the whole morning and was often accompanied by reluctance on the part of the people, because they didn't want to change "their" system. Users were afraid to get a system from their neighbor which was broken and not completely functional. Unfortunately after a few weeks this fear was reasonable, because in some cases the people used the system to an extreme in order to learn more about the system's functionality and duration. Therefore, batteries

[22] multiple references possible (3). For alternatives see Questionnaire in the appendix.

were deeply discharged, which had an effect on the subsequent functioning of the solar lamp.

The team consisted of two solar technicians, tow translators and the author. Every contact with the users of the village was made with the help of the two solar technicians, who had already gained a lot of experience during their former installation of solar systems in rural areas all over Ethiopia. They were also responsible for maintaining the solar systems during the field test, if there were any technical problems. Additionally, there was one functional intermediary of the village necessary for making contact with the village people. Whereas the village is located in the Oromia region, and therefore the people belong to the culture of Oromia, the technicians were Amharic. Because of this the intermediary could also mediate contact between the technicians and the village, because he was able to speak both Amharic and Oromifa.

The community of the village is very patriarchal. At the beginning of the field test only men participated the distribution of solar lamps. During the process more women were integrated, because they are responsible for the housework and, energy supply and often managed the use of the lamps. Even if the people of the village showed respect and pleasure at the author's work in the village, it was very unusual for them to pay attention to the will of a woman. There were cases in which men refused to fulfill the tasks the female author asked them to do. Some of the more educated people appreciated that a woman was placed in this position, because in their opinion this provided an example of how to deal successfully with the gender discrimination. However, the first time the author was introduced, people were astonished and some even laughed at the existence of a young woman in the project.

The interviews were conducted in the houses of the participants. Sometimes it was difficult to achieve a private atmosphere during the interviews, because the house was at the same moment a local bar or restaurant and the owner had to serve the customers. Needless to say, the people were very curious about the white, young woman. Therefore, sometimes many men (as well as children and animals, whose noises sometimes made a later hearing of the recording difficult) attended the questioning. The interviews were recorded and afterwards reviewed and transcribed. In order to talk about the systems, people were shown different photographs of the lamps. Even though they were colorful and made in the environment of the village, some people had

difficulties in recognizing the different types of lamp from a photograph (they hold the pictures the wrong way around for example). Sometimes this might be due to problems with their eyes (because of their age, illness or resulting from the use of kerosene) or because they are not used to evaluating photographs. The translator varied because of different requirements during the working process (for example some of the people speak Amharic, some of them speak only Oromifa) and with regard to deadlines and an accurate design of study. Even if a lot of discrepancies exist between the different Ethiopian cultures, in the opinion of the author no apparent impact was caused by the different cultures of the team on the working process, although underlying differences naturally exists.

In addition, a questionnaire about energy consumption and demographic data was administered. Furthermore, people were instructed to fill in a sheet of a few pictograms to document their daily use of the systems.

In order to complement the data from interviews participant observations were conducted at various times of day and night.

In the end of the field study a final event was organized during which all the people of the village decided whether they wanted to buy a lamp or not. Additionally, focus groups were conducted in order to find out which lamp was preferred by the people. It was also of special interest to get to know the reasons for this decision and which features the people like most. Furthermore, the people were asked to discuss the possibility of making as many lamps as possible available for the villagers.

3.4. Applied Pico Photovoltaic Systems

The selection of PicoPV systems consists of nine different lamps, which differ in size, color, battery, panel, mobility and functions (mobile charger or only light). Most of them were tested previously in a laboratory of Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg in order to verify their quality. The field test also helped to assess qualities such as robustness and usability. For detailed results in this regard please refer to the report by GIZ or ISE (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2009b)

Pico-PV-Systeme

									
Description	Aish-warya	Solar 2007-1	Solux LED 100	Mightylight	Solux 60	Sundaya	Sun-transfer2	Fosera	Phocus
Producer	Noble Energy Solar Technologies (India)	Solar-projekt Freil-assing e.V. (DE)	Solux e.V. (DE)	Cosmos Ignite Innovations (India)	Solux e.V. (DE)	Sundaya (Singapore)	Stiftung Solar-energie (DE)	Fosera (Thailand)	Phocus Solar (DE)
Battery	Lead Acid	NiMH	NiMH	NiMH	NiMH	LiMg	Lead Acid	LiFePO	NiMH
Steps of brightness	no	no	no	3	3	3	3	no	2
Mobility	yes	yes	yes	yes	yes	no	yes	no	yes
Mobile Charger	no	No	no	yes	yes	no	yes	no*	no*
Switch	yes	yes	yes	yes	yes	no	yes extendable	no	no (sensor)
Price (in Birr)	650	1200	1600	500	650	1300	650	900	900

*normally there is a mobile charger, but in this field study there was not.

IV. RESULTS

In the following section a system of categories will be presented. The category system was developed with the help of Mayring's qualitative content analysis as described in the above section on method. Categories were developed out of the interviews. During the analysis more and more abstract main-categories were generated. Throughout this whole process literature was continuously referenced. Therefore, when they represent a fitting generic term, the abstract main-categories were derived out of literature. These dimensions of evaluation originate from Rogers and Hofstede as well as other terms used in the literature on innovations. They are supplemented by new main-categories developed out of the interviews. In the final section of the thesis a graphic of the different categories will illustrate the coherent relations.

4.1. Dimensions of Evaluation

4.1.1. Perceived relative advantage

This main category is derived from Rogers (see chapter two). It describes advantages because of the use of the PicoPV systems, which are perceived by the users of the village themselves. This term can be referred to as perceived usefulness, as named in the technology acceptance model as well. In this context the author referred to the term of Rogers instead of the technology acceptance model, because least one was developed mainly for context of jobs. It could not be replicated well outside of this context up to now (Theuerling, 2010). In the following part the different advantages, which the interviewees mentioned, are presented in fitting subcategories.

Education

89% of respondents reported that children in particular benefit in terms of their daily studies:

> P: But the BEST of the lamp is the light for the children for their education. For this reason I am SO happy! They use the lamp the most, they use the lamp at night. (Interview 11, l. 55-56)

Quantitative as well as qualitative improvements were mentioned: a) the *quantity* of studying is enhanced by the possibility of longer learning at night. Additionally, more children can study simultaneously because of the brighter light.

> P: There was a problem. Before we only had one kuras and all of the children had to use one kuras and the gas to read their books. That was very difficult, because it was not enough light for all of them. (Interview 11, l. 39-41)

b) According to respondents, the *quality of study* is improved because learning at night becomes much easier and children claim to have better results in their homework and studies.

> P: I asked my children, if there was any change since we use the lamp in comparison to the previous, when we use the kerosene. And they told me that compared to the former time, there is improvement in terms of their education. They informed me that the results of the studying are good. (Interview 16, l. 38-41)

> P: Because sometimes we might not get the kerosene from the town and my children could not study. And even for saving the kerosene itself they could not study all of their subjects. But currently with the light they can study all of it. (Interview 13, l. 79-81)

Working for school is very important for children. They are extremely concerned about doing their homework and studying for school. They want to achieve a better life than their parents. Therefore they spent a lot of their free time in the evening for doing work for school.

> I[23]: When do you start to study? - P: From one o'clock until six o'clock. – I: that long?- P: We never become tired, we even want to exceed more than that in the future. (Interview 15, l. 26-28)

Health

Improvements in health were named by 89% of interviewees. Health is therefore also a very important criterion with regard to the benefit of using solar lanterns. To begin with, participants noticed advances in *hygiene*: Firstly, there is no smoke anymore, which was previously caused by the use of kerosene lamps. Furthermore, less damage to the house occurs, as carbon no longer blackens the inside of the house.

> P: This is so good for all my family. Because before we used the kuras and there were so many problems with that. We had the smoke everywhere, there were so many problems with the eyes. All people of the village they have some problems with the eyes because of the kuras smoke. Also the smoke damaged the house. Everything got black. (Interview 11, l. 45-48)

[23] "I" = Interviewer; "P"=Participant

Because people use corrugated iron roofs whenever possible (because of status and longer life span as a result of fewer animals in the roof and more strength against heavy rain or dust), the smoke from the kerosene lamps cannot escape the house anymore, as was the case with traditional roofs made out of straw.

> P: Before I used the kuras. Before I had a hat house, it was a little bit better for the health. The smoke there went out. The air was better. But now I got some money and I have this new house with corrugated iron. The smoke didn't go out. When we used the candles and the kuras and we had many problems with our health. (Interview 4, l. 9-14)

Additionally the village butcher can perform his work outside his house. This is accompanied by less insects and blood inside the house. Because he also sells food inside his house, the quality of meals for the whole village is improved.

> P: Before, when I used the kerosene I had to kill the cows in my house because the kerosene has blown off by the wind. If I used the local light, the blowing of wind has a great influence. But nowadays, the wind doesn't have any influence on the light. This is the good side. Now I can kill the cattle outside in the garden because I can take the light with me. –I: why is that better?- P: Before I used the kerosene I used to kill the animals around here in the house compound and it was not good, because everywhere was the blood on the ground and it flows out to the neighbor. It has a bad smell and it disturbed them. And it was very dirty and the flies came to our house. And they enter the drinks and the food and it was not clean. But now I kill them outside in the garden and the drinks and food are much cleaner than before. (Interview 7, l. 36-45)

Furthermore, people complained less about *pain* in their eyes and noses caused by the penetrating smell of the smoke from the kerosene lamps.

> P: Sometimes, we didn't have any more candles, we used the kuras (kerosene lamp) and we had the problem of bad smoke. We were often ill. The smoke was in the eyes and in the nose and we had many problems with that. [...] My children and I we all have problems with the smoke. It is everywhere in our eyes and our throat. (Interview 3, l. 81-87)

The people describe that this also results in *fewer illnesses* that result from the use of traditional energy resources.

> P: Sometimes we used the kuras and the child had so much problems, many times we had to take it to the hospital. Also me and my wife, we had problems because of the smoke. (Interview 10, l. 15-17)

Most of the people in the village, especially children, had a lot of problems with their eyes as a consequence of kerosene use. Avoiding the use of kerosene can help to prevent such problems.

> P: I have a problem with my eyes. The smoke that comes from the kerosene, it makes you not see very well. And attending the program with a TV at school [this is a new curriculum in Ethiopian school, with a TV], so I become unable to see the TV well. So when I examined, they made a health examination, they told me that comes from the kerosene smoke. So I am the victimized one. (Interview 15, l. 50-54)

In addition, respondents stated that *no stress* exists anymore, which was previously caused by a fear of a lack of light at night. Moreover, they mentioned that no worries exist anymore about making well organized plans for using the available traditional energy resources in an efficient way.

> P: I was stressed before. I was not happy during this time. I had to keep the money for the batteries. I am happy to prevent this problem. I had to think the daytime how can we have enough light in the evening time. I could not indicate. So I was very stressed with that problem. But now I can prevent this problem. Now I can charge during the daytime and at night we have light. (Interview 2, l. 85-88)

> P: First, I start with the candle. Sometimes the wind blew it off. I had very much stress. When the candle was finished I had to search the kuras in my house in the darkness. I had very much stress. When something disturbed me I sometimes fall down. Then I had to prepare the kuras in the dark without seeing anything. (Interview 1, l. 17-21)

Another important aspect is the possibility of *better care at night of people with special needs*, such as people who are ill or dying and women giving birth.

> P: If there is an accident in the future, if someone is ill, there will be no problem, we can see everything. I have no fear anymore about that. I am not afraid anymore. It is like the day. (Interview 4, l. 97-99)

Using the solar lanterns also reduces the likelihood of people *using dangerous substances to make light,* for example by burning tires if they run out of candles, kerosene, batteries or matches.

> P: Sometimes we forget to buy the gas, because I am old. Sometimes I didn't think about it. And then suddenly the light went off during dinner and we can't use the kuras anymore. And then we use the car tire [they took it from other people who throw it out their garage].

> We burned the tire and with this light we eat the food. But the smell is not good. There was too much darkness, and therefore we use the tire, we ate the dinner and then we went to sleep directly. But there were problems with the health with that. (Interview 12, l. 81-87)

If there is enough light, people do not make unhealthy choices, because they can rely on solar light.

Economy

50% of households interviewed claimed to have noticed savings in terms of money: Savings of *money* result from fewer losses of energy resources and material because of fights. Additionally, no expenditures for traditional energy, such as candles, kerosene, matches or batteries are necessary.

> P: We save the money and we use the money for other purpose instead of buying the kerosene. (Interview 15, l. 83-84)

Savings in *time* were also noticed. This is achieved because there is no need to go to town in order to buy material. Additionally, people do not have to search for light in darkness.

Social Community

Within social community the following improvements were observed by 39% of the interviewees: less boredom exists, because they do not have to sit in darkness in the evening in order to save energy or because they have run out of material.

> P: When the battery is finished I don't have another one standby I have to stay in the darkness. I tried to kill the time in the dark to save the time with the light. (Interview 2, l. 79-81)

Using solar lanterns means that it is possible to meet neighbors or friends after seven o'clock, despite the dangers of the environment, such as thorns, dangerous plants and wild animals, and therefore enhances social contacts; children can also study together in groups.

> P: Those who study, but live in another house, they come to this house to study. They stay only with us until the other members of our family goes to sleep. After that they go back to their house and have to use the kerosene again. They are forced to use the kerosene. It is a limitation of time. (Interview 15, l. 47-50)

Furthermore, 44% of respondents stated that their *family life improved*: Less conflict exists because now they can use the lamp at the same time. In former times disagreements arose between family members because the kerosene light could only be used by one person at a time:

> P: In the past time, we use a single local light for all the different children and there was disagreement between them because of the inclination of the light to only one side or another. But in the current time there is no disagreement anymore, no losing of materials, no fights. So we have this advantage. (Interview 16, l. 66-69)

Parents also started sharing ideas with their children in the evening time and they have family meetings and discussions, which did not occur before.

> P: In the past time even to save the kerosene, we don't have any time to have a discussion with the children, we never have that. But in the current time, because of the light, we chat, and we can share ideas and have a discussion with the children and we have more time to stay awake with the children. (Interview 16, l.63-66)

More visits to the houses of other family members are possible now.

> P: I have a son outside in another house. When I want to visit him, I am afraid of the dark, then I take the lamp and I can go outside to the house of my son and I visit him. (Interview 12, l. 45-46)

It was also observed that some children have to live in town on their own because they could not study at home due to the circumstances in the village. As a consequence they had to move to the city, which is very unusual in this collective culture. Another fact to be taken in account is the development of *free time or even hobbies*: sewing, relaxing, discussions, as well as the future plan of exercise/sports were reported by 28% of respondents.

Security

The feeling of increased security was expressed in various ways: a) *enhanced autonomy*: 33% of the parents reported directly that their children are more independent because they can study on their own at night. Parents are not afraid of accidents (for example fire) anymore and children are able to use the lamp on their own. This frees up time for parents to do other things and even to leave the house.

> P: I give the first priority to the children. Sometimes when they need peace and silence to study I go to another house, the hat house, with the kuras. They need the time for their education. We also take our little baby, so that it can't disturb them. So my wife, the baby and I leave the house. (Interview 11, l. 50-53)

In the same way, children can go outside the house on their own (for example to go to the toilet) at night without fear.

> Also when we go to the toilet, the children are also afraid, then we use it. -I: do they use it on their own?- P:Yes, the older ones use the lamp alone, but for the little ones I use the lamp. (Interview 12, l. 47-49)

Another aspect of autonomy is the *independence from the town's energy* resources (stated by 11%). Similarly, people are independent from natural energy resources, which are steadily disappearing (especially wood for fire). This remark was made by a girl who supported the technology because of what it could mean for her future:

> P: If it has much energy, like the normal hydro energy system, we can use it. Because at the moment we use a lot of fuel and wood for baking injera and cooking different purposes. But in the future if the energy is much out of only light, we can also use it for baking injera and cooking and we can also safe our fuel and the fire wood. Collecting fire wood is very tiring and we can replace it maybe. (Interview 15, l. 77-81)

Moreover, people reported about being more *flexible*: 50% of respondents stated that they can act more spontaneously and can plan their time in a more flexible manner as a consequence of more available hours in light.

> P: I can do WHATEVER I want to do at night I can do ALL the things at ANY time. (Interview 5; several times)

> P: Because of these light I can do my jobs whenever I like, there are no restrictions of time. I can wash my clothes even during the night and working my other jobs outside, so no problem with the time. (Interview 13, l. 98-100)

Additionally, helping their parents with housework and doing schoolwork are not mutually exclusive anymore. b) 28% of households noticed *less sorrow and stress*: women are mainly responsible for the household's energy supply, meaning that they organize and calculate the acquisition of material for light as well as the consumption of it. As a consequence of sufficient light (if charged properly), women often reported that

not feeling stressed anymore with thoughts about correct calculation or not enough light is the best advantage of the solar lanterns. This results in a feeling of serenity.

> P: I feel like I live in the town. Like with the electricity. I feel like this, because I am not thinking. Because sometimes the candle was finished when I didn't expect it and I had to search everything in the evening. At this time I had the feelings of stress I think about what to do if the light finishes. Because I have children, babies. (Interview 3, l.73-76)

In the same way it relieves women of the fear of not having enough light in an emergency situation, such as when someone is ill or dying and for people with special needs like women giving birth or families with very young babies.

On the other hand, it enables more *freedom* for the whole family, because they can do whatever they want at any time (see citation above).

> P: We feel free, we don't have the darkness anymore. (Interview 9, l. 31)

Finally, security in the environment both inside (stated of 28% of interviewees) and outside the house (response of 61%) is improved: c) Inside the house children can be better cared for. The number of accidents inside the house, for example with furniture or with fire, declines.

