

Rural Electrification with Aid of Decentralized Renewable Energy

An impact study on the livelihood capitals of the end users and sustainability of the solar home system component of the IDTR electrification project in Bolivia



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Master Thesis
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*Cover Photo by Juan F. Carvajal García
Taken in Casira Chica Bolivia 2008*

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In collaboration with

Energética – ‘Energía para el desarrollo’
www.Energética.bo.org
Cochabamba – Bolivia



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“We cannot solve our problems with the same thinking we used when we created them.”

– Albert Einstein –

Foreword

The following text presented here before you is my master thesis. This report took a bit longer to write than the average thesis, due the chosen research location. Spending time in Bolivia for my research project gave way to valuable lessons which could not have been learned if I had stayed at home. Throughout my time in Bolivia, I was assisted by many great people in different sorts of ways and I would like to take the opportunity in thanking them for making this experience possible.

I would like to start thanking Energética in Cochabamba. Without the cooperation of Miguel Fernandez and Edgar Terrazas, the following research would not have been possible. From the technical crew which assisted me during the two weeks of fieldwork in Villazon, I would like to thank Raul, Enrique and Johnny for their help and assistance during that period. I was able to witness firsthand the work that Energetica carries out in the quest of electrification for rural development and I can truly appreciate the work that they are doing for the rural communities in Bolivia.

During my time in Bolivia, I was living the majority of the time in Sucre. During that period I was welcomed by Fundación PASOS to work in their office while preparing my research. Therefore I would like to thank PASOS for their hospitality. And Roxana Dulón for her hospitality and willingness to help during my stay. Social contacts are important anywhere you are in the world and so I would like to thank all of the great people that I met during my stay, that helped me feel at home.

Last but not least, I would like to thank Ton van Naerssen for his input as my supervising professor of this thesis. Furthermore, I would like to thank my family and friends at home, who provided me with their support. And my girlfriend, who fortunately was able to accompany me during my time in Bolivia, for her own research.

Juan Carvajal

October 1st 2008

Table of Contents

List of Figures	I
List of Tables	II
List of Abbreviations	III
Summary	IV
1 Introduction	6
1.1 Rationale for the study	6
1.1.1 Research Aim	7
1.2 Central Questions	7
1.2.1 Terminology	7
1.2.2 Brief theoretical introduction	8
1.2.3 Sub-questions.....	9
1.2.4 Elaboration on the sub-questions.....	9
1.3 Research relevance	10
1.3.1 Societal relevance	10
1.3.2 Scientific relevance	10
2 Theoretical Framework	12
2.1 Introduction	12
2.2 The Livelihood Approach	12
2.2.1 The livelihoods perspective	12
2.2.2 The sustainable livelihood framework.....	14
2.3 Sustainability	16
2.3.1 The term Sustainability	16
2.3.2 Definition of project sustainability.....	17
2.3.3 Indicators for sustainability.....	17
2.3.4 Sustainability assessment	21
3 Empirical Framework	23
3.1 Introduction	23
3.2 Renewable energy: a short review	23
3.2.1 Solar	23
3.2.2 Wind.....	24
3.2.3 Water	25
3.2.4 Biomass	26
3.2.5 Miscellaneous	27

3.2.6	Energy production Bolivia	27
3.2.7	Renewable energy and livelihoods	27
3.3	Energética	28
3.4	Research Methodology	29
3.4.1	Literature study.....	29
3.4.2	Survey.....	29
3.4.3	Interviews.....	30
3.4.4	Observations	30
4	The IDTR and the local context	31
4.1	The IDTR project	31
4.1.1	Introduction	31
4.1.2	Actors	32
4.1.3	The solar home system component.....	33
4.2	Area of Villazón	36
4.3	The respondents; difficulties and challenges experienced.....	36
4.4	Geographical representation of the four communities surveyed	38
5	Impact assessment	40
5.1	Natural capital	40
5.2	Financial capital.....	43
5.3	Physical capital	47
5.4	Human capital	49
5.5	Social capital.....	51
5.6	Expectation of new SHS users.....	55
6	Project sustainability review.....	57
6.1	Human factors	57
6.2	Economic factors	59
6.3	Institutional factors	61
6.4	Miscellaneous factors	63
6.5	Previous experiences with renewable energy in Bolivia	64
7	Conclusion	66
	References	70
	Appendixes	73
A	Table of survey questionnaire with new users	73
B	Survey questionnaire taken among the existing with a SHS	74

List of Figures

Figure 1: The sustainable livelihood framework.....	14
Figure 2: Livelihood asset pentagon	15
Figure 3: Research model.....	1
Figure 4: SHS differentiation table.....	34
Figure 5: ANED SHS information leaflet.....	35
Figure 6: Relative geographical position of Villazón (red) Bolivia.....	1
Figure 7: Geographical locations of Quichina, Chaquicocha, Tica Cancha and Casira Chica	1
Figure 8: Bar displaying changes in the users land production since the SHS	1
Figure 9: Photo of pottery works as often found outside respondents homes	44
Figure 10: Photo illustrating a SHS warranty breach	1
Figure 11: Types of SHSs installed in Casira Chica	1
Figure 12: Photo displaying system components and instruction poster inside the users house	62
Figure 13: Photo of battery disposal at a surveyed household	63

List of Tables

Table 1: Cooking environment and the corresponding fuel of choice.....	41
Table 2: Changes in air quality and reductions in smoke produced by lighting sources	42
Table 3: Change in access to and quantity of drinking water	43
Table 4: Credit takers and financial difficulties.....	44
Table 5: Earnings and savings related to the SHS	45
Table 6: Types of fuels bought and the related savings since the SHS.....	46
Table 7: Electric equipment and uses for it	47
Table 8: Change in access to electricity, relative power and usage	48
Table 9: Change in electric equipment usage and communication tools usage	49
Table 10: Relation between SHS as facilitator for new and current activities and objectives	49
Table 11: Changes in education time and available knowledge and skills	50
Table 12: Change in health related to SHS.....	51
Table 13: Change in usage of different communication means since SHS	52
Table 14: Change in social contacts and opinion on change	52
Table 15: Changes in social activities, consequences and relation to the SHS.....	53
Table 16: SHS advantages and social inclusion	54

List of Abbreviations

ANED	Asociación Nacional Ecuménica de Desarrollo
DC	Direct Current
ESCO	Electric Service Company
GPS	Global Positioning System
IDTR	Infraestructura Descentralizada para la Transformación Rural
kW	Kilowatts
MAS	Movimiento al Socialismo
MSC	Medium Term Service Contract
MW	Megawatts
NGO	Non Governmental Organization
PV	Photovoltaic
SHS(s)	Solar Home System(s)
SHSC	Solar Home System Component
WCED	World Commission on Environment and Development
Wp	Watt Peak

Summary

Bolivia is one of Latin America's poorest countries. When it comes to development and the level of electrification, this fact is reinforced as only 65 to 70% of the population has access to electricity. The following research being presented took place in four dispersed rural communities in the municipality of Villazón (department of Potosí). These communities are located in close proximity to the Argentine border and are characterized by subsistence farming and small scale handicraft works as means for making a living. The respondent group to this investigation was accessing electricity by means of a decentralized solar home system, made available by a nationwide government project called the IDTR. In previous renewable energy initiatives for rural electrification, little is known about the impact on people's livelihoods. Previous studies often only refer to this in generalist terms of improvement. For this investigation the following central questions were posed:

(A) What is the impact of the new electric services provided by the solar home system component (SHSC) of the IDTR project on the livelihood assets of the end users?

(B) How sustainable is the IDTR SHSC project until now based on the impact assessment and the project sustainability review?

In order to answer the central questions, two main key dimensions were researched. The impact on people's livelihood asset portfolio, through a partial adaptation of the sustainable livelihood framework. And the project sustainability of the IDTR, focusing on its capability to last as a successful project. For this, the author has travelled to Bolivia and has worked in cooperation with Energética (an executor organization of the IDTR project), to gain further on-site information into the working of the IDTR project in one of the many locations. A visit to end users of solar home systems was paid during a yearly maintenance revision and installation trip into this zone. With this visit, the end users participated in a survey to assess the impact on their livelihood capitals as a result of their acquired solar home system.

During two weeks a respondent group of 39 people answered survey questionnaires which were used to analyze the impact on the livelihood asset portfolio and their corresponding livelihood capitals. An additional eight users were having a SHS installed during the same period and were also questioned about their expectations. Questioning rural users about their use of the SHS and the changes which have occurred proved to be a difficult task, primarily because of trust issues by rural inhabitants and a low level of interest. These factors combined, made it difficult at times to achieve accurate results. For the rest of the information, project documentation was gathered and interviews were conducted with key actors of the project.

The main actors that have been consulted for the analysis, were the vice ministry of electricity and alternative energies (project manager), Energetica & Isofoton (as the executors of the solar home system component) and ANED (the organization responsible for the credit component).

The solar home system component of the IDTR project has provided the new users with an extra asset in the form of a SHS for electricity. These SHSs were available in four different types (22Wp, 36Wp, 55Wp and 75Wp) with a limited capacity to power small electric equipment and provide lighting for up to 3 rooms. The SHS has brought about a change into livelihood capitals of the end

users. This impact has been analyzed and is rated as positive. However it can also be concluded that the impact - although positive - has also been limited to a certain extent, regarding the users' social capital, human capital and natural capital. The major impacts were noticed on the financial and physical capital in the livelihood asset portfolio of the SHS users. Since the acquirement of the SHSs, the rural households have been able to save on traditional forms of fuels such as candles, batteries and gas lamps. This is a significant improvement due mainly to the amount and quality of light provided by the system. The light has also created an advantage for the productivity of night time activities. In the area of this research, it created an increase in the working hours for pottery making and consequently a bit more earnings from this activity.