> P: My life has changed. And when the children were crying at night I ran and I didn't see anything and fell against the furniture. I was hurt on my teeth and my lips and I had to go to the hospital and they had to sew it with a needle –three stitches. (Interview 3, l. 103-105)

Finally, there are *no more accidents*, for example fire, inside the house because of either traditional energy, such as candle or kerosene, or unsecure and uncontrollable ways of making light, such as setting a tire on fire.

> P: One of them got problems with the hair, it burns. It burns the clothes, sometimes it burns the side of the clothes. That is the experience we have. Some time I was sleeping I lay on a pillow and it burned the side of the pillow while I was sleeping, I shouted very loud! (Interview 14, l. 44-48)

d) *walking outside* the house, for example visiting people or going to toilet, during the night is also more secure. With the help of brighter light which is resistant to wind, protection against wild animals, which attack people as well as animals and plants, is much easier. Moreover, people are safe from injuries by thorns, pointed stones or dangerous plants.

> P: Before, when I had no solar lamp, I used the candle. And sometimes when the candle was finished, and also the gas I used the match sticks. Even when there was a problem with the children and they had to go outside I use one match stick after another to help them. In the evening, in the midnight, we have the problem in the village area that the hyenas are coming to attack my animals. The donkeys and dogs are crying. At the time we don't have the lamp we use the kuras and the candle. But sometimes the wind blew it off. Also, when the candle was finished. I often was hurt because of the spikes on the ground. I couldn't see them. That is the reason why the lamp is better. When the hyenas come, I take the lamp and go outside. [..] Sometimes everything was finished I went out on my own without anything. And I often get injured, my feet, the nails of the toe. Also I had an accident where I got a scar on my forehead, when I stumbled. And also when it was dark and I had to go outside, I stumbled over this step. (Interview 3, l. 29-36 and l. 85-88)

Status

This category sums up two different aspects: On the one hand, a certain ambition *to live similarly to city dwellers* was expressed.

> P: Look at the houses! Thank you so much. It looks like Adama[24], it looks like in town. And look at this: These houses are with the kuras, they are much more dark. Even the color! See the difference!" (proud statement of a village habitant, during a nightly participant observation)

In this context the wish for a switch near the bed, like the people in town commonly possess, was also frequently mentioned.

> P: I have a wish. I would like to have a switch like in the town. It is much better, I want to have it in the bedroom, it is more comfortable. (Interview 3; unasked sentence at the beginning of the interview)

This wish was due to the desire to feel like the village residents lived in town (like above). On the other hand, it also expressed a desire for more comfort.

> P: And there is a problem about the switching position. It is not comfortable. It is not easy. It is too high and you have to search the line to switch the light on. I don't feel comfortable. I once had to go to the toilet and I couldn't find the line in the dark and I had to search very long. I want to facilitate the position of the switch. I want to have a switch in my bedroom so I could switch on the light from the bed. But I am not complaining because I am comparing with my life before. Now it is so much better. (Interview 1, l. 142-147)

[24] Adama is the Oromian expression for an Ethiopian city known as Nazret or Nazareth. It has about 228.623 inhabitants.

11% of households mentioned aspects of improved status.

Work

56% of respondents stated that jobs can be done easier. A woman who owned a little shop reported for example that she made fewer mistakes during work and could work longer hours.

> P: Now they gave me the lamp I am so happy, I feel happy … for my work. My work … you know I had the problem with the cents. Before I am working in the dark I lost some money –the cents, you know? Now I have the good – this is good. I don't have enough words for the lamp it is too great. I am too happy with the lamp. - I: Why do you lost some money?- P: Because of the dark. I gave the change for the people. I had the wrong. Now I have the light I work good [..] It changed my life. Before I had the lamp, I worked less. I had to close the shop at one o'clock[25] [19 o'clock] when it is getting dark. I was afraid to make mistakes. And now I close the shop at three o'clock [21 o'clock] in the night. I can work more. (Interview 1, l. 24-32 and l. 124-129)

This was also confirmed by people who sold local drinks or dishes in their houses.

Most of the people are farmers. The solar lantern has improved *security for their animals and plants*, which are attacked regularly by animals like hyenas. Therefore, they do not suffer damages anymore.

Because preparation for work in the fields, for example the preparation of food, can be done in the evening or at night, *leaving earlier for work* is possible.

Additionally, *daily life* is affected to a great extent. Three sub-categories summarize changes: a) People are not confronted with complete *darkness* anymore, because of either a lack of material, wind outside or not owning enough money. b) 78% of households described that *domestic jobs* can be done easier, including baking injera (national dish), cooking, washing, cleaning animal dung and the compound and feeding the animals. c) The need to get to town to buy goods for energy supply or to charge mobiles is decreased, as 11% of respondents stated. People consequently save time, money and energy (getting to the city is exhausting, because of the heat, desert and the

[25] In this case one o'clock Ethiopian time is equivalent to 19 o'clock European Time. In Ethiopia exists another calendar (during the study it was 2002) and another calculation of times. Day starts with sunrise at seven o'clock European time, but they start to count from one. Therefore three o'clock means nine o'clock in the evening.

bad condition of the roads). However, compared to other categories, this does not seem to be the most important advantage of using the solar lanterns.

Sight

Visibility for all activities has certainly improved significantly, as was stated by 67% of households. This implies quality as well as quantity. People used this new quality in a very economic way. Many users fixed the lamps in the middle of their houses. Due to the fact that most of the lamps shine in different directions, nearly all rooms of the house can be illuminated. Therefore, the whole family benefits from the light at once and no individual had to wait until they can use the light for their own purpose.

To summarize, perceived relative advantage, one aspect of the main category attitude, comprises education, health, economy, social community, security, status, work and sight. These are the main categories in which users perceive important positive changes in their daily lives through the use of the PicoPV systems.

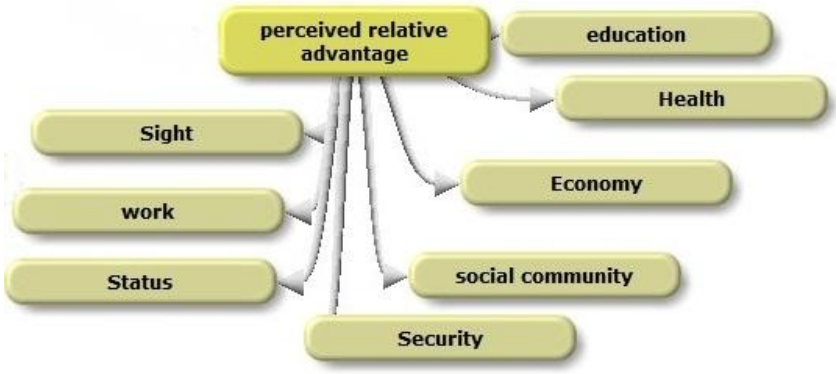

Figure 13. Overview of the category perceived relative advantage. Compiled by the author.

4.1.2. Negative Evaluation

It cannot be disputed that light has a great impact on human beings and their physical and mental health (Fisch, 2000). But negative aspects were also mentioned during the field study.

Social Community

17% of the respondents mentioned negative effects to social community. Within the village community both *jealousy* and *envy developed* because not all of the people got a PicoPV system. Even if they have not believed in the solar technology before (and

therefore did not attend the distribution meeting), they also expressed their wish for a system as soon as they observed the solar lanterns in their neighbor's houses.

> P: Other people of our village came to see the lamp. They came here and they said to us "give us the lamp, you should protect us, help us to get a lamp from the white people! Tell her! Please give us, for us, for us. Now we see the light, we want it!" [the people were angry]. We had an argue on that. They were jealous. Before I asked them to come to the introduction, but they didn't believe me, they didn't know about the solar lamp before, so they didn't come to the introduction. But now they see the light and they know about it, they want to have one, too. Now they are angry that they haven't got one. We went to another person who don't have this, and we have the luck. They want to take this lamp. They like the lamp, the people. –I: Were there any problems with the neighbor? – P: Yes, they want a lamp. They checked that this is nice. The others have the experience of me now, that I am satisfied with the lamp and I talked to some people and they want to have it, too. (Interview 4, l. 75-85)

Because of this demand, people who were lent a PicoPV system became afraid of theft. As a consequence mistrust exists amongst the village community. People take their system with them all the time and rarely leave it alone at their home for charging.

Lack of additional activities

As mentioned in the introduction the majority of Ethiopian people, especially those who are living in rural areas, are illiterate Therefore even if they have light, there are not many activities which habitants can carry out at night. 22% referred to a lack of activities:

> P: We are not educated, we are farmers. Most of the time we work outside. But during the night the children use the light to study. And I also use it for some domestic works at home. And for this reason since I am not an educated person I am not working with the light for other aspect. (Interview 13, l. 43-46)

In this statement a lack of activities as well as low self-esteem can be recognized.

> P: Because we are farmers only, we don't have that much work with the light. (Interview 15, l. 76)

Parents often only attended school for a short period. Conversely, children want to change their lives and achieve a better future and studying is of high priority.

To summarize (see figure 14), negative evaluation is the second aspect of attitude after perceived relative advantage. Users reported negative impacts in areas of social community and a lack of additional activities. Remaining aspects which influence the attitude towards PicoPV systems and thus the decision about buying one of the systems are quality and usability of lamps. They are presented in the next two sections.

Figure 14. Overview of the category negative evaluation. Compiled by the author.

4.1.3. Quality

As will be discussed in the following section, quality as a Western concept can mean something different in other cultures. Features of the solar lanterns that have been highly rated in laboratory tests in Europe (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2009b) rated poorly in Ethiopia. Criteria from the laboratory tests conducted by the GIZ and Fraunhofer ISE included: weather protection, battery capacity deviation, battery capacity loss, efficiency of charge controller, light duration and costs. For example, the winner of the laboratory test in price-performance (Aishwarya) did not rate well in Ethiopia due to its short duration of light and frequent technical problems with the battery. The positive rating of its deviation from battery capacity (deviation of 10-20% of rated capacity), efficiency of charge controller (between 80% and 90%) and good light duration (between 5 and 6 hours until luminous flux falls to 70% of the initial value) in the laboratory test differed to the experience and user evaluation in the field study. The PicoPV system, clearly favored by all people in the village (Freilassing Solar 2007-1), was valued as having a weak light output and being too expensive in the laboratory test. Furthermore, the efficiency of the charge controller was rated only as good, while the Freilassing Solar 2007-1 and Solux LED 100 were the only PicoPV systems within the field without any technical problem at all. Furthermore, users especially liked the light output of the Freilassing Solar 2007-1 and

described it as being very convenient in its brightness.[26] It seems that a large angle of radiation is favored over a high number of lumens. Even if the price was considered as being high, 21 orders out of 30 ordered the Freilassing Solar 2007-1 19.

Another test conducted by the World Bank's Lighting Africa (Lighting Africa, 2010b) only took into consideration two PicoPV systems tested in the present field study: Sun Transfer2 and Solux LED-50. Sun Transfer2 was placed second in the top performers category. Compared to the other systems in the field study it was not completely without technical problems, but nevertheless performed well. The following sections outline features that are important for inhabitants of the Ethiopian village.

The *Cone of light* is an important attribute, because users hang the lamp in the middle of their houses in order to use the light both inside the whole house as well as outside for several members of the family at the same time. 67% of households named the angle of radiation as an important criterion of quality.

> P: Now it is better with this lamp, because it is so bright. I open the door and the light shines outside. I can go outside on the street without taking the lamp with me. To go inside and outside the house. If I wanted to change the room, I had to take the kuras with me because there was so less light. The room then was dark for the others. Now I leave the lamp in this area. And now the light is bright enough for the whole house, for every room. I put it in the middle, and it shows in every direction because of its brightness. It shows in every room. (Interview 4, l. 65-72)

In order to use electricity in the efficient way mentioned above, a large angle of radiation is necessary:

> P: The solar lamp gives more light in three directions, the torch only gives light in one direction and when I keep it here, it only shined in this direction. This is the reason why I decide to use the solar lamp. Before I should have three torches to cover all rooms. (Interview 2, l. 23-26)

> P: Also outside the light is very good, even if the lamp is inside, there is a little bit light outside. –I: how is this useful for you?- P: before we sleep, the door is not closed, when we want to go to the toilet, we can get out without taking the lamp with us. We can see outside, too. (Interview 11, l. 75-78)

[26] Mightylight was too bright for example and temporarily blinded people, while the Phocus was described as being too dark.

Easy Handling is required because the lamps are used for multiple purposed both inside and outside the house. The lamp should therefore be easy to take outside, for example by a handle bar, and should also be easy to hang inside. 11% of respondents cited handiness as an important feature.

The *Brightness* of the lamp is also an important factor, as confirmed by 94% of interviewees, in order to use the lamp for reading, for persons with special needs and additionally to use the lantern at the same time as other family members. Brightness was measured by the people by testing how much of their compound was illuminated by the lamp:

> P: This one can give enough light even for the whole compound. The green German, the brightness. [Explanation of translator: this is the local way of measuring, they relate to example, and in this case to the compound]. (Interview 16, l. 50-52)

Even though the lamp should be very bright, people appreciate if they do not *glare*. 28% of respondents paid attention to this feature.

> P: It has a glare for the eye, it is difficult to see. It makes the room very bright. So unless it is controlled, it is very bright, it harms the eyes. We put clothes on top of the lamp to make it more dark. (Interview 6, l. 19-21)

Children in particular, who are not used to electric, bright lights were often dazzled by the bright light from the solar lanterns.

> P: The light is a little bit strong for the eyes. It is a little bit difficult for the children. Because their eyes are damaged with the kuras[27] and now it is too much light for them. The light is very white and shiny and they have an eyes problem. […] Maybe they have no experience with the light, they look in the lamp and their eyes were a little bit confused. There was pain in the eyes. (Interview 4, l. 47-50 and l. 52-53)

In regard to the attributes of the light itself, white, bright light was favored by 44% of respondents[28] in comparison to the yellow, warm light preferred by most people in northern countries (Solar Energy Foundation, 2010). No one cited yellow as their favorite *color*.

[27] Kuras is an Amharic expression for kerosene lamp.

[28] Missing people do not give a statement about the color of light. It seems to play no role for them.

> *P:* These three have the white color, we love the white one, the bright one. But there is one with yellow light with the red lamp, we don't appreciate this yellow light. (Interview 17, l. 72-74)

Respondents associated the color of the light with sunshine:

> P: The light is so bright, I like the white very much, I feel like I am in the sunshine even if it's night, like the good sunshine. This light is amazing. I appreciate. (Interview 3, l. 56-57)

67% of respondents stated, that the *duration of light* is a very important aspect of quality. When asked directly, they confirmed that the lamp should shine as long as possible. According to their statements a satisfying duration was two days (which means an estimated duration of eight hours):

> I:- And how many hours should the lamp lasts? When would you say that it is a good lamp? - P: A good lamp should last for two days. If it is good charged. (Focus group 2, l. 44-45)

Participant observation during the weekly rotation of lamps showed, however, that people are also satisfied with a lamp if the light is sufficient for one evening. That is to say about 4-5 hours.

People expressed the wish for a long duration due to the fear of a lack of sunlight for charging during the rainy season:

> P: The power of the light from the sun is not equal as compared to the cloud time, to the rainy time. The power of the light is not the same and it may turn off because of the charging, the green Germany. And this is just a fear for the future. Because of the clouds I am afraid that we can't charge it enough and it may turn off. But this we don't have experienced up to now, it is just a fear. (Interview 18, l. 66-70)

17% of respondents described the *robustness* of the solar lamp as another factor of quality and stated that a lamp's material should not break easily. Parents can then allow their children to use the lamp without fear of broken lamps.

> P: And my children also told me, that this is very strong. And my children can use it in an easy way. And it even didn't break in the hands of children, that means everyone can use it, it is strong. […] This one is strong in terms of the material [Suntransfer], the quality of the material , the Green Germany is also strong. Fosera is not like them. I appreciate that the material of the Suntransfer and Green Germany is very comfortable even for the children. The strength. And it is very tight [Suntransfer], and VERY tight and even the children can use it. So the strength is different. This is very simple and very strong [Suntransfer], so the

> children can even use it. It never breaks up. But for this one not [Fosera], it is challenging somehow. It never breaks up, the Green Germany. (Interview 16, l. 16-18 and l. 44-50)

Participants were also afraid that the pull-switch could break and 50% of respondents[29] preferred a built-in-switch. With a built-in-switch users only have to press the button. This helps to gain more trust in the technique and the life-cycle of products.

> P: There were some problems with the line. I must take care, otherwise it will be broken. Without taking care it will break. They gave me the advice to take care. I feel responsible for the lamp. I only use it one time to switch on the light. After I pull it, I don't use it. I am afraid to break it. [Her lamp is turned on. The woman wants us to turn it off again. She refuses to do it herself, because she is afraid]. But it never broke until now. When I go to bed, I switch it off, but then I don't use it anymore, because I am afraid that it will break. When I have to get up at night to go to the toilet, I don't use the lamp again, because I am afraid. (Interview 1, l. 132-140)

Another advantage of the built-in-switch is that users do not have to search for the line of a pull-switch in darkness, as already cited in the section on status (Interview 1). Users hang the lamp above their heads in bed or put them next to the bed. In this context 28% of respondents expressed the wish for a switch next to their bed without being asked.

If the lamp or a switch is next to the bed, it is very easy to find the lamp and its built-in-switch. This is very helpful in terms of being able to swiftly protect the family and animals at night or while taking care of babies. This aspect of the switch is clearly linked as well to the robustness for children's' use, as mentioned above.