According to the on-site observations, the acknowledged impacts and the project setup, the IDTR project can be labeled as a successful project up to the time of the research. It exhibits qualities that will prolong the project sustainability. Among such qualities is the four year service and warranty component for the solar home systems. With this tool, the end users of solar home systems are receiving yearly maintenance for the first four years and warranty on the system components. The yearly maintenance for four years not only serves to provide customer satisfaction, but it also increases the chances to capacitate the users during the annual maintenance, as the process of education is proven to be very important for the lasting and correct use of solar home systems. Despite trends of outward migration in this zone, user interest is still high and people seem keen on purchasing a system for their home. This interest among new potential users, the positive impacts witnessed in the research area and the current credit system as a delivery mode, have all contributed to the current high state of project sustainability.

1 Introduction

1.1 Rationale for the study

We are entering an era in which our energy supply is increasingly being put under pressure due to our current and past day practices of unsustainable energy exploitation and ever increasing demand. Energy is a key factor for economic growth as well as development in general. In fact it has been stated that there is a positive relation between electricity generation and the overall wealth of a country (Richards, 2006, P. 2). It could be said that at the moment we are facing an energy crisis, based on the unsustainable use of fossil fuels and oil prices continuously making the headlines. One way to tackle this energy crisis is by applying and improving our current technology for a more sustainable and renewable way of energy production. Renewable and sustainable energy development is gaining ground due to the sky rocketing oil prices and global challenges posed by the threats of global warming and it's accompanied climate change, putting renewable energy high on the development agenda.

In the development field, sustainability and sustainable development play a major role and are increasingly being advocated through all layers of current day society. Renewable energy production in the forms of solar photovoltaic (PV), wind and hydro are some of the common methods being applied to date in order to bring energy to those where; common grid electricity is not viable, not affordable and simply not the best option. This is where decentralized renewable energy production plays an important part. Decentralized renewable energy productions systems such as solar PV energy, can be setup in rough terrains where regular mainstream grid electricity is not viable. Furthermore on both a macro and micro scale, renewable energy can provide a way for developing regions and sub regions to rid themselves of their energy dependency.

The impact that renewable energy can have on development is great and it requires careful assessment. One of the ways in which such renewable energy projects can impact people is through the addition of a new asset, namely electricity. Making people capable of carrying out different activities previously not possible and impacting other aspects of their lives. Electricity as an energy service for these people has the potential to alleviate poverty, as the access to electricity is what matters for human development, activities and fundamental growth (WEAO, 2004, P.35).

This research will focus on (1) decentralized renewable energy in particular as the method for supplying energy services to people in isolated rural communities and (2) how such services have impacted the people and their resources for a livelihood. Focusing not so much on the combination of renewable energy and climate change, but rather renewable energy for development purposes. Although there are alternative methods for generating electricity besides renewable technology methods, the continuous rise in price of fossil fuels makes these less viable and unsustainable for low demanding isolated rural communities.

It is commonly understood that renewable energy is a sustainable and a better way of energy production than the current day practices of fossil fuel production (although momentarily renewable energy may not be competitive enough for high scale production). On the other hand little is known

about the sustainability of renewable energy projects themselves in terms of lasting appeal for the locally targeted people and the impact on their livelihood assets due to the electric services. It is this particular aspect in which the following research will also be focusing upon.

1.1.1 Research Aim

The main goal behind this research is to gain insight into the impact of the solar home system component of the IDTR project in Bolivia, by studying the impacts on the livelihood asset portfolio. The latter will be done by analyzing the changes brought about to the different livelihood capitals available to the people. And with additional information, to review the project's sustainability based on the impact on the livelihood assets and project sustainability criteria.

Reaching this goal means carrying out an impact assessment of the SHSC of the IDTR project on the livelihood assets and thereby also relating the concept of sustainability behind such types of projects within the real life practice. This goal will therefore contribute to the current debate on the sustainability of renewable energy projects. Helping to reach a better understanding on the impacts such a project may have on rural households. Thereby coming to a better understanding on how negative or unwanted impacts, if present, can be avoided when applying renewable energy in development help, more precisely so in the case of rural electrification with the aid of renewable energy systems.

1.2 Central Questions

- A What is the impact of the new electric services provided by the solar home system component (SHSC) of the IDTR project on the livelihood assets of the end users?**
- B How sustainable is the IDTR SHSC project until now based on the impact assessment and the project sustainability review?**

1.2.1 Terminology

Impact

The word impact is commonly defined as, "the effect or impression of one thing on another"¹. In the context of this research, the impact is indeed used to refer to the effect that the project SHS has had on the end users' livelihood assets due to this intervention.

Electric Services

This term encompasses all services provided to the targeted population thanks to electricity in the form of a solar home system. Meaning that electric light provided is a service as well as the electric outlets provided to connect small electric equipment.

¹ <http://www.thefreedictionary.com/impact>

Livelihood Assets

The livelihood assets form an integral part of the livelihood framework. These assets are illustrated in the form of different kinds of capitals (resources available to people). These capitals are respectively; the human, natural, physical, financial and social capital which encompass the asset portfolio. These different capitals are the underlying functions to the livelihood assets².

Sustainability

Because of the broad array of definitions in the term sustainability, the definition used for this research will specifically be derived. First of all the sustainability dimension in this case concerns primarily project sustainability. This means that the lasting appeal of the project will be the primary focus. Secondly this definition has a soft focus on the environmental dimension as in practice this is very difficult to measure without a prior environmental study³.

IDTR

The IDTR project will form the main focus of the investigation. It is the governments current nationwide electrification project in Bolivia. IDTR stands for: "Infraestructura Decentralizada para la Transformacion Rural", which literally translated stands for; decentralized infrastructure for rural transformation⁴.

1.2.2 Brief theoretical introduction

Before dealing with the sub questions, this paragraph will give a very brief theoretical underpinning of the research and the questions derived from this. The theoretical framework further on will expand on the following.

The research at hand seeks to find out the impact of renewable energy systems, such as a solar home system on the livelihood assets of the targeted population as well as the sustainability of such a project. In order to research this dimension a renewable energy project for decentralized communities was chosen, the nationwide IDTR project of Bolivia and its corresponding solar home systems component.

Previous studies similar to this, regarding impact of decentralized renewable energy on the population have made very general remarks on what they consider the impact to be. It is this shortcoming in which the following research seeks to expand the information available. And more specifically the social aspect, focusing on the livelihood assets of the people. This is why it is chosen to measure impact with the resulting changes brought forward in the different types of capitals people make use of. The livelihood assets come forth from the livelihood approach which characteristically is a holistic and people centered approach, placing the person as the main empirical unit of analysis.

² For further elaboration on livelihood assets see chapter 2

³ For further elaboration on sustainability see chapter 2

⁴ For further information on the IDTR see chapter 4

Sustainability is another key aspect in this research. This particular aspect plays a role since it is common to assume that renewable energy is sustainable and therefore so must be decentralized renewable energy projects. However the way energy is produced and how people benefit from this energy can have very distinct outcomes for sustainability. It is therefore necessary to consider other aspects of the project besides the direct energy generation method in order to make sustainability judgments on the project itself in terms of its lasting appeal.

1.2.3 Sub-questions

1. How are the IDTR and its SHSC setup?
2. What were the energy supply methods of the end users before the SHS?
3. What constitutes the new electric services being provided to the targeted population?
4. What are the livelihood assets of the target population at the start?
5. What are the current livelihood assets of the target population?
6. What factors have influenced the project sustainability criteria?

1.2.4 Elaboration on the sub-questions

Question one is introductory into the research case, that is the IDTR. Before beginning to deal with the main questions, some background to the project and general setup is necessary to better understand the context as well to get insight into project details, which will be of value for making the sustainability and impact assessments. This question will lay out general information concerning the IDTR and more specifically its SHS component.

Question two is to reach an understanding of what kind of energy supply methods the people had before the SHS. Not so much the direct electricity generation as is the case now, but other generating fuels for daily purposes such as candles, biomass, diesel, gas and such.

Question three will give a description of what the new electric services are for the end users of the SHSs. With this information in mind a general idea will be given of what the end users can do with these services and also what the possible limitations are.

Question four deals with the livelihood assets portfolio. It will try to identify the different capitals and give examples in which form these are available to the end users in their direct environment. This is necessary to later determine what possible changes can occur as a result of the intervention, that is the SHSC of the IDTR.

Question five, logically following question four, will deal directly with the different capitals that are available to the people now and trace to what extent these have changed since the installment of the SHS. The capitals that will be looked at are the; human, natural, physical, social and financial capital. As outlined in the sustainable livelihood framework, these will come forth in the survey.

Question six builds up on the information gathered on the changes in the different capitals of the asset portfolio, together with the information about the SHSC setup and other miscellaneous

information. These factors influence the proposed project sustainability criteria and will provide a basis for the project sustainability assessment of the IDTR SHSC.

1.3 Research relevance

1.3.1 Societal relevance

At the present day, renewable energy is strongly intertwined with the debate on climate change. At the same time development aid continues to try to reach those in need in most of the developing world. Linking these aspects together in the development circle, translates to sustainable development. In relation to the climate change predicament which has many socio-economic repercussions, a way to tackle this problem is by adapting energy production with means of renewable technologies. However relevant climate change may be and the promoting position it has for renewable energy, the fact remains that renewable energy brings with it the a very simple yet effective means of energy services to those who lack access to them, while at the same time promoting development in a more sustainable way.

The proposed research will be of added value to society in general and also in the development sphere, for any future projects concerning decentralized electrification with renewable energy. As valuable information gathered can inform us better about the impacts that a renewable energy project has on livelihoods and its sustainability for future applications. This is something of great value for those living in areas where development is taking off, governments wishing to expand their electric coverage and as well as for development agencies working with electrification. Making sure they do not follow unsustainable paths as did most of the world in the past century, but also to come to the most effective and sustainable way of electricity densification for general development. It is crucial to put our modern day technologies and knowledge in to use, in order to avoid any further problems in the near future.