> P: But with these two, the Green Germany, Solux, there is no need of pulling, only to press the switch. And the way of operating the system is better. –I: The children are allowed to use it?- P: Yes, even the children are allowed to use the lamps. I appreciate these two [Green Germany and Sundaya], but what I am afraid of is, if I stay outside sometimes, and they pull it forcefully [Sundaya], it may break. (Interview 18, l.88-92)

Finally, participant observation, as well as conversations with local people showed that great skepticism exists about products from Asia. In Ethiopia a lot of bad quality products from China are on the market. Hence, a great mistrust in many manufactured goods has developed. Therefore, people would never buy such products if they knew

[29] This does not mean that 50% also favor a pull-switch. The other half of the sample did not mention any fears or preferences with regard to the switch. It did not seem to be important for them.

that they were produced in China. Users had already developed awareness about products of high quality and were willing to pay higher prices for such products. This observation was confirmed during the sales event. Due to the newness of PicoPV systems, users are not yet aware of special *brands.*[30] Until then, they trust in brands from "reliable countries".

Within focus groups participants put the main emphasis on duration of light (long lasting even during cloudy periods), brightness and robustness. In terms of price-performance ratio different lamps were chosen than in terms of quality

To summarize (see figure 15), the third aspect of attitude is quality. This category is influenced by the following aspects: cone of light, handiness, brightness, color of light, branch, duration of light, glare and robustness. The last factor constituting attitude is usability, which is described in the following section.

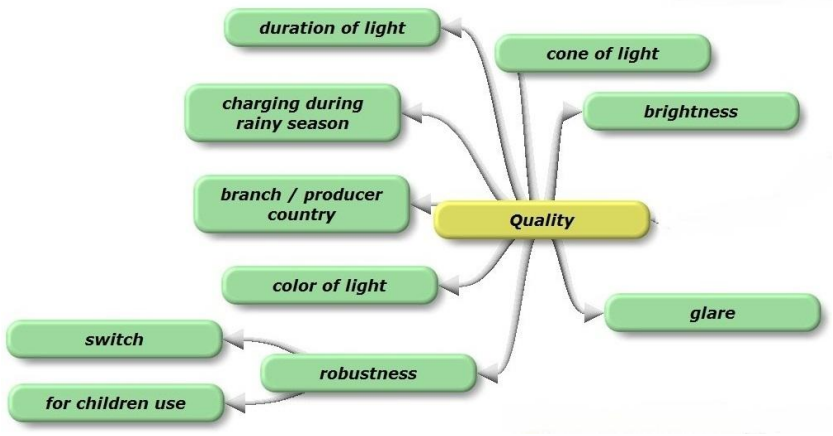

Figure 15. Overview of category of quality. Compiled by the author.

4.1.4. Usability

Regulator

28% of households interviewed appreciated if the lamp had a *regulator* to change the intensity of illumination. As a consequence people can use the light at the level of brightness they need for their activity. It is therefore also possible to save energy.

[30] Concerning mobile phones, which is a very successful innovation in Ethiopia (even in rural areas), all people favor a special brand. One can hardly find people, who posses mobile phones of other brands.

> P: These also don't have minimize and maximize, maybe this is the problem, we don't know. –I: What is good about the different steps of light?- P: When you minimize and maximize we can use it the way we need and to the extent to read the paper for example and we can save even the light. That is why we need it. (Interview 15, l. 65-69)

Ease of operation - carefree use for children

On the other hand, interviewees stated carefree use for children as another crucial factor. This implies safety as well as ease of operation. As can be seen in the following quotation, safety was seen to be very important:

> P: I always was afraid, I have children. When they were playing, sometimes the lamp fell off and there were fire. Therefore I was afraid that there could happen something to my children with the kerosene, but now not anymore. I am not thinking anymore. I am not stressed anymore and that is the reason why I like the lamp. I am happy. It improved my stress. (Interview 4, l. 23-27)

Apart from safety, *ease of operation* should not be set aside. 22% of households stated that the system should also be easy for children to use the system.

> I: Are the children allowed to use it on their own?- P: Yes, they can carry it around. I passed to grade nine, we are educated. We got the experiences, so we all can manage it, even the little one. All of them including the little child. (Interview 15, l. 34-37)

This implies that the application should be self-explanatory. In addition, if the system is not used for a period of time, how it works should be memorable. Although at the beginning of the trial how the lamps worked was introduced, a few additional questions emerged about correct use in general and behavior during rainy season or cloudy periods.

As already cited above, parents even left their children alone (to study or to go to the toilet) with the solar lamp. But parents only left their children alone with the systems that they evaluated as robust and easy to use. Systems with a line to switch the system on and off were not left with children without hesitation. To summarize, this symbolizes parent's need for a solar lamp that is easy to use, is robust in nature and that can be safely used.

Possibility of fixing

22% of Interviewees stated that the *possibility of fixing* the lamp as well as the panel is important for easier use:

> P: I put this one on the roof of my house. I put a line into the whole of the panel and I fixed it on a wood. This wood I put on the roof of my house. That is the way of charging, I do it like this. I like this very much about this lamp. I always put the panel on the roof. By fixing the panel on the wood.. Sometimes on the wall and sometimes on the roof. Then I always change the position of it, so the charging may be addicted to the way, so the light might stay longer. (Interview 17, l. 34-39)

In addition, having an easy way to hang up the lamp makes using the light more efficient. It enabled people to hang the lamp on a nail in between their rooms in order to use them simultaneously in the whole house and sometimes even in the compound.

Portability

In order to fulfill the various demands of the different family members inside and outside the house, 44% of interviewees expressed their wish for a *portable system*. Most of the families in the village built two or three little houses made out of dung. Traditionally, the kitchen is not integrated into the rest of the house. It is outsourced in this way even in the city. Furthermore, animals sometimes sleep in the same house in order to protect them from wild animals or thieves. During the rainy season it is not possible to hear enemies due to heavy rain that beats on the roof. Thus it is important to be able to carry the light to different places.

> P: Since it is portable to have it here and there, they can use it here and there in different areas. It is very simple, we can use it even in the kitchen or some other areas in the compound. The portability it has, makes us love it. (Interview 17)

Handiness

Strongly linked with the portability of the PicoPV system is *handiness*. In order to protect their animals and plants, farmers are often forced to hunt wild animals at night. It is therefore essential that the system is easy to hold. In this way men are able to carry the light in one hand and a weapon, like a spear, in the other. Thus they can catch the animal, protect their goods and earn some money at the market. 17% of households mentioned this aspect.

> P: Interruption during the interview: A man express his urgent wish to lent the smallest lamp for another week, in order to hunt a porcupine, which attacks his tomatoes and potatoes at his field. He wants to sell it at the market. (Interview 9, l. 83-85)

Fault tolerance

Another aspect of usability is *fault tolerance*. This was not mentioned in the interviews directly, but was observed during the field study when different technical problems occurred. Most problems were connected with discharged batteries, because charge controllers and low-voltage disconnect outputs did not work properly. A few systems could not be recharged again with sunlight and had to be charged manually. Aside from incorrect use, people tested the duration of light to a maximum limit to gain trust in technology. Systems with little fault tolerance were evaluated poorly and people complained about the low duration of light.

> P: These three we can charge one day and then we can use it even for the next day without charging, that is something we like about it. And we try this one. We charge this one for the first day and I try to check the lamp.. and for the first day even from one o'clock [seven o'clock p.m.] in the night up to ten o'clock [04 o'clock a.m.] in the night. I tried all this and this is very interesting. So I wanted to check the duration and it serves from one up to ten o'clock even. (Interview 17, l. 24-29)

Mobile Charger

The addition of a mobile charger was described as a useful feature.

> P: I don't have any complain. For me it's so good. But I like to have a mobile charger. I haven't one, that is my only complain. (Interview 3, l. 39-40)

On the other hand not all of the participants possess a mobile. Additionally, only 22% of interviewees asked for a mobile charger or described it as an important feature. The most crucial factor is light.

> P: From darkness to brightness. It's all about the light. (Interview 6, l. 58)

> P: Before I had a light with mobile recharger, but important for me is only the lighting. That is the best! (Interview 11, l. 67-68)

Without being asked for it, 22% of respondents expressed their wish for other additional features, like a radio.

In summary (see figure 16), attitudes towards the PicoPV systems can be seen to be constituted of perceived relative advantage, negative evaluation, quality and usability. The latter is made up of the wish for a regulator, ease of operation, possibility of fixing, portability, handiness, fault tolerance and a mobile charger.

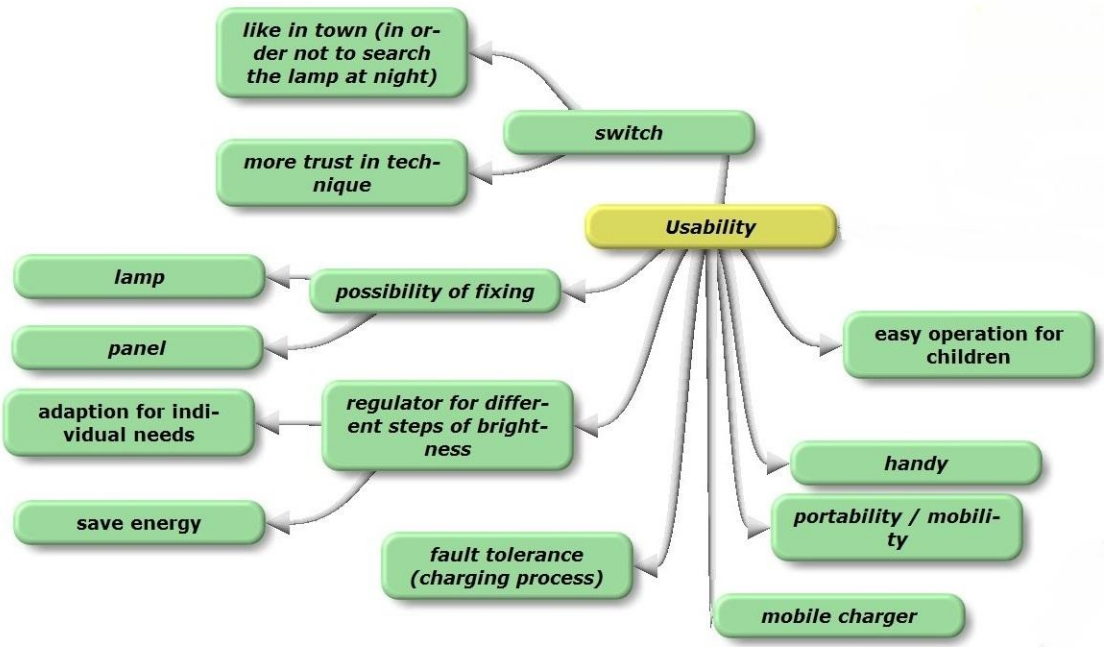

Figure 16. Overview of category of usability. Compiled by the author.

Derived from participant observations and statements of users as well as theoretical investigations of successful innovations (Rogers, Kaplan) the following aspects of experience, familiarity, observability, trust and cultural values also seem to enhance acceptance.

4.1.5. Experience

Gaining experience and getting used to new technology is an important factor in deciding whether to use it. Previously, inhabitants of the village hardly had any experience with modern energy, except for a small amount of experience in the city. As described in the above section on theory, Rogers (2003) claims that within the acceptance process gathering information is essential. This takes place in the first step of "knowledge". Kaplan (1999) emphasizes the importance of experience. He states experience as a separate variable. Due to the fact that knowledge about solar technology is not very widespread in Ethiopia, people previously had no access to information. Some of them even regarded attending the distribution meeting as not worthwhile.

Thus, testing the new technology plays an important role in gaining trust in this new way of generating energy and is up to now the best way to gather information.

Familiarity

One aspect of experience is familiarity. As already described in the section on theory, Kaplan refers to the concept of familiarity as "the cognitive state resulting from experience: a degree of close acquaintance. To be familiar suggests a level of comfort, a closer association with something than would arise from technical, objective knowledge alone (e.g. Whittlesea, 1993). It requires both exposure to, and experience with, the object" (Kaplan, 1999, p. 472). Hence, users do not have to think a lot about the functioning process during usage. It can be compared with using a computer with instinctive assurance without knowing its underlying functioning. Similarly, participants described the way of using the lamp as easy, as they did not have to think much about it.

> P: No, it was very easy. My husband asked for instruction and they came to explain and afterwards it was very easy to use it. There were no problems. Also we have children, they have education, they know how to use it. (Interview 12, l. 90-92)

Observability

As highlighted above, Roger defines observability as "the degree to which the results of an innovation are visible to others" (2003, p. 16).

The PicoPV systems can easily be observed in the darkness. It is even possible to recognize the difference between traditional methods of lighting and PicoPV systems from a few hundred meters away from the house. Additionally, participants show a keen interest to compare their lamps with that of their neighbors.

> P: And I have seen this one with my neighbor, I have seen ALL the lamps from my neighbors. (Interview 16, l. 12-13)

Furthermore, interest in PicoPV systems increased immensely as soon as other people in the village saw their neighbors' lamps.

Trust

As described in the theory of arousal by Raju (1980), assumed components of novelty and conflict exist. If both components are extremely high, a product might not be

accepted. In this context the novelty and surprise component was very high, as described by these participants:

> P: When we had only the candle the children always blew it off [shows how]. And now with the solar lamp they didn't know how to switch off and they tried to blow the solar lamp off. They do not switch it off. They were running around and laughing. For this reason they are happy, they are learning. They didn't sleep the first night when we got the lamp. [...] Before I had not the experience I didn't know the experience. I feel like a blind person in the darkness, who has grown up his whole life like this and who suddenly can see for the first time. I feel like I am changed completely. (Interview 3, l. 64-80)

> P: Thanks to God, before I used the kuras. I thank to God he sent us an angel to give us this. I didn't expect such a thing, I was surprised. I never knew about such a lamp. I expect the future – maybe there is something good that is similar to that. (Interview 4, l. 54-56)

Due to the fact that the lamp was perceived as very new, users first had to gain trust to minimize the component of conflict. This includes an aspect of trust in solar technology as well as trust in its maintenance.

In order to gain trust, users tested the lamps and tried out different ways of using them.

> P: We charge this one for the first day and I try to check the lamp.. and for the first day even from one o'clock [seven o'clock p.m.] in the night up to ten o'clock [four o'clock a.m.] in the night. I tried all this and this is very interesting. So I wanted to check the duration and it serves from one up to ten o'clock even. (Interview 17, l. 25-29)

> P: I change the lamp system about five times now. I tried to use the lamp outside, the lamp and the lighting outside is good. [...] At the beginning I wanted to see how much light it gives. So for this reason I tried the light outside and walk. (Interview 11, l. 51-55)

As users experienced, both service and maintenance of the system are necessary. Every now and again the lanterns needed to be repaired. Problems like discharged batteries or broken switches occurred. This is an important aspect because the users had no experience with this kind of technology and did not know how to maintain it.

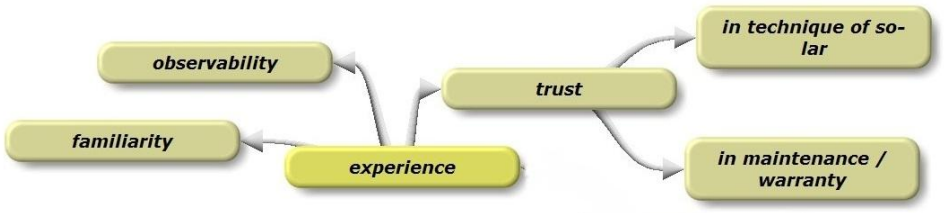

Figure 17. Overview of the category of experience. Compiled by the author.

Social Influence / Cultural values

Social impacts, which influence the decision to adopt or reject an innovation, are described later on in the section on the subjective norm.

4.2. Integration into Theory

In the following section developed main categories of perceived relative advantages, negative evaluation, quality, usability, experience, social influence and cultural values are integrated into a theoretic model. This is the last step of analysis proceeding qualitative content analysis according to Mayring. As described in the results chapter, induction and deduction were alternated during the process of analysis. Important in-vivo codes were extracted and compared with abstract terms from literature. In this section extracted categories and evaluation dimensions are integrated in the *Theory of Planned Behavior* according to Ajzen (1991). Main components in this model are attitude, perceived behavioral control and the subjective norm. This model involves not only individual attitudes, but also inter-subjective and physical contexts. These factors are perceived subjectively and evaluated as well. These evaluations in turn influence human behavior. But inter-subjective and physical contexts can also influence behavior in a direct way, without the individual's evaluation (Kaufmann-Hayoz, Bruppacher, Harms, & Thiemann, 2010). Hence, this model takes various systems into consideration. A framework is therefore considered, rather than regarding only one phenomenon in isolation. This approach was chosen in order to integrate results in a holistic way and to be consistent with the transactional worldview.

Figure 18 in the end of this section depicts developed categories integrated in the *Theory of Planned Behavior.*

4.2.1. Attitude

In the author's opinion the following extracted categories have an influence on the user's attitude:

- *Perceived advantages*, such as improvement in education, health, economy, social community, security, status, work and sight and their individual importance form the attitude towards the PicoPV systems. At this point it is important to know what kind of changes users expect in their daily lives as a consequence of using the lamps. In order to find out if people adopt the solar lanterns, it is also important to ask what kind of value they attach to these changes. Therefore, this category makes an important contribution to the component of attitude.
- *Negative evaluation* is the counterpart to relative advantages, which create in sum the positive or negative attitude towards the PicoPV systems.
- Apart from positive and negative aspects of the usage of PicoPV systems, characteristics of the lamps itself also contribute to the attitude: *Quality* plays a role in forming the user's view of the solar lanterns. In this context it is important to discover what kind of features indicate quality according to participants.
- Another feature of the solar lantern which contributes to the user's attitude is its *usability*. Again it is important to find out which features make using the lamp easier.

4.2.2. Perceived Behavioral Control

This component is described by Ajzen (1992) as the perceived ease or difficulty of performing a behavior. It implies confidence in one's own ability as well as external factors.