1.3.2 Scientific relevance

Renewable energy and its use in the context of developing countries is something which is increasingly gaining ground as a way to ensure sustainable development. Several studies have been carried out concerning renewable energy systems for rural/isolated communities. However many authors often treat the matter in a very technical manner, expressing feasibility of certain systems in terms of costs and watts per hour as well as productivity increase in the local production of goods. These types of studies by consequence form the majority pertaining to renewable energy in the rural context. Many neglect the social component which such energy projects can have on communities and their targeted households.

Gustavsson and Ellegård speak of the impact of solar home systems on livelihoods in the rural Zambian context (Gustavsson & Ellegård, 2004). Although they study the impact on livelihood, their study focuses largely on the energy service companies (ESCO's) providing the electric services to the people and making fairly general remarks on the livelihood changes. Their study is to some extent similar to the study as outlined for this investigation. It primarily differs in the sense that the authors review the electric services provided by an ESCO using solar photo voltaic energy systems. The

people simply pay for these services and have little to none to do with the photo voltaic systems themselves, since the maintenance and materials are the task of the company providing the electric services (e.g. light). However as mentioned above, the social component seems to be left out in their study. Too little attention is paid to the livelihood framework in which the study of Gustavsson and Ellegård outlines.

A similar study was carried out by C. L. Gupta focusing on the role of renewable energy technologies in generating sustainable livelihoods (Gupta, 2003). Gupta emphasizes more on the generation of sustainable livelihoods by adapting current income earning activities, such as small scale industry, by using renewable energy in order to improve productivity, create jobs and ensure competitiveness and survival. Gupta discusses several successful diverse projects in India and describes their respective goals and results very briefly. In his description of the cases several aspects are described as well as the impacts achieved by such projects. However once again the livelihood aspect is taken for granted as no exact details are discussed and it is generally assumed that the livelihoods have become sustainable. What exactly is sustainability in this context and what constitutes a sustainable livelihood is not elaborated upon.

The study as proposed here, will be adding to the scientific debate on the impact of renewable energy projects. As outlined above, the two authors speak of impact as well as the role of renewable energy in this. However the problems here are the two components which seem to be neglected around this issue. One is the sustainability component. What is sustainable in the context of such projects? And are renewable energy projects always sustainable? If so, in which way are these sustainable? Secondly what exactly is the impact on livelihoods brought forward by such projects? Livelihoods are a complex social construction affected by many different types of variables. In the context of renewable energies for rural/isolated communities it is these two components which the following research will focus upon in order to reach a better understanding of the impact and sustainability of decentralized renewable energy projects have on rural isolated communities and their households.

2 Theoretical Framework

2.1 Introduction

In order to research the impact of a decentralized renewable energy project, a certain change must be traced. The situation like it was before and the situation like it is now after the implementation of the project. Whether this change has been positive, negative or neutral is what the impact is all about. In the case of decentralized renewable energy, people are given or offered new ways to access electricity. In the case of the IDTR, this is achieved by a solar home system made available through micro credit. How people are impacted can be traced in the changes made in their livelihoods as a result of an extra asset such as the SHS and the provided electricity.

For this theoretical framework I opted for the sustainable livelihood framework, more specifically the livelihood assets portfolio component, as the main tool to research the impact brought on with the solar home systems of the IDTR. The paragraphs to come will sketch the livelihood approach as well as the sustainability dimension and how these will be applied in this theoretical framework.

2.2 The Livelihood Approach

The terms livelihood and livelihood approach are encountered hand in hand with poverty and development in the literature. This consequently at the same time characterizes the livelihood approach. That is to perceive poverty differently, in order to reach a deeper understanding and develop better strategies to help people in poverty situations. This approach clearly separates itself from other macroeconomic approaches in combating poverty and stresses the importance of the individual in terms of capacity and capabilities to be part of the solution (Kaag, 2004). In the context of decentralized renewable energy for isolated rural communities in Bolivia, this approach has its advantages as it is geared towards this kind of poverty situations.

2.2.1 The livelihoods perspective

Although the livelihood approach is increasingly gaining importance, it is not a new concept. The term livelihood has been used since the 1940's by Evan Pritchard to describe the strategies of the Nuer people for making a living (Kaag, 2004, P.2). The term has since then been increasingly used in the social sciences and has more recently been subject of debate and implementation into policies.

To gain a better understanding of the livelihood approach, it's necessary to know what exactly is meant by livelihood. As mentioned above, the livelihood approach differs from other approaches on poverty, perspective wise. This different perspective is that it, "... aims to be people-centered, non-sectoral and it is grounded in the multidimensional reality of daily life" (Kaag, 2004, P.1). Another most common definition is that of Carney (Carney, in de Haan & Zoomers, 2003, P.6), "a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from

stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base”.

Within this livelihood approach several frameworks for analysis are adapted for specific situations. One such adapted framework is that of sustainable rural livelihoods by Scoones (1998, P.4). Scoones’s framework is based on the sustainable livelihoods framework of the DFID (Department for International Development, 1999). He also negotiates several livelihood definitions to adapt for his own use, which according to him characteristically typifies the livelihood term. This ability to adapt itself to the context at hand, has given the livelihood approach a prominent position in development issues.

Taking this diversity into account, is what distinguishes the livelihood approach as a versatile one in the sense that it studies the human subject in the context of the subject’s personal life, which in reality is very complex. This diversity makes the livelihood approach suitable for multi disciplinary perspectives. In the case of human geography where the relation between man and his environment is central, the livelihood approach is in par with this view. Although this diversity of multi disciplinary perspectives can at the same time create weaknesses, making it difficult to derive a common theory. However when certain patterns do emerge, it may occur that theories can be applied to several problems in different contexts. None the less some still criticize that the sustainable livelihoods approach is an over ambitious one and that it still needs to prove itself on a more practical level (Carney, 1999). It is also stated that the livelihood concept with its increasingly holistic outlook, may put it at risk of becoming a “... container for everything that occurs in human life and thus will lose its analytical value” according to de Haan and Zoomers (2003, P.7).

The danger of arriving at a common theory or consensus has been illustrated in practice. Bebbington (1999, P.2021) speaks of such short comings in the context of rural livelihoods in the Andes. He illustrates how livelihood strategies have failed. This is according to him due to a wrong perception of rural livelihoods which get categorized into agricultural and resource-based strategies by organizations, when in fact they should come to a deeper understanding of what it is the people want and what is available to reach that goal.

The livelihood approach, like many others, is also susceptible to greater discourses depending on the author or organization. In practice this means that livelihood analysis frameworks in the development field may get adapted accordingly to a certain way thinking. Bebbington (2000) warns the reader about such threats in his example of the Andes, where he raises the question of whether the Andes people are viable. This forms a threat because of the fact that hegemonic neo-liberal frameworks (viewing viability of rural places in terms of economic competitiveness) may endorse certain policies which would mean the end of the ‘campesino’⁵ sector in the Andes (Bebbington, 2000, P.499). Zoomers (1999) reasserts this warning about misperceived aid strategies that have failed Andean farmers in the past, through the biasness towards material assets. In the following research, which takes place in the southern Andean region of Bolivia and focuses on the livelihood assets of the end users of the solar home system component (SHSC) of the IDTR project. This is of

⁵ Spanish for farmer

relevance to consider the degree of the impact on the livelihood assets as a possible result of a misconceived rural strategy.

The livelihood approach, characterized by its people centered approach, has much to offer in the development arena with its versatility in analyzing livelihoods by means of custom made frameworks. However the livelihood approach is not risk free, in the sense that a dominant discourse may affect the way livelihoods are interpreted and carried out. It is therefore necessary not to take anything for granted when studying livelihoods and to critically assess the effects of development policy/projects on livelihoods themselves. This after all carries on the incremental character of the livelihoods research which makes it so versatile.

In the case of this study, the livelihood approach will not be used to derive a common theory but rather to act as a tool in analyzing the impact on the livelihoods. More specifically; using the livelihood asset portfolio to identify the changes brought forward by the extra asset acquired, thanks to the electrification project. With this in mind, a common theory will not be derived but rather a practice oriented research will be carried out, based on the process of change brought on by the new asset of electricity in the form of a decentralized renewable energy system, more specifically speaking; a solar home systems (SHS). The following paragraph 2.2.2 will focus on the livelihood assets within the sustainable livelihood framework, and its relative position as well as usage for this investigation.