- As cited in various models of innovation diffusion (see the chapter about innovations literature), *experience* also plays a role in this context. Subcategories, as described in the section on results, are familiarity, observability and trust.
- Although it was not mentioned in the results section, *finance* is also relevant. It clearly significantly influences the component of perceived behavioral control as

a consequence on intention towards a behavior. As people have to calculate their savings for one year, being solvent is crucial. Income is measured per year and per family.

- The *user's behavior* also plays an important role. Due to the fact that people had only had a few experiences with electricity before, using a solar system was very new to them. They therefore tested the lamps intensively. As mentioned previously, some mishandlings occurred during the pilot phase, including wrongly or insufficiently charging the batteries. This affected how the quality of the lamps was evaluated, as well as impacting how confident individuals felt about using the lamp.

As Ajzen states, "the more resources and opportunities individuals think they possess, the greater should be their perceived behavioral control over the behavior." (Madden, Scholder Ellen, & Ajzen, 1992, p. 4). The categories mentioned above are hence crucial in order to increase user's perceived resources and opportunities.

4.2.3. Subjective norm

According to Ajzen (1991, p. 195) subjective norms contain normative beliefs, which "are concerned with the likelihood that important referent individuals or groups approve or disapprove of performing a given behavior". Rogers also emphasizes the importance of attributes of the social system. He describes the rate of innovation adoption as being dependent on five variables: perceived attributes of innovation, the type of innovation-decision, the communication channel, the nature of the social system and the extent of the change agent's promotion effects (Rogers, 2003, pp. 221-266). Since criteria of compatibility (as one of the attributes of innovations), the type of innovation-decision (for example optional, collective or authoritative) and the nature of the social system (norms, interconnection of network structure) represent qualities of culture, it is important to examine these variables in the context of the field study in Ethiopia. Because this study was conducted in a completely different culture, an approach of an overview should be given to understand aspects of Ethiopian culture, especially because acceptance of inter-cultural contexts is confronted with special challenges:

> "Transfer of technology is always implicitly also transfer of culture. Worldwide attempts at development aid in the second half of the 20th century were often

> unsuccessful, and cultural processes on the sides of both donors and recipients played a major role in these failures" (Hofstede, 2001, p. 423).

Therefore, it is worth taking a closer look at social acceptance in the context of cultural processes.

The author is aware that she is not able to disregard her Western perspective and background. It is important, however, to try to understand which cultural issues have an influence on the user's decision about acceptance. In order to understand which normative beliefs are important in this process, *existing* normative beliefs and theories of culture must first be discussed.

The process of attempting to come to a cultural understanding supports the view of transactional approaches, which state that culture is both a precondition and consequence of human actions (Eckensberger, 2008). Hence, exploring the Ethiopian culture fulfills the requirement of the transactional view of also focusing on people, psychological processes and the physical environment. Using another source of data and perspective (participant observations and Hofstede's theory) the following further answers the demands of the transactional approach.

In this context the investigations of Hofstede, as one of the most influential and quoted researches in intercultural exploration, should be referred to (Boersch & Elschen, 2007). He carried out intercultural investigations in over 50 countries. He then presented his theory on cultures and their description on the basis of five dimensions. In the following section his theory, integrated with experiences and observations from the field study in Ethiopia, is described.

Hofstede (2001) holds the view that individuals are predictable and do not act or think independent from their environment. In order to understand his definition of "culture", his conception of man first has to be comprehended: In his opinion individuals are determined by so called "mental programming," which exists at the universal, collective and individual levels[31]. The *universal* level is shared by almost all human kind, and includes expressions, such as weeping, laughing and aggressive behaviors. This level is mainly inherited. Contrary to this, the *collective* level is only shared by people

[31] This perspective might be comparable to the Ecological Systems Theory according to Bronfenbrenner (1979). It considers as well the whole contexts of individuals.

belonging to a certain group. It includes the language spoken by the individual, behavior towards elderly people and perception of human activities in general and matching ceremonials (eating, etc.). Hofstede suggests that this is learned by culture. The *individual* level describes human's individual personality. Main characteristics are inherited as well, such as temperament.

In order to be able to discuss different aspects of culture, firstly "culture" has to be defined: "it is the collective programming of the mind that distinguishes the members of one group or category of people from another" (Hofstede, 2001, p. 9). He also gives another definition, which fits more in context of the theory of planned behavior: "Culture could be defined as the interactive aggregation of common characteristics that influence a human group's response to its environment. Culture determines the uniqueness of a human group in the same way personality determines the uniqueness of an individual." (Hofstede, 2001, p. 10) The first definition corresponds to the well-known definition of Kluckhohn (1951, cited in: Hofstede, 2001). He also refers to values as the most important factor of culture, which Hofstede picks up in his model of an onion: The different layers are symbols, heroes and rituals, with values as the core. *Symbols* are referred to by Hofstede as words, gestures, pictures. High fluctuation exists in terms of symbols and they are often copied by other groups. Therefore, they appear on the outside of the onion. *Heroes* are models within a culture. They can be dead or alive, real or figurative, the main thing is that they are prized. *Rituals* are described by Hofstede as collective activities, which are perceived socially as very important in order to feel connected with culture. They do not necessarily have a clear objective; a way of greeting is one example. Symbols, heroes and rituals are summarized in the terms of the practices which make them visible. Additionally, it is possible to interpret their underlying meaning. With regard to other authors' definitions (Kluckhohn; Rokeach), Hofstede defines values as "a broad tendency to prefer certain states of affairs over others" (2001, p. 5). He claims that they are dimensional and always have a positive and negative pole, concerning such terms as dangerous vs. safe or moral vs. immoral. They are often irrational, due to the fact that they are programmed early in development.

In the following section five cultural dimensions are described, all of which Hofstede indentified empirically. They symbolize national culture differences. On the basis of empirical studies Hofstede calculated indexes for each dimension and the 50 countries and three regions were then ranked. Ethiopia is classified as a part of the East African

region. Other countries included in this region are Kenya, Tanzania and Zambia. According to Hofstede (2001, p. 438), gaps exist in the different dimensions of culture between developing and industrialized countries. These gaps interfere with mutual understanding and can lead to the failure of development cooperation programs. It is therefore valuable to understand and explore these gaps. In the following section results from Hofstede's investigations in East Africa for each dimension are compared with participant observations made during the field study. Participant observations were noted down after every visit and analyzed with reference to Hofstede's dimensions at the conclusion of the field study.

1. Power distance

This category describes human inequality, concerning for example prestige, wealth and power. Inequality exists in every country and it is important to understand the way individuals within a specific culture react to it. Countries with a low power distance index regard inequality as a "necessary evil" (Hofstede, 2001, p. 97), which should be reduced to a minimum. On the contrary, in countries with high power index inequality is perceived as the basis of societal order. Power needs less legitimation. Hofstede's investigations placed East Africa at rank number 21 out of 53 with 64 points out of a range from 11-104. The mean score was 57 points. As a comparative value, the rank of author's cultural background (Germany) will also be quoted. In terms of power distance, Germany was ranked 44 with 35 points.

The following statements symbolize a high power distance index and can be confirmed by participant observations. It is not possible to present all results and implications of the study at this point. The following results, however, give an indication of the broader results and provide information that will lead to a greater understanding and clarification of the issue. The remaining statements for a low power distance index that will not be discussed here can be read up on in Hofstede (2001, pp. 79-137).

Statements of high Power Distance Index	Situation in Ethiopia
"Middle age starts before 40"	As life expectancy is only about 55 years, middle age starts earlier.
"older people are respected and feared"	In analysis section already referred to a high respect of elders. It is regarded disrespectful to explain sth. to them.
"power holders are entitled to	This aspect is applied to a lot of different

privileges"	privileges, such as using the university car for personal use.
"the way to change a social system is by dethroning those in power"	Historical events have proven this statement: rebellion to end power of Haile Selassie, suppression of opposition 2005 and since then. Opposition cannot work properly and would have to dethrone recent government if they wanted do participate in governmental decisions. Kapuscinsky (1995, p. 160) reports of an interview, in which an Amharic person refers to an Amharic philosophy with long history: If a human hungers his whole life, he will never rebel against government.[32] Hence, people perceive that they are weakened by the government. This implies that decisions, such as elections, are accomplished violently (if necessary) rather than democratically.
"Parents teach children obedience"	Most of the children were very shy during the interviews. It was explained to the author by the translator and students that they are seldom asked for their opinion. They are not generally allowed to speak and therefore are not treated as equal.
"Children should work hard even if this is a burden"	Walking through Ethiopian the landscape, hard working children can be seen everywhere: Girls collect fire wood or get water, boys look after herds of cattle.
"Respect for parents and older relatives is a basic virtue and lasts throughout life"	Daughters and sons take care of their parents. They even terminate their education to have more time for them if it is necessary.
"Children a source of old-age security, especially to fathers"	Due to the fact that people are farmers, children are a source of security even before parents become older and after children have taken control of their own lives.

[32] „Wie soll man dieser gefährlichen Bestie Herr werden, die der Mensch nun einmal ist, oder die in uns allen steckt, wie soll man sie zähmen und niederringen? Wie sie entwaffnen und unschädlich machen? Dafür gibt es einen einzigen Weg mein Freund: den Menschen zu schwächen. Richtig, in dem man ihm seine Kraft nimmt, denn ohne seine Kraft vermag er nichts Böses anzurichten. Der Hunger aber schwächt und raubt die Kräfte. So ist unsere amharische Philosophie, das haben wir von unseren Vätern gelernt. Die Erfahrung beweist die Gültigkeit dieser Lehre. Wenn ein Mensch sein Leben lang hungert, wird er nie rebellieren (Kapuscinsky, 1995, p. 160)."

2. Uncertainty Avoidance

This index describes the dimension of stress within a society with regard to an uncertain future. If it increases to an extreme, it causes high anxiety. Cultures develop different ways to manage it. For example, it can evoke a need for foresight, which can be reached through technology, rules and rituals. Hofstede describes one phenomenon which may be familiar to individuals raised in Western societies, but was not that distinctive in Ethiopia: "Higher anxiety leads to higher stress and a more hurried social life, but also to higher energy release, which means an inner urge to be busy." (Hofstede, 2001, p. 159). In this category East Africa was ranked 36 with 52 points out of a range from 8 to 112. The mean score was 65. Germany was ranked 29 with 65 points.

Statements of low Uncertainty Avoidance Index	Situation in Ethiopia
" Lower work stress"	Most people are unemployed. If they have a job, an endeavor to do everything correct can be observed, but less pressure is put on employees.
"Less hesitation to change employers"	High fluctuation exists.
"The uncertainty inherent in life is relatively easily accepted and each day is taken as it comes"	Limited plans or other methods of time management are made. And if done so, it is no problem to change everything within short period of time. Furthermore, visits from friends, relatives or even acquaintance need not be announced before arrival. Meetings are not arranged, but occur spontaneously. It is even not necessary to ask if the host has any time at all. Thus, a great willingness to accept each day as it comes can be observed.
"Most people can be trusted"	This statement is contrary to experience in and literature about Ethiopia: an Ethiopian interviewee of Kapuscinski states that it is really difficult for an Ethiopian to confide something to somebody (Kapuscinsky, 1995, p. 26). This description matches with the observations of the author. Relatively great mistrust and begrudging exist amongst people. Even if Hofstede's statement itself is probably true, peoples' perceptions seem to be different.

Regarding uncertainty on a more detailed level, during the field study with the PicoPV systems, varying experiences were observed in Ethiopia: although problems with lamps

occurred or people expressed their wish for another lamp, for example with a mobile charger or a brighter light, most of them did not want to change their lamp for another one. They were also afraid to get a broken system from their neighbor. Apparently, the threat of losing the lamp was greater than the possible additional gain. Hence, uncertainty in the context of lighting is strongly avoided by users. But this phenomenon might be explained as well by the prospect theory of Tversky and Kahnemann (1979), which states that loss always weigh more than gain.

Another aspect is that users tested the lanterns to an extreme in order to be sure about their functions and quality. This shows that, although people do not have such a great need for uncertainty avoidance in general, when it comes to their own investments and survival they have to avoid extreme uncertainty. Even small wrong decisions can be life-threatening for the whole family. As analysis of other investigations also shows that a "high risk aversion due to small financial buffer" (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b, p. 21) exists.

3. Individualism and Collectivism

This category describes the relationship between individualism and collectivism in a society and its influence on people's values. In collective societies the interest of groups (for example family) clearly supersedes an individual's interests. In collective societies the norm of treating everybody alike (universalism) cannot be found. Favoring friends or relatives is regarded as morally correct (particularism). Therefore, trust is an important factor in a lot of areas, which is not expected in the same way in individualistic societies. Correlations show that individualism is more likely in wealthy societies. East Africa was ranked 35 with 27 points with a mean of 43 (range: 22-91) on the individualism index. Whereas East Africa remained relatively near the mean in the first two categories, in this case it can be classified clearly as collective society. As a comparison, Germany ranked 15 with 67 points.

Statements of Collectivism Index	Situation in Ethiopia
"Horizontal integration: People live with or close to relatives or clan members"	People live with their family for as long as possible. Moving to another city to study at university is a big challenge for students.
"Treating friends better than others is normal and ethical: particularism"	This phenomenon can especially be found in the allocation of jobs; nepotism.
"Family provides protection in	Families always take care of all relatives.

exchange for lifelong loyalty."	Everyone who is employed gives part of his earnings to other family members. This behavior is expected.
"Strong family ties, frequent contacts"	Students are not independent even if they live in another city. Several calls during the week are common, as are as frequent visits.
"Fewer divorces"	Divorce is something to be ashamed of, as a man during his interview admits.
"A marriage without children is incomplete"	As children are a source of age-security, only few families are without children. In the village where the study took place, all families had children.
"Nobody is ever alone"	The Ethiopian people found it very unusual that the author travelled alone to their country. If they are alone at home for example, various relatives and friends will always come immediately for a visit.
"Opinions predetermined by in-group"	When talking about preferred lamps, users always reported their opinion about a their neighbor's lamp, rather than their own. In addition, in terms of quality all people chose the same solar lantern.
"Belief in collective decisions"	Users all made the same decisions. No one questioned this decision and even non-participants of the field test relied on the decision made about the favorite lamp without even testing it themselves.
"Financial and ritual obligations to relatives"	As mentioned before, it is expected that members of a family who are employed share part of their income with the rest of family.
"Pupils' individual initiatives discouraged"	Children are not encouraged in school to think on their own or develop individual ideas. Emphasis is placed on learning things by heart.
"High risk of domestic intergroup conflict"	Over 80 different ethnic groups live in Ethiopia and tense relations can exist between certain groups. In universities students from different ethnical groups are accommodated in one room. As a consequence conflict often occurs, as they are often not able to understand each other (because of different languages, habits and attitudes).
"Religions stress collective devotional practices"	Ethiopians are very religious. A lot of fasting phases, church services, church festivals and religious rituals are collectively performed by people.

Further aspects of Collectivism according to Hofstede which will not be discussed in this thesis but which were also observed in Ethiopia include: less economic development; less social mobility and weak development of middle class; survival less dependent on individual initiative; more traditional agriculture, less modern industry, less urbanization; extended family or tribal structures and more children per parent couple (Hofstede, 2001, p. 254). At this point Kapuscinski should also be referred to. He states that African cultures are mostly collective ones because it is not possible to manage the difficult daily tasks alone (Kapuscinski, 1999).

4. Masculinity and Femininity

This category deals with roles of gender, with particular emphasis on socially and culturally predetermined roles. Hofstede describes masculinity and femininity as the distinctness of gender roles in society: "Masculinity stands for a society in which social gender roles are clearly distinct: Men are supposed to be assertive, though, and focused on material success; woman are supposed to be more modest, tender and concerned with the equality of life. Femininity stands for a society in which social gender roles overlap: Both men and women are supposed to be modest, tender, and concerned with the quality of life." (Hofstede, 2001, p. 297)

East Africa is located was ranked 39 with 41 points and a mean of 49 on the masculinity index (range of points: 6-95). Germany ranked 9 with 66 points. However, a few statements are perceived completely the other way round.

Statements of low Masculinity Index	Situation in Ethiopia
"Living area and employment security important"	As stated in the interviews, security is an important need of people. They are afraid either of theft or of wild animals, such as hyenas. As a consequence there are many jobs for security guards.
"Values of women and men hardly different"	Regarding the official rights of women and men, women already have more rights than in other African countries. But practically women are regarded as less valuable than men, because they will leave their family in order to move to the man's family (Beyene, 2008). They have restricted opportunities as well (Dejene, 2001). If men enter the room, women immediately get up to give them their

	chair. While men sit on the chair, women sit on boxes, sacks or the ground. Before and after meals men are always the first to be given water to wash their hands.
"Belief in group decisions"	The buying decision at the end of the field study was a collective decision. Even people who had not participated supported the decision.
"Work in order to live"	Work is mainly not done because of its own purpose, but to ensure survival of the family.
"Macho behavior ridiculed"	In this category the converse was observed: for example, only men attended the distribution meeting. It was regarded as normal that during the whole process men were the contact persons. Women did not even open their door if men were not around.
"Buying decisions and shopping shared between partners"	The decision to buy in the village was clearly made by men. Although energy supply is the task of women, men made the decision.
"Low percentage poor and illiterate."	As described in the introduction, the majority of households are low-income and not able to read or write. The population below the poverty line is 38.7% (Central Intelligence Agency).
"Larger development cooperation budget"	Since various years, Ethiopia receive a large sum of foreign aid and development assistance as well as an increasing development cooperation budget (Österreichische Forschungsstiftung für internationale Entwicklung, 2009). It is even taken for granted and a lot of developing countries are used to the fact, that foreign countries are responsible for development. In some countries, this has even destroyed initiative of one's own (Seitz, 2010, pp. 47-48). This could be observed various times in Ethiopia as well.
"In poor countries less corruption"	The 2010 Corruption Perceptions Index showed that Ethiopia is highly corrupt. It has an index of 2.7, which is the third highest rank possible (Transparency International. The Global Coalition against Corruption, 2010). In this category Ethiopia therefore also diverges from Hofstede's results.
"Homosexuality is a fact of life"	Even if men who know each other well

	hold hands and embrace each other, no-one would ever think of homosexuality which is punishable equal to rape with prison sentence of 6 month to 25 years (Auswärtiges Amt, 2011).
"Religion is not so important in life"	As described before, this is completely contrary to the statement in Ethiopia. Religion is of particular value to the people.

A few categories are not applicable and in the author's opinion a clear separation of gender roles exists in Ethiopia (which would be classified as masculine society according to Hofstede). Men are responsible for farming, working and calculation of money. Women's tasks in rural areas include energy supply (collecting firewood, buying candles or kerosene in a city) and taking care of children as well as doing domestic work. This separation may be less strict in middle class and urban areas. An aspect that favors a lower masculinity index is that a lot of women also do hard work, such as carrying weigh firewood or water over large distances. They even help their men in the fields or to build houses. Concerning gender roles an Ethiopian woman stated: "Although we may take these families to be male-headed, the breadwinners for these households are women" (The World Bank, 1999, p. 162). But this is not valid the other way round. While women also do physically exhausting jobs, which in other countries may be viewed as men's work, men do not show behavior that is associated with femininity. It is even ridiculed if men cook or celebrate the traditional coffee ceremony. Hence, an unilateral overlap of roles exists in Ethiopia. To summarize, the Ethiopian society can be classified more as a patriarchal one.

4. Long- versus Short-Term Orientation

This last category was added afterwards by Hofstede. As an explanation for the late addition, he names the Western perspective of the designers of the questionnaires. Questionnaires lacked items which described values important in Eastern countries for example. An instrument was thus developed which incorporated Confucianism. Because the results of the questionnaires gave new insights into Eastern countries, Hofstede also asked Africans to explore a new questionnaire. Resulting items were a replication of the existing dimensions and therefore the development of another dimension was not necessary. Hofstede describes this category as follows: "Long Term Orientation stands for the fostering of virtues oriented towards future rewards, in particular perseverance

and thrift. Its opposite pole, Short Term Orientation, stands for the fostering of virtues related to the past and present, in particular, respect for tradition, preservation of "face" and fulfilling social obligations" (2001, p. 359). Unfortunately, Hofstede did not apply this dimension in East Africa, but he compares different regions and concludes, that East Asian countries score highest on Long Term Orientation, followed by Western countries, while developing countries score lowest (Hofstede, 2001, p. 351). Additionally, he describes statements which he summarizes as "wisdom". This dimension was extracted from the African questionnaire and correlates in a negative way with the Long-Term Orientation scale (Hofstede, 2001, p. 370). Only a few statements of wisdom are elaborated. "It is important to show hospitality to strangers" is the only one which can be confirmed. While Germany was ranked 14 with 31 points (range 0-118), Ethiopia seems to be short term orientated. Hofstede also found a strong correlation between Long-Term Orientation and economic growth.

Figure 18. Integration of Results in Theory of Planned Behavior

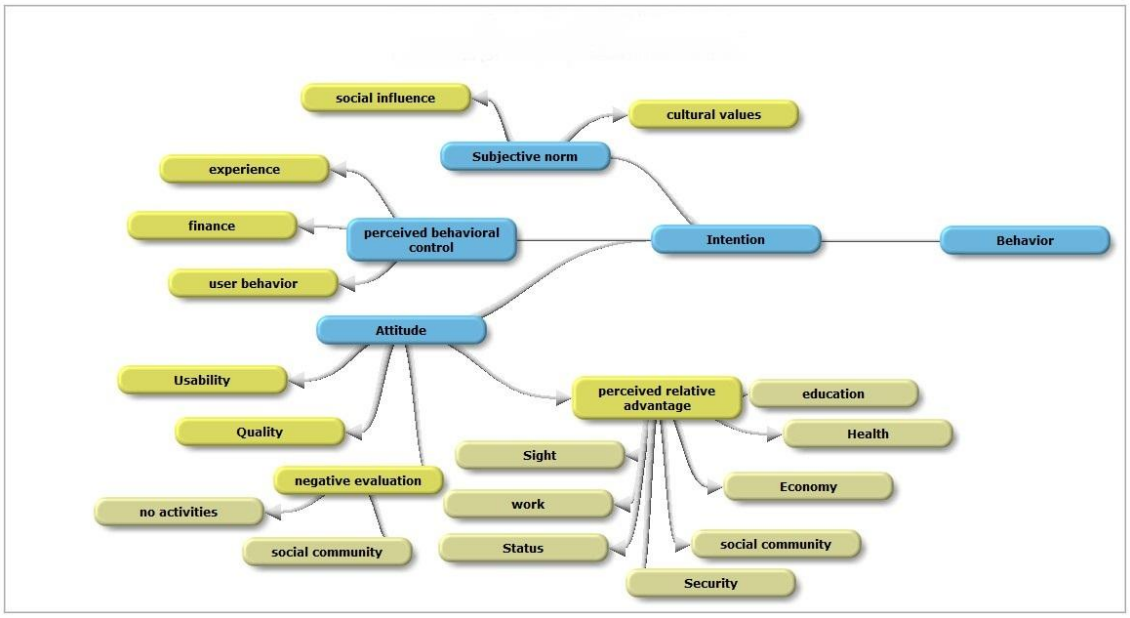

Figure 18. Relevant Categories in the innovation adoption process, integrated in the Theory of Planned Behavior according to Ajzen. Compiled by the author.

According to the transactional worldview, behavior is always determined by an interaction of an individual's attributes and their context. Behavior can therefore not be regarded in isolation. Thus, it was important to regard the realization of decision in the context of attitude and perceived behavioral control, as well as in its environmental

context of a collective, short term orientated, masculine culture, which is characterized by low avoidance of uncertainty and high power distance.

V. DISCUSSION

In the following chapter the results of the study are discussed with regard to future investigations and implementations of the PicoPV systems in rural areas as a part of development cooperation. The objective of the present study is to gain an insight into the decision making process and to further understand important dimensions of how people evaluate innovation within their context of a non-electrified village in Ethiopia. Problem focused interviews were chosen as method of data acquisition. The method of analysis was the content analysis method established by Mayring (2003).

5.1. Restrictions of study

5.1.1. Critical Examination of Attainment of Data

A critical aspect, which has to be kept in mind regarding the sample, is the choice of village. The chosen village is perhaps not wholly representative of all rural villages in Ethiopia, seeing as it is relatively near to a town, as is often the case in development cooperation. Villages further away from towns are often disregarded as it is significantly more difficult to reach them. But there might be very different conditions in such villages, for example since people ca not sell their products at markets in town they have to search for different possibilities of income. Furthermore, people living in the village where the study took place mainly belonged to the Oromian culture. Due to the fact that over 80 different cultures exist in Ethiopia, another culture might respond to the interviews and the use of solar lamps in another way. Moreover, translations (into two different languages) had to be made. Needless to say, someone who understands the Ethiopian languages Amharic and Oromifa gets more information during observations as well as from the original statements of people (without translation mistakes or summaries). Even if the translator was well trained, misunderstandings due to cultural differences cannot be completely excluded. In context of the Sapir-Whorf hypothesis it is even stated that “reality of a culture is discoverable in its language. […] Language structure controls thought and cultural norms” (Jandt, 2010, pp. 130-131). To summarize, culture is seen as predetermined by language. Access to a profound understanding of culture through language was denied within this study. This leads to the author of this research, who conducted the field study as well as the interviews. Due to the fact that the German culture is very different to the Ethiopian one, mutual

understanding first had to be gained. For example, it was very unusual, that a [foreign] woman was chosen for this project. Moreover, asking "why" is regarded as impolite in Ethiopia. This is a question only asked if people know each other very well or in order to complain about something. On the contrary, "why" is an inevitable question for a German researcher, even if it is only implied in a question. As Grill (2003) has previously stated, Westerners are used to trying to understand each phenomenon and analyze every situation, whereas it is more common in African countries to accept ambiguity (Grill B. , 2003). Regarding the interviews, it was not always possible to maintain a private atmosphere during the whole conversation. Furthermore, a lot of respondents were not educated very well. Likewise, they were not used to being interviewed. Therefore, answers were not as long and detailed they may have been in other studies. Moreover, people first experienced solar lamps during the course of the field study, meaning that they could not give clear statements immediately regarding which features and qualities they preferred, since they did not have any other systems to compare to. But when participants tested different models, answers became more differentiated. This represents the prospect of trying to implement and diffuse the PicoPV systems.

Furthermore, distortions due to social desirability have to be taken into consideration. Interviewees were possibly inhibited towards the foreign interviewer. Furthermore, participants were happy about the solar lanterns, which might have prevented negative statements or complaints being made about the PicoPV systems. The author tried to avoid this by means of indirect questions and comparisons of the advantages of the different types of lamps. It still has to be acknowledged, however, that respondents might have wanted to show themselves in a way that was socially desirable and gave only answers which fit to their cultural and societal norms. In order to understand these cultural and societal norms, they were further examined in the results chapter.

5.1.2. Critical Examination of Methods

The use of qualitative interviews had both advantages as well as disadvantages. First of all it has to be said, that other options of gaining data, such as questionnaires, could not be utilized in this context. Due to the fact that most of the habitants of the village could not read, quantitative data could be gained at most by means of structured interviews. Since habitants were not used to being interviewed, qualitative interviews helped to

ensure that those being interviewed understood the questions being asked correctly during interviews, because questions could be explained in detail to the interviewees. Any misunderstandings due to cultural differences and the translation of language could be resolved within the conversation.

A disadvantage is that the results of qualitative methods are limited in general. Using qualitative interviews is a method which is suitable to gain a preliminary insight into a new field of research. It gives new impetus and suggests ideas to focus on. But due to the fact that analyzing the data is very time consuming, only a restricted number of interviews can be considered. In order to increase objectivity, interviews were standardized with a guideline. Guiding the interview (see appendix) ensured that the interviews were comparable. Thus, on one hand, it was possible to get detailed, individual descriptions of answers but, on the other hand, interviewees were asked the same main questions. Furthermore, interviews were recorded and afterwards transcribed and reviewed with the help of the translator.

Regarding the criteria for testing quality, objectivity has already been discussed above. The criteria for testing reliability when gathering quantitative data (such as split-half reliability (Moosbrugger & Kelava, 2007)), does not make sense for qualitative research. Therefore, inter-rater reliability was used to define reliability (Mayring, 2003, p. 110). In this study it was not possible to analyze all the interviews by various persons. But results were discussed in a research group and an exchange of ideas was continuously carried out. Furthermore, ensuring reliability in the data gathering process was established through the use of the guideline. Due to the guideline, the answers of interviewees were likely to be the same when asked by different interviewers in the same order. In order to verify the results of the qualitative content analysis, adapted criteria of quality, for example by Steinke (2008) and Krippendorff (2004), were developed.

5.1.3. Criteria of Quality

Criteria of quality define the quality of research results. The most important criterion of empirical research is validity (Coolican, 1994). Questioning is valid if characteristics that can be measured, are exactly measured and not anything else (Moosbrugger & Kelava, 2007, p. 13). Regarding content analysis, Krippendorff states that an analysis is valid if “the inferences drawn from the available text withstand the test of independently

available evidence, of new observations, of competing theories or interpretations, or of being able to inform successful actions" (Krippendorff, 2004, p. 313). Validity is essential to reduce the risk of making false decisions in practice, which are derived from inferences of investigations which do not measure the intended characteristics. Traditional dimensions of ensuring the validity of quantitative data cannot be applied in the same way to qualitative data (Mruck & Mey, 2010), hindered as it is by substantive, conceptual and methodological obstacles (Krippendorff, 2004).[33]

Various criteria for measuring quality already exist for qualitative methods (Lamnek, 2010; Lamnek, 2005; Mayring, 2010 (11. Ed.); Steinke, 2008; Flick, 2004). The next section introduces the criteria of quality used for qualitative methods (suggested by Mayring (2003)) and particularly for content analysis. These criteria were applied to the present study.

On this account, Steinke (2008) suggested criteria of quality for qualitative methods. In terms of the present study, the criterion of *inter-subjective comprehension*[34] was fulfilled. Three measures ensure this criterion: 1. Detailed documentation of the research process should be made available in order to enable a broad audience to understand the process. The process of the present study was described in the sections regarding the theoretical considerations, method and results. 2. Interpretation in groups: the analysis of the interviews was discussed with two qualitative research groups as well as with the two Ethiopian translators. 3. An application of codified proceeding is necessary, such as content analysis as per Mayring (2003). The criterion of *indication of the research process* was fulfilled in the methods chapter, in which the qualitative procedure and choice of method were described. It has been shown that they were appropriate. The criterion of *empirical base* requires that the development and verification of the hypothesis and theory should be grounded in empirical data. This is ensured for the present research through utilizing codified methods and evidence from literature (Steinke, 2008). The criterion of *limitation* verifies any generalizations in the results and their limits. This thesis also questions if the present results are applicable to other conditions. Clearly, results of qualitative studies are limited in generalization, but a few correlations with other studies can be listed. In the subsequent section *results in*

[33] For further information about these obstacles and a conceptual framework of content analysis refer to Krippendorf (2004, pp. 316-318).

[34] Intersubjektive Nachvollziehbarkeit (Steinke, 2008, pp. 324-326).

comparison with outcomes of other investigations, generalization is discussed, as well as in the section above. The *Coherence* of generated theory and data as well as questions and contradictions were already discussed in the results. Hence, this criterion is fulfilled as well. In addition, the criterion of *relevance* reviews the pragmatic benefits of theory, which was already proven in the introduction, theoretical considerations and method chapters. The last criterion according to Steinke (2008) is *reflective subjectivity*[35]. Within this criterion a basis of trust between the interviewer and respondents is needed. Since the field study was carried out alongside local technicians and translators, a certain level of trust can be assumed. Furthermore, the author learned the most important polite phrases in order to enhance a trustful atmosphere during conversation. This was increased with the help of regular visits over a period of three months, as well as informal meetings, for example over lunch. On the other hand, participants hoped for PicoPV systems, which might have affected their actions and answers. Moreover, the significant difference between the cultural backgrounds of the interviewer and the interviewees may have had an effect on interactions. In order to become aware of the whole research process, the author reflected on all meetings in a research diary.

Triangulation is additionally named as a criterion of validity in qualitative research (Lamnek, 2010, p. 132; 142). Denzin (1978; cited in Lamnek, 2010, p. 132 and Flick, 2008) defines triangulation as combination of different methods, theoretical approaches, interpreters and data sources, used in order to understand the same phenomenon more precisely and deeply. In the present study, methods were triangulated: Participant observations, focus groups, as well as qualitative interviews were conducted to gather a broader understanding. Furthermore, different theoretical approaches were combined, including the Theory of Planned Behavior (Ajzen, 1991), Hofstede's Culture's Consequences (2001) and Rogers' Diffusion of Innovations (2003). A triangulation of data sources was, however, not accomplished. Moreover, triangulation of interpreters was not completely conducted, but another research group discussed the results of this study with the author.

Typology for validating evidence, especially in content analysis, has been developed by Krippendorff (2004). Figure 19 summarizes the different types of specific validity.

[35] Reflektierte Subjektivität (Steinke, 2008, pp. 330-331).

Face validity is "common truth"; even unskilled persons are able to judge on the surface about the credibility of researches. This kind of validity is negligible due to the fact that it is omnipresent and can be referred to as common sense (Krippendorff, 2004). Nevertheless, the introduction explains to inexpert individuals the underlying reasons for this study. The section on theoretical considerations refers to the content of the questioning and the methodology chapter explains the choice behind the type of questioning and analysis used in the study. Moreover, it was plausible to ask users about their evaluation of the PicoPV system, its characteristics and consequences of use, in order to explore their acceptance. Therefore, plausible causes for a need of research as well as for the proceeding are shown. In conclusion, face validity can be assumed.

Figure 19. A Typology of Validation Efforts in Content Analysis

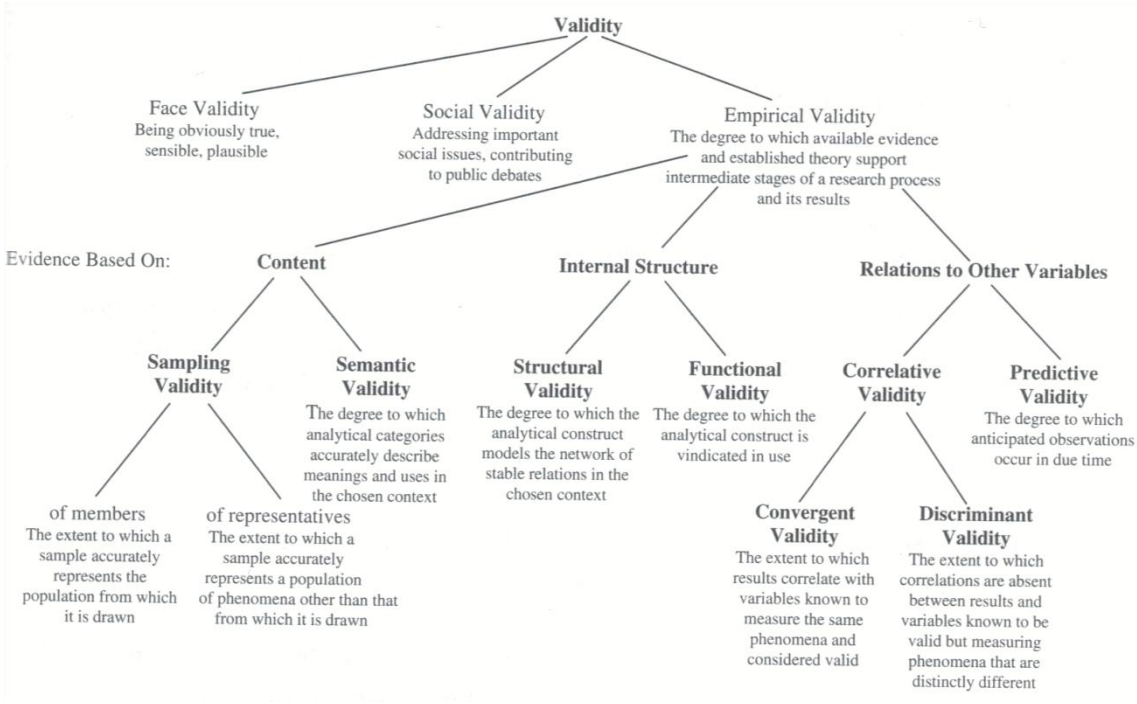

Figure 19. Typology of Validation Efforts in Content Analysis according to Krippendorf. Compiled from: Content Analysis. An introduction to its Methodology by Krippendorf (2004). Copyright (2004) by Sage Publications, Inc.