2.2.2 The sustainable livelihood framework

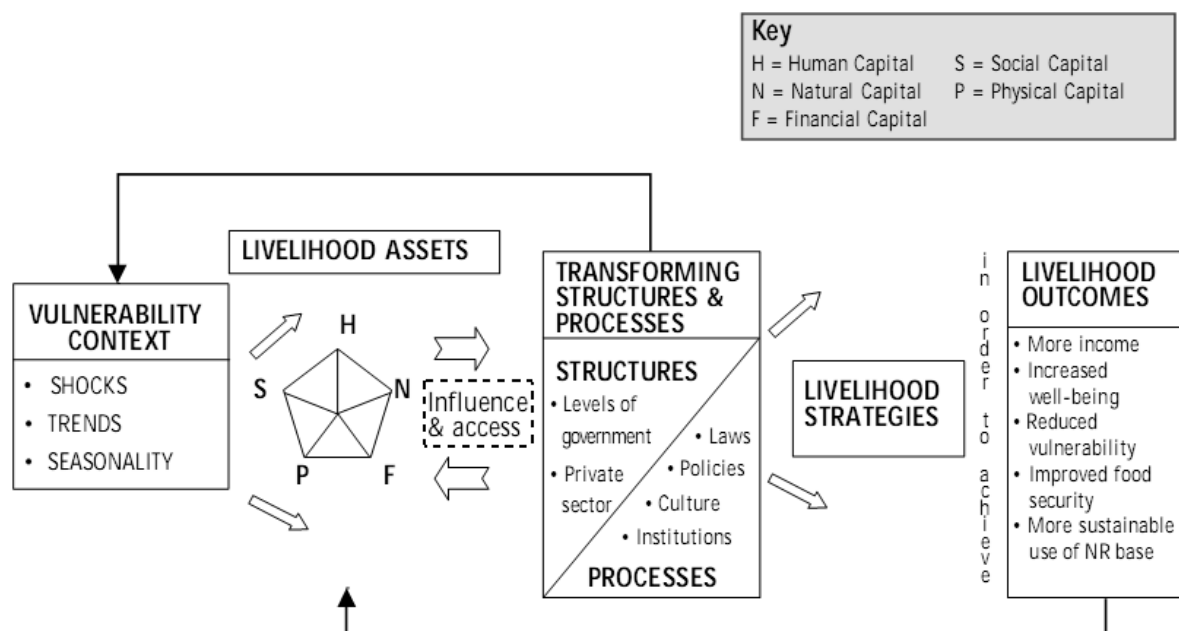


Figure 1: The sustainable livelihood framework

Source: DFID, 1999

The sustainable livelihood framework depicted here is from the DFID (1999). As shown above, the framework consists of five main components; the vulnerability context, the livelihood assets, the transforming structures & processes, the livelihood strategies and the corresponding livelihood outcomes. From this sustainable livelihoods framework, the livelihood assets component and the corresponding capitals as the subcomponent, is what primarily will be used for the impact analysis. The asset pentagon depicted above incorporates the following capitals; human, natural, financial, social and physical capital. Besides these capitals other relevant project information and documentation as well as sustainability dimensions will be used to arrive at the final conclusion of what the impact has been on the peoples livelihood capitals.

Livelihood assets and the capital pentagon

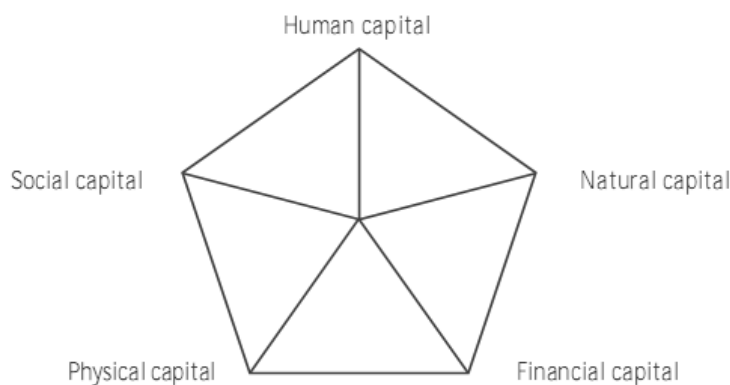


Figure 2: Livelihood asset pentagon
Source: DFID, 1999

The livelihood asset pentagon forms an integral part of the sustainable livelihood framework, also in its many adaptations. The assets are depicted in five different forms of capitals. Access to these types of capitals is to a large extent providing the means for the people to form a livelihood strategy. As seen in figure 2, the assets pentagon is composed of five type of capitals namely; human, natural, financial, physical and social capital. These thus form the basis of what the people have to work with on a daily basis. These capitals change as asset possessions of the people changes. With the installation of an SHS the asset portfolio receives an extra asset and the different types of capitals available may experience a positive or negative shift or may not be influenced at all.

The livelihood assets and the corresponding capitals have been chosen to act as the tool in measuring the impact or, in other words, the change which has occurred in the asset portfolio since the SHS has been acquired. Bebbington (1999, P.2022) in his redefining of the livelihood framework, exemplifies the importance of assets within livelihoods, referring to the livelihood assets (and the corresponding capitals) as, "... not simply resources that people use in building livelihoods: they are assets that give them the capability to be and to act." With this in mind, the assets in the livelihood give the people the capability of being and acting upon their daily lives. For this reason the asset portfolio and the corresponding capitals form a suitable indicator for the impact analysis based on the acquirement of an extra physical asset of the SHS, which in turn will impact the available capitals by adding new capabilities and resources to act upon.

2.3 Sustainability

Up to now, the sustainable livelihood approach has been discussed, with the livelihood asset pentagon as the tool to analyze the impact of the SHSC on the end users of the IDTR. The following paragraphs will outline the position of sustainability within this theoretical framework as depicted in the research model (see Figure 3).

The sustainability component, although it is of secondary nature in the empirical data collection process, is none the less crucial in the impact analysis of the project at hand, and thus the theoretical framework proposed. This is why in the theoretical model, both the sustainability dimension and changes in capitals interplay with one another to reach an assessment of the total impact. Although there are direct changes brought to the capitals in the livelihoods of the people, the sustainability of the project will mark to what extent these changes brought forward in the asset portfolio will last.

2.3.1 The term Sustainability

The terms sustainability and sustainable development have become very common. The following paragraph will provide an overview on what is understood by sustainability. A choice will also be made in what definition to consider for the research and which direction to follow regarding the sustainability dimension of the research in question.