Social validity concerns the social relevance of the research topic. Developed categories should not only affect academic audiences (Krippendorff, 2004). Regarding the present study, in the methods chapter (3.1.Problem focused Interview according to Witzel) the social relevance of the research topic has already been discussed. Access to renewable energy services improves living conditions in developing countries (as shown in the introduction) and as a result of a globalized world can defuse international conflicts and

problems, such as refugees due to climate change, environmental destruction and inconvenient living conditions.

As can be seen in figure 19, *empirical validity* is divided into validity regarding content (justification of text treatment), internal structure (justification of conclusion) and relations to other variables (justification of results regarding questions of other researchers). The following section deals with each type of validity.

Sampling validity describes the extent to which the chosen sample is representative of the underlying population (Krippendorff, 2004). In this context, the size and composition of the actual sample can be evaluated positively. In terms of income, participants of the field study earned little below the monthly average income of other studies (Lighting Africa, 2008b). This might be due to the fact that Lighting Africa referred to a sample that included urban populations as well. In comparison, in this study only rural populations were of interest. As mentioned in the introduction, 85% of Ethiopians are farmers. In the actual study, 100% of respondents relied on farming. This difference might also have been caused by including the urban population in official data. Acquiring the age, education level, income and family size of choice of the participants showed that these variables differ significantly to official data. In regard to living conditions, participants of the study lived in typical Ethiopian "Tukuls", traditional thatched roof huts made of mud or dung. The roof is mainly made from grass or corrugated iron (Kumie & Berhane, 2002). The people involved in the field study therefore live in a traditional way, like the majority of Ethiopians. As already discussed in the first part of this chapter, the village is relatively near to a town (10-15 km). Thus, there might be different conditions in comparison to villages far away from town. Regarding the composition of the sample, not all habitants of the village attended the distribution meeting, because they did not believe in solar technology. They were not interested in participating until they saw the functioning of lanterns. It is possible that only people who felt enthusiastic about technology or who were extremely desperate because of the lack of energy participated in the first meeting. Furthermore, a typification was not possible due to a lack of well founded knowledge about the cultural background. Therefore, a distortion may have been present in the composition of the sample. But due to the fact that after the first distribution other villagers also got a lantern by chance, this effect is only small. Furthermore, the objective of qualitative

research is to find out a relevant set of behaviors instead of a representative analysis of frequencies in a population (Lamnek, 2005).

Semantic validity describes how correctly the meaning of material is constructed out of the original context (Krippendorff, 2004). This refers to how appropriate the definitions of the categories are. In order to make categories comprehensible, interviews were discussed with the translator after conversation. Furthermore, a second interviewer analyzed certain interviews again, to verify their correctness regarding translation and underlying meaning. Moreover, results were discussed as well with a German research group, who accomplishes also qualitative research with content analysis according to Mayring.

The validity of the internal structure shows "how well the analytical construct in use actually does model what it claims to model" (Krippendorff, 2004, p. 320). Again, two kinds of validity can be determined: *Structural validity* compares theory with the rules of conclusions derived from data regarding structural correspondences (Krippendorff, 2004). Within structural validity it is shown that the analytic procedure can be deduced from general principles. A major part of the interviews was to explore the attitude toward and evaluation of PicoPV systems and certain features. This was accomplished due to the fact that the origin of deciding whether to perform a behavior results from intention, which is in turn a consequence of an attitude, a subjective norm as well as a perceived behavioral control. Attitude is defined as consisting of three components: cognitive, emotional and behavioral factors (Stroebe, Jonas, & Hewstone, 2003) which are formed through experience. In the present study, features of the PicoPV systems, as well as perceived advantages and disadvantages of such features, were of keen interest rather than a distinction into cognitive and emotional components. Advantages and negative evaluation include cognitive and emotional components, but they are not especially subdivided. The actual behavior of participants was verified by means of a sales event at the end of the field test. 30 participants bought the PicoPV system, at which characteristics presented in the results section on subjective norm, perceived behavioral control and attitude were fulfilled. Empirical investigations found a strong correlation between intention and behavior. Hence, structural correspondence with already established models can be assumed.

Functional validity is defined as the extent to which correspondence regarding usage exists, for example on usefulness and success (Krippendorff, 2004). This study concentrates mainly on the theories of Rogers (Diffusion of innovations, 2003), Ajzen (The Theory of Planned Behavior, 1991) and Hofstede (Culture's Consequences, 2001). These models are considered as classical works of literature and are often applied: Ajzen's theory is considered as one of the most influential works relating to attitude and behavior (Stroebe, Jonas, & Hewstone, 2003, p. 7). Contrary to the technology acceptance model it has been successfully applied to various contexts. Furthermore, in terms of innovation literature, Rogers is considered to be the classical point of orientation (Wiswede, 2007). Finally, Hofstede is referred to as the most influential and quoted researcher in intercultural exploration (Boersch & Elschen, 2007). In conclusion, the applied models in this research are broadly used and verified. The usefulness of this study is that it will aid in understanding which characteristics and features of PicoPV systems support user behaviors and help people in developing countries make their daily lives easier. In order to evaluate this approach in the context of the millennium development goals and its contribution to combat poverty, impacts of access to modern energy are important to verify its usefulness.

Within *predictive validity* a prediction is derived from available material. If a prediction is possible, its examination is easy and convincing (Mayring, 2003). As mentioned in the above theory chapter, a general rule of Ajzen states that "the more favorable the attitude and subjective norm with respect to a behavior, and the greater the perceived behavioral control, the stronger should be an individual's intention to perform the behavior under consideration." (Ajzen, 1991, p. 188). This prediction can be confirmed within this field study, because the attitude, subjective norm and perceived behavioral control are generic terms of developed results. If a PicoPV system fulfills desirable characteristics in terms of attitude (perceived relative advantage, quality, usability) as well as behavioral control (especially in terms of finance and user behavior) and a subjective norm (collectivism and status), people performed the behavior and bought a system. It remains to be seen, however, if this model with its certain characteristics can be applied to other villages and cultures. This criterion of validity is also somewhat contradictory to the transactional view, which claims that predictions are not possible due to the fact that behavior is a result of an environment and the individual, which continually change.

Another important criterion of quality according Krippendorff (2004) is *correlative validity*. This describes validity through a comparison of results with other studies. Although only a few studies regarding PicoPV systems exist at the moment, a comparison was made and is presented in the following section.

5.1.4. Results in Comparison with Outcomes of other Studies

Comparison with Pilot Studies in Developing Countries

Early findings made by studies in countries such as Bolivia, Ghana, Mozambique, Nicaragua, Uganda and Senegal are promising: respondents all over the countries confirmed the importance of improving their lighting conditions, clearly naming better lighting as an improvement of first priority for their households, businesses and other facilities (Lighting Africa, 2008a; Lighting Africa, 2008b; Lighting Africa, 2008e; Lighting Africa, 2008f). Researchers also found improvements in economic, education, health and security (in terms of fewer accidents inside houses) (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b). In this context, the results of the present study support the assumption that electrification with PicoPV systems is positively contributing to the attainment of the Millennium Development Goals and sustainable development.

In the following section impacts will be referred to that have not been mentioned so far in recent literature. Studies have generally found already anticipated aspects (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b) or have focused specifically on the quality and usability of lamps (Lighting Africa, 2009a; Lighting Africa, 2009b; Lighting Africa, 2009c; Lighting Africa, 2009d; Lighting Africa, 2009e). *Security*, defined as a feeling of serenity, was one of the impacts found in this study that had not been mentioned before. In particular, daily life without the added worries about energy supply, about having enough light to care for people with special needs and as a consequence a more flexible life were alluded to by respondents, resulting in a new perspectives of possible advantages. As observed repeatedly, categories are often connected to each other. In this way, as already described, feeling secure contributes to improved health (due to less stress). This leads straight to other revealed aspects of security, including fewer accidents outside the house, protection from wild animals and fewer incidences of using unhealthy and/or dangerous methods to produce light. Moreover, the *autonomy* of children, who can use the system on their own without

hesitation, is an important advantage, which should be kept in mind in future studies and marketing. In addition, *improved family life* and *social community* should be paid attention to, due to the fact that survival without family is often impossible. Lastly, domestic jobs, daily life and businesses are also improved.

Findings of *negative outcomes* also distinguish the present study from previous studies: aspects of envy and a lack of activities were seen to play a role in how users assessed the system. But aspect of envy could perhaps be prevented through appropriate application of distributional and procedural justice (see section on acceptance). Negative impacts were not found in former studies. Former investigations (Lighting Africa, 2008a; Lighting Africa, 2008b) only highlighted acceptance barriers such as the expensive initial investment and fear of non-functioning solar systems during the rainy season, which were also mentioned by respondents in this study.

Finally, in terms of quality and usability matching results were found: *Cone of light* (large radiation) and *brightness* (high intensity) were both identified as one of the most important criteria by the interviewees. This statement confirmed what the majority of respondents in other studies had said (Lighting Africa, 2008a). Respondents in other studies also emphasized the importance of portability and ease of use. Similar to the present study most people did not associate environmental impacts with the type of energy source they use (Lighting Africa, 2008b). Whereas users in the market research conducted by Lighting Africa mostly did not worry about health effects, respondents of the present study, as well as Tanzanian users (Lighting Africa, 2009d), perceived improvements of health as an important benefit of using PicoPV systems. Outcomes of former investigation show that users attach high value to products of good quality with a long life-cycle (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2010b). People often do not want to buy products made in Asia, because of the association with bad quality and thus this observation can be confirmed within the present research. Users in other countries, however, also attach value to prominent and reputable manufactures (Lighting Africa, 2009c; Lighting Africa, 2009d), although the evaluation of manufactures' quality differ. While Tanzanian users estimated products from Japan as being of high quality (Lighting Africa, 2009d), the Ethiopian users from the present study presumed that all products from Asia were bad quality. Contrary to findings in South American and African countries, additional features, such as a radio or *mobile charger*, were also evaluated positively, although the crucial factor remained light.

The last point deals with visual design features. Studies imply the effects of certain colors and shapes. Users prefer, for example, dark colors because dirt on the solar lanterns can only hardly be noticed (Lighting Africa, 2009c; Lighting Africa, 2009d). Users also reject certain colors because they evoke what are perceived to be negative associations with a political party. Furthermore, familiar (Lighting Africa, 2008a; Lighting Africa, 2008c; Lighting Africa, 2008d) or new designs which are associated with already existing (as well as positively perceived) products (Lighting Africa, 2009c) are favored. However, these criteria do not seem to play a significant role in the sampled village in Ethiopia. Regarding the visual design, only the color of the light itself was important, with white light being clearly preferred. The same observation regarding the white color of light was made in Tanzania (Lighting Africa, 2009d). Instead of design aspects, participants in Ethiopia placed importance on features such as quality and usability: A PicoPV system seems to be more valuable if it is easy to handle (even for children), portable, easy to hang up, handy and able to be adjusted in terms of the intensity of brightness. Moreover, the duration of light is an important feature.

Additionally, both the aspects and consequences of being poor mentioned by people themselves in the study conducted by the World Bank (see Introduction) also appeared in the interviews carried out in this study. People described poverty as “like living in jail, living under bondage, waiting to be free”, “lack of freedom”, the will “to do something and have no power to do it”, “dependence on everyone” and “no progress in family” (see Introduction). During the interviews conducted for this study, respondents mentioned advantages that resulted from using the PicoPV systems, such as a feeling of being free, to be able to do whatever one wanted at any time, independence and freedom of worries and thoughts about energy supply. Therefore, a few mentioned aspects of the multidimensional concept of poverty seem to be improved by the PicoPV systems. As presented in the introduction to this study, access to modern energy services, especially solar energy, not only combats poverty as defined by Western institutions and organizations, but also aspects of poverty defined by the people who are affected directly by poverty. Therefore, both descriptions of poverty – the Western approach and the perception of people in developing countries themselves - are taken into consideration.

Finally, the effects of pilot studies should be further examined. Bruppacher and Truffer (2004) found that pilot studies and demonstration projects minimize extreme positions

concerning attitudes of "green electricity" and renewable energies. Their conclusions can be confirmed within this study. People who were not open to new technologies did not appear at the announced distribution meeting. Later on they observed test lamps in their village and asked for an own lamp. But whether extreme positive opinions about solar lamps decreased as well could not be observed.

Comparison with Theoretical Considerations

Concerning the definitions of acceptance discussed in the section on theory, in this field study the acceptance of consumers was of keen interest. Therefore, a narrow definition (Schweizer-Ries, 2008) of acceptance (high positive valuation and active contribution) was assumed. In comparison to the definition produced by Wüstenhagen, Wosink and Bürer (2007), mainly market acceptance was explored. It is of further interest to also investigate socio-political and community acceptance in prospective studies. This approach would enable a more extensive and detailed picture of the relationships concerned with the implementation of PicoPV systems. A categorization of circumstances and conditions into the model of Schweizer-Ries (2008) could then be carried out. The results from the present study can be integrated in the model, but taking all of the required systems into account during attainment of data (interviews) would have exceeded the demands of a diploma thesis. Therefore, the next section gives an overview of the results integrated in the model and factors which should be considered in any future studies. A deeper analysis of external structure is particularly a matter of great interest.

External structure is constituted through the possibilities and limitations of physical, economic, social and cultural processes, which are perceived by individuals and interact with the internal structure, which influences action, leading in turn to changes in external structures. Regarding the present field study, physical factors included the model of the PicoPV system's implementation, such as the possibility to gain trust through experience, trail, maintenance and warranty. Furthermore, "objective" qualities of the PicoPV systems (in contrast to a subjective evaluation of quality[36]), such as reliable functioning of batteries and lamps, fall under this category. Economic factors clearly include financial solvency and conditions of use, as well as financial models,

[36] For example brands may be an aspect of a subjective evaluation of quality. Certain images of brands might influence the evaluation of quality although there might be a comparable no-name product.

such as lending systems, micro credits, subsidies or credits. In this category the price of PicoPV system and import taxes are also included. The classification of cultural values according to Hofstede (see the chapter on subjective norms) can be summarized as social and cultural factors. Political factors include agreements made with the government and their plans of grid expansion. Internal structure is composed of cognitions, emotions and interests. Also under this category fall other parts of the remaining results, such as perceived relative advantages, negative evaluation and the subjective evaluation of usability and quality. This approach is very interesting in terms of getting a detailed perspective of circumstances. It presents the complex and interacting systems and their conditions. As a consequence how these different actors and conditions relate to each other can be explored. Prospect studies should take the aspects of this model into consideration.

The next section integrates the results from the field study with theoretical investigations concerning characteristics and diffusion of innovations. As already presented in the results section, criteria used by Rogers', such as perceived relative advantage, observability and the ability to be trialed, could also be observed as being important within this pilot study. Furthermore, familiarity, as outlined by Kaplan, is assumed to be another important characteristic of innovation within a sustainable adoption process. As already presented in of the section on theoretical considerations (Characteristics of Innovations), Darley und Beniger stated the following important features of a successful innovation: capital costs, perceived savings, certainty of savings, compatibility of innovations with values, attitudes and lifestyle of target groups, possibility of trail, dissatisfaction with the existing situation, necessary efforts and skills in installing the innovation. Within the present study, capital costs (financial abilities), perceived savings (economical factor), compatibility and attitudes (in this study consisting of quality and usability of lamps, perceived relative advantage and negative evaluation) could be confirmed as important characteristics. Due to the fact that some systems had to be repaired and people worried about the rainy season, certainty of savings might have played a role as well. Having the possibility of a trail was also accomplished and regarded as an inevitable factor (see results chapter). In addition, necessary efforts and skills in installing the innovation (perceived behavioral control) were asserted as well. Moreover, dissatisfaction with the existing situation was confirmed by users: 91% named light as an improvement of first priority in their

households. But as Völlink, Meertens, Midden (2002) have already proposed, the most crucial aspect is perceived relative advantage. This assumption can be supported from this study's perspective.

Regarding the diffusion process of the PicoPV systems in Ethiopia, only the interpersonal channel (Rogers, 2003) was used. It soon became apparent how powerful social influence is: habitants from other villages than the test village were interested in buying a PicoPV system as well. Furthermore non-participants also bought systems and trusted participants in their decision to choose the PicoPV system. Comparing the characteristics of the diffusion process according to Gatignon and Robertson (1985) with the present research, the following assumptions can be made: according to the author's appraisal, the system was homogenous and cultural values were not injured. Regarding the temporal aspect, culture was assessed to be rather traditional (see chapter on the subjective norm). However, within this study innovation was accepted quite well (30 orders of PicoPV systems [24 participants]). This is contrary to previous findings of Rogers (2003), who assumed traditional cultures to be rather slow in acceptance. The diffusion process should, however, also be observed during a longer period of time.

5.1.4. Critical Examination of Results

Although this study was based on the approach of asking people themselves and refraining from determining development cooperation in detail, it should be admitted that the underlying approach regarding planning, analysis and integration into (Western) literature follows Western perspectives. In general, it is nearly impossible to avoid Western models and theories as an underlying perspective in such studies. But this results from the way of Western researches in African countries in the context of development cooperation. In order to compensate this biased view, a peer review with Ethiopian colleges is conceivable.

Moreover, although classification according to Hofstede is well researched, it also contains critical aspects. He supports a biased view of cultures, because he does not refer to each country on the African continent separately, but rather unites them into regions. Due to the fact that Africa is at least as rich in cultures as Europe, he does not fulfill the demand of a well founded analysis of individual African countries. This problem intensifies if it is taken into consideration that differences also exist within all of these cultures. Most African countries, like Ethiopia, have various ethnic groups.

Moreover, Hofstede only interviewed employees of IBM. Thus, it may be that he explored only differences between organizational cultures instead of national cultures. He mainly asked for attitudes towards work, which intensifies this problem. Furthermore, questionnaires were filled out by members of the middle class, while observations from Ethiopia came from both the middle and mainly the lower classes. In order to make convincing statements, comparisons with cultural investigations, which include the lower class as well, should be considered. This is especially the case for countries in which the lower class represents a major part of population, as in Ethiopia.[37] Finally, Hofstede did not distinguish between behavior and values, which do not always correlate positively. To summarize, even if Hofstede developed a valuable approach of cultural differences, the generalization of his theory is limited in certain aspects.

Finally, during the duration of the three month field study, only short-term impacts were examined. Long-term outcomes remain to be seen. Since the results of this study show mainly positive outcomes, it is of special interest to explore long-term impacts with regard to both the benefits as well as the undesirable and indirect consequences. In this context it is a matter of interest to observe, for example, the development of respect for older people. As described in the section on results, they cannot use solar lanterns themselves, but rely on their children and relatives. Although it is regarded disrespectful to explain anything to older people, they are forced to ask their relatives for help. This may lead to decreasing respect for the older generation as a consequence of increasing dependence. Such a change of status relationships has already occurred among an aboriginal tribe in Australia as an indirect consequence of the implementation of new technology and lead to a confusion of age and gender roles (Rogers, 2003, pp. 449-450). This should therefore be an important aspect for future studies in order to observe long-term consequences and where to classify them on the scale of desirable-undesirable, direct – indirect, anticipated - unanticipated.

5.2. Outlook

A first glance at the impacts and user perspectives in terms of the social acceptance of the PicoPV systems was granted by this study. In order to generalize these results, further quantitative and qualitative studies in other countries and cultures should be

[37] Population below the poverty line in Ethiopia is 38.7% (Central Intelligence Agency).

carried out. This is of particular interest, especially with regard to an international comparison of user behavior and cultural classification according to Hofstede. A contribution to the Millennium Development Goals was also observed, as shown by the perceptions of people living in poverty themselves as to how different aspects of poverty were improved.

It is therefore worthwhile to investigate further in order to make access to modern energy possible for non-electrified areas.

Technical problems, such as deeply discharged batteries, occurred during the trial period and participants had to ask questions regarding the system. This suggests that in future field studies, special attention should be paid to warranty and maintenance services. Due to the recent mass production of PicoPV systems, products of good quality should be labeled with an international certification in order to prevent users from purchasing expensive products with a low life-span. The reputation of solar products could otherwise be destroyed. Furthermore, education and training for the maintenance of PicoPV systems should be focused on in order to guarantee quality. Furthermore, when PicoPV systems will be introduced in developing countries on a large scale, recycling of the systems, especially batteries (as first component which will have to be replaced) and awareness of appropriate waste disposal have to be taken into consideration.

In prospective studies, diffusion and communication channels during the implementation process of the PicoPV systems should be focused on more intensively. Because mass media channels, such as internet access, are not spread widely, other means of advertisement have to be developed. In this study, communication channels attracted people even from other villages. Hence, future studies should focus on these aspects. Furthermore, an integral way of viewing things should be considered while implementing PicoPV systems, as described for example in the environmental model of behavior according to Kaufmann-Hayoz (2006; Schweizer-Ries, 2009).

VI. RECOMMENDATIONS

Experiences during the field tests regarding implementation, distribution and marketing lead to the following recommendations for further investigations with PicoPV systems:[38]

6.1. PicoPV systems

- Built-in switches are preferred over a pull switch (cord).
- Users prefer white, bright light which does not glare instead of yellow light.
- A regulator to adjust the brightness of lighting devices is appreciated.
- Angle of radiation should be large enough to illuminate different directions in order to serve various users simultaneously.
- Solar lantern should be usable for multipurpose: inside and outside usage; possibility to hang the lamp as well as the possibility to carry the lamp around; use for children and adults
- Light should last about 4-8 hours.
- Because users fear theft, the panel should be separately and the solar lantern resistant to frequent shifts of place (carry around).
- Charge controller and low-voltage disconnect should prevent the solar lantern from deeply discharged batteries.
- Batteries which are resistant to deep discharge are important.
- Maintenance service and warranty are very important factors during the test and acceptance process as well as afterwards.
- International criteria of quality should be introduced and explained simply to consumers (labels / pictograms).

6.2. Users

- Short education and training for users are necessary. This can be supported by labels and operating instructions in a simple manner (pictograms).
- Due to the newness of solar technique, trust (through experience and maintenance service) is an important factor.

[38] These recommendations were developed on basis of the field test in Ethiopia. Thus, their generalization is limited. It is of further interest to compare them with the outcomes of other countries.

- Women should be empowered. As few people expressed the wish for a TV or radio, empowerment can be reached by giving a TV, Radio, tape recorder or a mobile recharger (or a Laptop) to a woman. Receiving a little fee, she could make it accessible to the other people of the village. Another possibility is to give her a light, which is very powerful, bright and handy. Using this light she could help people at night, who are ill, die or to help women giving birth at night.

6.3. Marketing and advertisement

- Men make decision about purchase even if energy supply is the responsibility of women.
- Children benefit most, because they can do their homework at night.
- Using solar lanterns, elder people depend on their children.
- Additional activities and possibilities of using electricity should be offered for illiterates.
- Carefree use for children might be an incentive to enhance use as well as an improved family life (see chapter of results).
- Evaluation of lamps is not individual, but collaborative.
- Communication through social networks is very powerful.
- Images of branches should be checked for each country. People buy products from reliable companies more likely.
- Due to small financial buffer, users attach value to high quality products.
- If products have to be ordered (due to non-availability), order of the systems should be accomplished with the help of the local administrator. He is a person, in whom both sides (the company as well as the people of the village) can trust. He can collect (a part of) the money of the systems before the delivery of the systems, additionally to a contract.

6.4. Field tests

- A functional intermediary is very helpful for the communication with people of the test village.

- During harvest time, people do not have much time. On the other hand this is the time of the year, in which they have the biggest savings and are able to consider affordability according to the outcome of harvest.
- During rainy season, evaluation of lamps can be distorted, due to very different weather conditions.
- Extremely used solar lanterns can distort evaluation and ratings of different types of lamp due to less duration of light or damaged batteries.
- Laboratory tests *and* field studies are essential to develop correct criteria for evaluation of solar lantern's quality. Criteria of laboratory tests should be adapted.

VII. REFERENCES

Adelmann, P. (2010, May 24). Vortrag Pico PV Systems. Adama University.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes* , pp. 179-211.

Ajzen, I., Ellen, P. S., & Madden, T. J. (1992). A Comparison of the Theory of Planned Behavior and the Theory of Reasoned Action. *Personality and Social Psychology Bulletin* .

Altman, I. (1993). Challenges and Opportunities of a Transactional World View: Case Study of Contemporary Mormon Polygynous Families. *American Journal of Community Psychology, VoL 21, No. 2* , pp. 135-163.

Auswärtiges Amt. (2011, 01 04). *Auswärtiges Amt*. Retrieved 02 12, 2011, from http://www.auswaertiges-amt.de/DE/Laenderinformationen/00-SiHi/Nodes/AethiopienSicherheit_node.html#doc356960bodyText6

Bardouille, P. (2004, February). *Millenium Project*. Retrieved June 15, 2010, from http://www.energycommunity.org/documents/MckinseyMDGProject.pdf

Berkhout, P. H., Muskens, J. C., & Velthuijsen, J. W. (2000). Defining the rebound effect. *Energy Policy 28* , 425-432.

Beyene, H. (2008, April 01). Viele Sprachen und fragwürdige Sitten. (R. Kees, Interviewer)

Boersch, C., & Elschen, R. (2007). Lokales Denken, globales Handeln. Interkulturelle Zusammenarbeit und globales Management. In C. Boersch, & R. Elschen, *Das Summa Summarum des Management. Die 25 wichtigsten Werke für Strategie, Führung und Veränderung.* (pp. 201-216). Wiesbaden: Betriebswirtschaftlicher Verlag Gabler.

Bronfenbrenner, U. (1979). *The Ecology of Human Development. Experiments by Nature and Design.* USA: Harvard College.

Bruppacher, S., & Truffer, B. (2004). Effekte von Pilot- und Demonstrationsprojekten auf Einstellungen gegenüber "Grünem Strom" und erneuerbaren Energien. *Umweltpsychologie 8* , 108-119.

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung. (2010, 07 29). *Erneuerbare Energien und Energieeffizienz fördern*. Retrieved 07 29, 2010, from Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung: http://www.bmz.de/de/themen/energie/index.html?follow=adword

Central Intelligence Agency. (n.d.). Retrieved June 14, 2010, from https://www.cia.gov/library/publications/the-world-factbook/geos/et.html

Cervinka, R., & Schmuck, P. (2010). Umweltpsychologie und Nachhaltigkeit. In V. Linneweber, E.-D. Lantermann, & E. Kais, *Enzyklopädie der Psychologie. Spezifische Umwelten und umweltbezogenes Verhalten.* (pp. 595-642). Göttingen: Hogrefe.

Commission for Africa. (2005, March). *Commission for Africa.* Retrieved 10 18, 2010, from http://www.commissionforafrica.info/2005-report

Coolican, H. (1994). *Research methods and statistics in psychology.* London: Hodder & Stoughton.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989, August). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science, Vol. 35, No.8* , pp. 982-1003.

Dejene, T. (2001). *Women in Ethiopia.* Deutsch-Äthiopischer Verein E.V.

Department for International Development. (n.d.). *Department for International Development - Ethiopia*. Retrieved 12 06, 2010, from http://www.dfid.gov.uk/Where-we-work/Africa-Eastern--Southern/Ethiopia/

Dethloff, C. (2004). *Akzeptanz und Nicht-Akzeptanz von technischen Produktinnovationen.* Lengerich: Pabst Science Publishers.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (n.d.). Promoting Sustainable Development in Ethiopia. Addis Abeba, Ethiopia.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (1999). *Solarkocher in Entwicklungsländern. Akzeptanz und Markteinführung.* Eschborn: GTZ.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (2007). *Here comes the Sun - Options for Using Solar Cookers in Developing Countries.* Eschborn: Federal Ministry for Economic Cooperation and Development.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (2008). *Baseline Study. Access to Modern Energy Services in Ethiopia (AMES-E).* Switzerland: entec.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (2009a). *Target Market Analysis - Ethiopia's Solar Energy Market.* Eschborn, Germany.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (2009b). *Solar Lanterns Test: Shades of Light.* Eschborn: GIZ.

Deutsche Gesellschaft für Internationale Zusamenarbeit. (2010a). *Energising Development Report on Impacts.* Eschborn: GIZ.

Deutsche Gesellschaft für Internationale Zusammenarbeit. (2010b). *What difference can a PicoPV system make? - Early findings on small Photovoltaic systems - an emerging low-cost energy technology for developing countries.* Eschborn: GIZ.

Easterly, W. (2005). *Reliving the '50s: the Big Push, Poverty Traps, and Takeoffs in Economic Development.* New York: New York University.

Eckensberger, L. H. (2008). Kultur und Umwelt. In E.-D. Lanternmann, & V. Linneweber, *Enzyklopädie der Psychologie. Grundlagen, Paradigmen und Methoden der Umweltpsychologie* (pp. 237-272). Göttingen: Hogrefe.

Entwicklungspolitik Online. (2009, Januar 02). *Entwicklungspolitik Online*. Retrieved June 15, 2010, from http://www.epo.de/index.php?option=com_content&task=view&id=4531&Itemid=33

Festinger, L. (1957). *A theory of cognitive dissonance.* Stanford, California: Stanford University Press.

Fisch, J. (2000). *Licht und Gesundheit Das Leben mit optischer Strahlung.* Ilmenau: Technische Universität Ilmenau .

Flick, U. (2004). *Qualitative Sozialforschung. Eine Einführung.* Reinbek bei Hamburg: Rowohlts Enzyklopädie.

Flick, U. (2008). *Triangulation. Eine Einführung.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Füllkrug-Weitzel, C. (1999, June). Das Trauma äthiopischer Frauen. *Mission - Äthiopien* , pp. 24-27.

Gatignon, H., & Robertson, T. S. (1985, March). A Propositional Inventory for New Diffusion Research. *Journal of Consumer Research Vol. 11* , pp. 849-867.

Glaser, B. G., & Strauss, A. L. (1998). *Grounded Theory. Strategien qualitativer Forschung.* Bern: Hans Huber.

Goldemberg, J., & Johansson, T. B. (2004). *World Energy Assessment.* United Nations Development Programme; United Nations Department of Economic and Social Affairs; World Energy Council.

Grill, B. (2003). Ach, Afrika. Berichte aus dem Inneren eines Kontinents. Berlin: Siedler.

Grill, B. (2007). Wofür das Ganze? *DIE ZEIT* .

Gross, C. (2007). Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance. *Energy Policy 35* , pp. 2727-2736.

Hirschman, E. C. (1982). Symbolism and Technology as Sources for the Generation of Innovations. *Advances in Consumer Research Volume 9* , pp. 537-541.

Hofstede, G. (2001). *Culture's Consequences.* California: Sage Publications.

Huijts, N. M., Midden, C. J., Meijnders, & L., A. (2007). Social acceptance of carbon dioxide storage. *Energy Policy 35* , pp. 2780-2789.

Human Rights Watch. (2010). *Ethiopia: Repression Rising Ahead of May Elections.* Nairobi: Human Rights Watch.

International Energy Agency. (2003). *Summary of Models for the Implementation of Photovoltaic Solar Home Systems in Developing Countries. Part 1: Summary.* Paris.

Jandt, F. E. (2010). *An Introduction to Intercultural Communication. Identities in a Global Community.* California: SAGE Punblications.

Jo Hatch, M., & Cunliffe, A. (2006). Organization Theory. Modern, Symbolic and Postmodern Perspectives. In M. Jo Hatch, & A. Cunliffe, *Technology* (pp. 141-174). New York: Oxford University Press.

Kahneman, D., & Tversky, A. (1979, March). Prospect Theory: An Analysis of Decision under Risk. *Econometrica, Vol. 47* , pp. 263-292 .

Kaplan, A. W. (1999). From passive to active about solar electricity: innovation decision process and photovoltaic interest generation. *Technovation 19* , 467-481.

Kapuscinsky, R. (1995). *König der Könige. Eine Parabel der Macht.* Frankfurt am Main: Eichborn Verlag.

Kapuscinski, R. (1999). *Afrikanisches Fieber. Erfahrungen aus vierzig Jahren.* Frankfurt am Main: Eichborn.

Kaufmann-Hayoz, R., & Gutscher, H. (2001). *Changing Things - Moving People.* Basel: Birkhäuser.

Kaufmann-Hayoz, R. (2006). Human action in context: a model framework for interdisciplinary studies in view of sustainable development. *Umweltpsychologie 10 (1)* , pp. 154–177.

Kaufmann-Hayoz, S., Bruppacher, S., Harms, S., & Thiemann, K. (2010). Einfluss und Beeinflussung externer Bedingungen umweltschützenden Handelns. In H.-D. Lantermann, V. Linneweber, & E. Kais, *Enzyklopädie der Psychologie: Grundlagen, Paradigmen und Methoden der Umweltpsychologie.* (pp. 697-734). Göttingen: Hogrefe.

Kleinhückelkotten, S. (2005). *Suffizienz und Lebensstile. Ansätze für eine milieuorientierte Nachhaltigkeitskommunikation.* Berlin: BWV.

Kluckhohn, C. (1951). The study of culture. In D. Lerner, & H. Lasswell, *The policy sciences* (pp. 86-101). Stanford, California: Stanford Universtiy Press.

Krippendorff, K. (2004). *Content Analysis. An Introduction to Its Methodology.* California: Sage Publications.

Kumie, A., & Berhane, Y. (2002). Crowding in a traditional rural housing ("Tukul") in Ethiopia. *Ethiopian Journal of Health Development Vol.16* , pp. 303-308.

Lamnek, S. (2005). *Qualitative Sozialforschung. Ein Lehrbuch.* Weinheim, Basel: Beltz.

Lamnek, S. (2010). *Qualitative Sozialforschung.* Weinheim, Basel: Beltz.

Lighting Africa. (2008a). *Ethiopia - Qualitative Off-Grid Lighting Market Assessment.* Lighting Africa.

Lighting Africa. (2008b). *Lighting Africa Market Assessment Results Quantitative Assessment - Ethiopia.* Lighting Africa.

Lighting Africa. (2008c). *Kenya Qualitative Off-Grid Lighting Market Assessment.* Lighting Africa.

Lighting Africa. (2008d). *Tanzania Qualitative Off-Grid Lighting Market Assessment.* Lighting Africa.

Lighting Africa. (2008e). *Lighting Africa Market Assessment Results Quantitative Assessment - GHANA.* Lighting Africa.

Lighting Africa. (2008f). *Lighting Africa Market Assessment Results Quantitative Assessment - KENYA.* Lighting Africa.

Lighting Africa. (2008g). *Ghana Qualitative Off-Grid Lighting Market Assessment.* Lighting Africa.

Lighting Africa. (2009a). *Lighting Devices Test Results. Ethiopia Results.* Lighting Africa.

Lighting Africa. (2009b). *Lighting Devices Test Results. Ghana Results.* Lighting Africa.

Lighting Africa. (2009c). *Lighting Devices Test Results. Kenya Results.* Lighting Africa.

Lighting Africa. (2009d). *Lighting Devices Test Results. Tanzania Results.* Lighting Africa.

Lighting Africa. (2009e). *Lighting Devices Test Results. Zambia Results.* Lighting Africa.

Lighting Africa. (2010a). *Solar Lighting for the Base of the Pyramid - Overview of an Emerging Market* -. Lighting Africa.

Lighting Africa. (2010b). *Lighting Africa 2010 Outstanding Product Awards*. Retrieved December 23, 2010, from http://www.lightingafrica.org/node/109966

Luhmann, N. (2008). *Einführung in die Systemtheorie.* Heidelberg: Carl-Auer Verlag.

Madden, T. J., Scholder Ellen, P., & Ajzen, I. (1992). A Comparison of the Theory of Panned Behavior and the Theory of Reasoned Action. *Personality and Social Psychology Bulletin* , pp. 3-9.

Mayring, P. (2003). *Qualitative Inhaltsanalyse. Grundlagen und Techniken.* Weinheim: Beltz.

Mayring, P. (2010 (11. Ed.)). *Qualitative Inhaltsanalyse. Grundlagen und Techniken.* Weinheim, Basel: Beltz.

Messner, D. (2010, 07 02). *Bundeszentrale politische Bildung.* Retrieved 07 02, 2010, from Bundeszentrale politische Bildung: http://www.bpb.de/die_bpb/2V4F0M,2,0,Armut_und_Reichtum_in_der_Welt.html

Moosbrugger, H., & Kelava, A. (2007). *Testtheorie und Fragebogenkonstruktion.* Heidelberg, Germany: Springer.

Mruck, K., & Mey, G. (2010). *Handbuch Qualitative Forschung in der Psychologie.* Wiesbaden: VS Verlag Springer.

Nieuwenhout, F., de Villers, T., Mate, N., & Aguilera, M. E. (2004). *Reliability of PV stand-alone systems for rural electrification.* Universidad Politecnica de Madrid, Energy Research Centre of the Netherlands, Innovation Energie Development, Itpower India.

Österreichische Forschungsstiftung für internationale Entwicklung. (2009). *Working Paper 25. Budgethilfe in Äthiopien: Ein Dilemma für die Gebergemeinschaft.* Wien: Österreichische Forschungsstiftung für internationale Entwicklung.

Raju, P. (1980). Optimum Stimulation Level: Its Relationship to Personality, Demographics, and Exploratory Behavior. *The Journal of Consumer Research 7* , 272-282.

Rawlence, B., & Lefkow, L. (2010). *"One Hundred Ways of Putting Pressure" - Violations of Freedom of Expression and Association in Ethiopia.* United States of America: Human Rights Watch.

Reiche, K., Grüner, R., Attigah, B., Hellpap, C., & Brüderle, A. (2010). *A Primer on Pico PV.* Eschborn: GTZ.

Robertson, T. S. (1971). *Innovative Behavior and Communication.* New York: Holt, Rinehart & Winston.

Rogers, E. M. (2003). *Diffusion of innovations.* New York: Free Press.

Roselund, C. (2010, May 08). *Solarstrom für den Rest der Welt: Netzunabhängige Photovoltaik für Millionen Menschen*. Retrieved June 15, 2010, from Solarserver: http://www.solarserver.de/solarmagazin/download/solarstrom_fuer_den_rest_der_welt.pdf

Rosenstein-Rodan, P. (1943). Problems of Industrialization of Eastern and South-Eastern Europe. *Economic Journal* , 202-211.

Sachs, J. (2005). *The End of Poverty - Economic Possibilities for Our Time.* New York: Penguin Books.

Sahin, I. (2006, April). Detailed Review of Rogers' Diffusion of Innovations Theory and educational technology-related studies based on Rogers' Theory. *The Turkish Online Journal of Educational Technology* , pp. 14-23.

Sauter, R., & Watson, J. (2007). Strategies for the deployment of micro-generation: Implications for social acceptance. *Energy Policy 35* , pp. 2770-2779.

Schachenmann, U. *Licht an! Warum der Mensch nicht gern im Dunkeln sitzt.* Zürich.

Schöpfer, F. (2004). *Untersuchung über erfolgreich integrierte PPP's.* Frankfurt am Main: Gesellschaft für technische Zusammenarbeit (GTZ).

Schweizer-Ries, P. (2004). Nutzung von Solarstromanlagen. Ein umweltpsychologisches Thema. *Magdeburger Wissenschaftsjournal* , 27-34.

Schweizer-Ries, P. (2008). Energy sustainable communities: Environmental psychological investigations. *Energy Policy 36* , pp. 4126-4135.

Schweizer-Ries, P. (2009). Nachhaligkeit: Burnout eines revolutionären Anspruchs? Umwelt-Wirtschaft-Soziales: Zuspitzung eines Dauerkonflikts. *Loccumer Protokolle 71/08* (p. 136). Rehburg-Loccum: Evangelische Akademie Loccum.

Seitz, V. (2010). *Afrika wird arm regiert.* dtv.

Sherry, L. (1997). The boulder valley internet project: Lessons learned. *THE (Technological Horizons in Education) Journal* , pp. 68-73.

Shikwati, J. (2002). The developing world needs trade, not aid, to help the poor. *The Sydney Morning Herald* .

Solar Energy Foundation. (2010). *Sun connect. What is good Light?* Zurich: Solar Energy Foundation.

Spada, H. (1990). Umweltbewußtsein: Einstellung und Verhalten. In L. Kruse, C.-F. Graumann, & E.-D. Lantermann, *Ökologische Psychologie. Ein Handbuch in Schlüsselbegriffen* (pp. 623-632). Weinheim: Psychologie Verlags Union.

Steinke, I. (2008). Gütekriterien qualitativer Forschung. In U. Flick, E. von Kardoff, & I. Steinke, *Qualitative Forschung. Ein Handbuch.* (pp. 319-331). Reinbek: Rowohlt Taschenbuch Verlag.

Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. *Information & Management 33* , pp. 1-11.

Strauss, A., & Corbin, J. (1996). *Grounded Theory: Grundlagen qualitativer Sozialforschung.* Weinheim: Psychologie Verlags Union.

Stroebe, W., Jonas, K., & Hewstone, M. (2003). *Sozialpsychologie.* Berlin Heidelberg New York: Springer.

The International Bank for Reconstruction and Development / The World Bank. (2005). *World Bank.* Retrieved 10 18, 2010, from Global Monitoring Report: http://siteresources.worldbank.org/GLOBALMONITORINGEXT/Resources/complete.pdf

The World Bank. (1999). *Poverty Reduction & Equity- Listen to the Voices*. Retrieved 11 30, 2010, from http://go.worldbank.org/NTVCW2JYW0

The World Bank. (1999). *Voices of the Poor.* The World Bank.

Theuerling, H. (2010). Einflussfaktoren auf Technikakzeptanz bei Novizen und Experten. Technische Universität Darmstadt.

Transparency International. The Global Coalition against Corruption. (2010). *Transparency*. Retrieved 11 19, 2010, from http://www.transparency.org/policy_research/surveys_indices/cpi/2010/results

UNESCO. (2007). *The UN Decade of Education for Sustainable Development (DESD 2005-2014). The First Two Years.* Paris: UNESCO.

United Nations Development Programme. (2010). *Human Development Report 2010 - The Real Wealth of Nations: Pathways to Human Development.* New York, USA: United Nations Development Programme.

United Nations. (2005). *The Energy Challenge for Achieving the Millennium Development Goals.* United Nations.

United Nations. (2010). *The Millennium Development Goals Report 2010.* New York: United Nations.

Völlink, T., Meertens, R., & Midden, C. J. (2002). Innovating „Diffusion of Innovation" theory: Innovation characteristics and the intention of utility companies to adopt energy conservation interventions. *Journal of Environmental Psychology 22* , pp. 333-344.

Warner, K., Ehrhart, C., de Sherbinin, A., Adamo, S., & Chai-Onn, T. (2009). *In Search of Shelter- Mapping the Effects of Climate Change on Human Migration and Displacement.* Bonn, Germany: prepared for Climate Negotiations.

Werner, C. M., Altman, I., & Brown, B. B. (1992). A Transactional Approach to Interpersonal Relations: Physical Environment, Social Context and Temporal Qualities. *Journal of Social and Personal Relationships* , pp. 297-323.

Werner, C. B., Brown, B. B., & Altman, I. (2002). Transactionally Oriented Research: Examples and Strategies. In R. B. Bechtel, & A. Churchman, *Handbook of Environmental Psychology* (pp. 203-222). New York: John Wiley & Sons.

Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen. (2004). *Welt im Wandel. Armutsbekämpfung durch Umweltpolitik.* Berlin: Springer.

Wiswede, G. (2007). *Einführung in die Wirtschaftspsychologie.* Stuttgart: UTB.

Witzel, A. (2000, January). *Das Problemzentrierte Interview.* Retrieved March 23, 2010, from Forum Qualitative Sozialforschung / Forum Qualitative Social Research [Online Journal]: http://qualitative-research.net/fqs

Wortmann, K. (2010). Energie. In V. Linneweber, E.-D. Lantermann, & E. Kais, *Enzyklopädie der Psychologie. Spezifische Umwelten und umweltbezogenes Verhalten* (pp. 409-436). Göttingen: Hogrefe.

Wüstenhagen, R., Wosink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy 35* , pp. 2683-2691.

Yunus, M. (2007). *Banker to the Poor - Micro-lending and the battle against world poverty.* United States: PublicAffairs.

VIII. APPENDIX

Appendix A: Interview Guideline

Appendix B: Group Discussion Guideline

Appendix C: Questionnaire for Kerosene Utilization Assessment

Appendix D: Photographs of the field study

Appendix E: Declaration

Appendix F: Interviews (CD)

Appendix G: Detailed Mind Map of System of Categories (CD)

Guideline Interview

Stimulation to tell about one's experiences:

"This interview will help us to get to know which type of lamp is most useful for you and your community. It is the first time that not a Western country choose the lamp, but you on yourself. In this kind of way, we want to electrify many villages in Ethiopia with your help.

There is no „right" or „wrong" answer. We would like to get to know your personal opinion about the solar lamps, therefore you can't give a wrong answer.

I already talked to a shop owner in another village. This was very interesting and helpful for me because the shop owner told me every detail about each difference, the use of the solar lamp makes for her. She said that she could see much more even in the night and thus selling her things is much easier. She even could sell more things. On the other hand she told me, that she could not use the lamp in her second room, the bedroom, because the solar system was not mobile. Therefore, she still has to use a candle there. But she'd like to buy another lamp, when she has enough money.

So I am very happy, if you'd tell us your experiences with the solar lamp you tested last week (show a foto). What have you experienced?

Please tell me about your week with this solar lamp!

What do you like about the lamp?

Technique (diversity, functions)
Ease to put up?
Mobility
Fault tolerance / errors / problems
Appearance / design

How would you describe its appearance?

color,
weight
operation
pleasure/ delightful / fun / enjoy to use?

How has your family used the lamp?

for which activities,
when,
who,
how long

where (outside/mobil)?
Which necessary compromises did you make between the members of family?
(Have you used the mobile charger? How long/ often?)

How would you describe the quality of the lamp

color of light,
quality of light,
cone of light,
robustness,
charging

Which member of your family likes the lamp the most? Why?

Are you satisfied with the lamp?

Why /why not?
What else do you need to be completely satisfied with the solar system?

Which problems did you experience using the lamp?

Problems
Technique:
Noise of the lamp
heat
errors (ease to turn off?)
charging
warranty (→ broken?)
community

What is useful about the lamp? How has your life changed by the use of the lamp?

In which way was the lamp helpful in your day to day life?
Which negative consequences have you experienced?

Please describe the ease of operation

Comfort
Easieness / Intuitiveness
Doing without thinking?

Which type of lamp do you prefer? Why?

Guideline Group discussion

Greeting

Explanation: Thanks a lot, that you are willing to participate in this discussion. It is very important to us and you help us a lot to check, which lamp meets your needs. We want to find out which type of lamp is best. In addition we want to find out how to make the lamp available for as many people in the village as possible!

Which lamp is the best? Why?

Possible questions, which can be asked, if there is no discussion / people don't know what to talk about:

What is especially important?

Which feature is the best?

What is the crucial factor to buy the lamp?

If you were responsible for the solar lamps, which changes would you make at first?

What should be changed about the solar lamps to transform it into a great offer?

What would you tell your best friend about the solar lamp?

Please tell me five positive/negative aspects about the solar lamps. It doesn't matter how small or important they are.

Imagine you are responsible for selling the solar lamps. What would you point out to stimulate the sales?

What kind of things should the solar lamp have, in order that you rate it as attractive?

What can you do to make a solar lamp available for as many people in the village as possible?

duty/ tax system?

Share?

Lend?

Which way is the best to diffuse / dispread the lamp in the other villages?

How can the people be informed?

How can they be convinced that it is a good technology / that it works?

How should the sales be arranged? (contract?; instant/direct payment, rates, …)

Questionnaire for Kerosene Utilization Assessments

Date of interview_____

Name of respondent_____

I) Biography

1) Sex of the family head: a) male b) female

2) Total No of family size_____

3) How many houses belong to your household?_____

4) Major occupation of the family:

a) Governmental employee b) Non-governmental employee c) Private employee

d) Trader e) Farmer f) Gastronomy g) Cottage industry h) Daily laborer

i) Pension d) Other specify_____

5) Highest level of education of one of the household members? 1. None, 2.Primary,

3. Secondary, 4.Technician, 5.University

6) Average monthly income of the family (includes all the family members):

a) Below 50 birr b) 51-100 birr c) 101-200 birr d) 201-500 birr

e) 501-1000 birr f) 1000-2000 birr g) over 2000 birr

7) What kind of electrical equipment you have?

a) Radio b) tape c) mobile phone d) all e) other_____

What is the regular occupation of each household member? (multiple answers possible) CODE MAIN OCCUPATION=1 FURTHER OCCUPATION =2								
	1. School	2. Agri-culture	3. Commerce	4. Artisan	5. Construc-tion worker	6. Tech-nician	7. Domestic work	8. Other What?
1. Head of household								
2. Spouse								
3. Children < 16								

7) If there were three things you could do to improve your household or its facilities, what would these be?

(Better lighting, Better access to water, Better toilet facilities, Better bathing facilities, Better kitchen, Improved furniture, Better communication, Better media access, Increase size of dwelling/home, Improve security, Improved structure itself (upgrading the roof, walls, windows, doors))

8) What do you use the cell phone mainly for? ONE CODE ONLY

a) call friends/family b) work c) entertainment d) other, what?

II Fuel Consumption

4. Which of the following Energy sources do you use in your household?	5. Code the most important ones 1= most important	6. Quantity per typical week	7. Unity price	8. Expenditures per typical week	9. Place of purchase	10. Distance to the place of purchase	11. Time of purchase per week
1.- Candles		_____Pieces	One candle			_____Km.	_____h
2a.- Kerosene for illumination		_____Liters	One liter			_____Km.	_____h
2b. Kerosene for other		_____Liters				_____Km.	_____h
3a.- Dry cell batteries for lighting		_____Pairs	One pair			_____Km.	_____h
3b.Dry cell batteries for radio		_____Pairs				_____Km.	_____h
4.- Car battery		_____Piece	One pair			_____Km.	_____h
5.- Gas		_____Liters	One bottle			_____Km.	_____h
6. Wood		_____Package	One package			_____Km.	_____h
7. CHARCOAL		_____Kg	One sac/kg			_____Km.	_____h
8. Diesel/ fuel (generator)		_____Liters	One liter			_____Km.	_____h
10.- Other		_____( )	Unity___			_____Km.	_____h.

Where do you take it from?_____
Who buys/ collects it?_____
Where is the lighting device located? _____
Did the use of one of the lighting devices have caused any accidents in your household?
What is your preferred type of light? (except Solar) _____
9) What is your major energy source for lighting purposes? a) Wood fuel b) Kerosene c) both wood fuel and Kerosene d) Other specify_____
10) What would you or other members of your household do at night if you had better light?_____
General comment of the enumerator _____

Shop in the village with a solar panel on its roof.

Woman with a PicoPV system in front of her house.

Part of the village's community at the distribution.

Familiy with a PicoPV system.

Girl studying in the light of a Solar lantern.

Child during the weekly rotation.

Charging the PicoPV systems.

Declaration

Declaration according to § 27 Abs. 7 APB of the Diplomprüfungsordnung

I declare that I have written the present thesis by myself, and that I have not used any other resources than the ones listed. All literal and other citations have been marked as such. I have not submitted this thesis for evaluation purposes at any other institution.

Erklärung gemäss § 27 Abs. 7 APB der Diplomprüfungsordnung

Hiermit versichere ich, die vorliegende Arbeit ohne Hilfe Dritter nur mit den angegebenen Quellen und Hilfsmitteln angefertigt zu haben. Alle Stellen, die aus den Quellen entnommen wurden, sind als solche kenntlich gemacht worden. Diese Arbeit hat in gleicher oder ähnlicher Form noch keiner anderen Prüfungsbehörde vorgelegen.

Hannah Müggenburg
2011, Darmstadt, Germany