In relationship to this study, it is coincidental yet logical that the term sustainable development has its roots for a great deal in energy. This is because since the beginning, people have been using natural resources in the form of fossil fuels for primarily energy production. The term sustainable development began making its presence in the 1970's. In 1972 the Club of Rome report "Limits to Growth" was released. This report made it clear that if current growth trends kept consuming as much natural resources and energy, we would face serious shortages in the near future. This charted the term 'sustainable' for future meetings. Later on in 1987 the term 'sustainable development' gained more momentum as the report "Our Common Future" was released by the World Commission on Environment and Development (WCED) (more commonly known as the Brundtland Report). According to this report sustainable development is shortly defined as; "Humanity has the ability to make development sustainable to ensure that it meets the need of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987).

With its increasing popularity, it is not surprising that the term sustainability has progressively become a buzz word throughout time and even more so in the development sphere. Taking this into account has rendered the term a bit confusing, as many different actors provide their own definitions for sustainability depending on the situation. At the same this has resulted in the large adoption of the term by many different organizations and actors in society.

The main dimensions which encompass the term sustainability are; economic, social, environmental and political. It is these dimensions of key processes of our society which influences our resources use. It is also why the term sustainability and sustainable development are a mix of all these dimensions working together to achieve a common goal in not jeopardizing the future for the next

generations to come. Although the rapid consumption of resources affects our environment, in current day society it can be said that some dimensions are more dominant than others. The political dimension is very dominant, as it is responsible in determining the way we run society on a daily basis and so it has the power to affect the other dimensions in a positive way in order to reach sustainability.

An example of the strength of the political dimension can be traced back to the 1970's when considerable oil shocks brought on a temporary oil crisis (which might be re-lived soon again). During this period governments and their policies responded by demanding more energy efficiency and pollution restrictions. As a result more fuel efficient cars and energy saving adaptations were made. Cox and Ziv (2005) refer to this as the human ingenuity factor. Human ingenuity is what has the potential to innovate on current technologies and ways of doing things in order to make our current day issues more sustainable. Thus politically messages sent can trickle down into society in order to achieve higher levels of sustainability.

When it comes to decentralized renewable energy projects for development, political will and a change in the discourse towards a biasness of fossil fuels and centralized grid extension is of essence. The IDTR being a government initiative, demonstrates such trends in sustainable development.

2.3.2 Definition of project sustainability

From an energy generating perspective, renewable energy by definition is already sustainable, as its raw material source for energy (in contrary to fossil fuels) is not being depleted, but rather captured and transformed to other forms of energy. Such is also the case with solar PV and the SHSs transforming the sunlight directly to direct current (DC) electricity.

From the argumentation above and the relation to the livelihood capitals impact assessment, sustainability in this context will be that of project sustainability regarding the IDTR's lasting appeal towards the end users and its ability to continue functioning as a successful rural electrification method. In other words, what are the prognostics and aspects of this project so far that will make it last and not lose its appeal towards the end users, who take part in the project and thus propagate its existence? The project itself and the way it has been executed will form the main dimension to the sustainability. In this case, environmental and detailed economic information take a step back as the project layout and scheme together with the so far impact on the livelihood capitals and observations, will lead towards the sustainability review of the IDTR and its SHS component.

2.3.3 Indicators for sustainability

Experiences in the past with similar projects such as the IDTR have generated results on the way projects are setup and whether these mechanisms reproduce a successful formula or not. These experiences from the project setup and related mechanisms are what will form the indicators for the project sustainability. A great deal of these factors influencing the project sustainability deal with the project setup, planning and execution phases. This is therefore why the main indicators will relate towards this. These indicators will be split into three categories namely; the human factors,

institutional factors and economic factors. Besides these three main indicators, an additional category with miscellaneous factors will also be taken into account. This miscellaneous category includes factors that can also influence the projects sustainability, but do not fall exactly under the three main categories.

The human factors

One of the critical components influencing a projects sustainability as identified by Huacuz and Agredano (1998, P.387), are the human factors from the projects approach. The promoter, who is the one responsible in selling the capabilities of the system, plays an important role in the first contact with the potential users. The installer, once the people have purchased a system. The installer must be capable to adapt to the different situations encountered locally, such as the construction materials and local availability of equipment. In this category the end user as the final beneficiary is left over as potential thread to the system. End users in rural areas are often illiterate, unfamiliar with the functioning of such technologies and thus form a risk in abusing or damaging the system (Huacuz & Agredano, 1998, P.388). What type of information the user will receive upon installment of the SHS is essential to the correct usage of the system. For this same reason the SHS design for maintenance should also be kept simple and minimal, so that the end user can carry out these tasks without any major problems.

From the beginning of the process, user involvement is also crucial. In contrast to electrification by grid extension, SHSs require a deeper involvement by defining the uses for the electricity generated by the SHS (Huacuz & Agredano, 1998, P.391). A proper level of user involvement, whether through purchasing versus gift or by participation, means the difference between possible success and failure of the project.

The attitudes of the end user also form a crucial factor when speaking of project sustainability. From observations of the Mexican program, Huacuz and Agredano (1998, P.391) noted that attitudes can be positive if the expectations are fulfilled, but also negative in the opposite situation. It is also mentioned that this is a very important as well as difficult task, as many residents in the rural areas are often illiterate and unfamiliar with technology. In the case of the isolated Bolivian rural communities this very likely to be the case. Throughout the whole process, it is thus of importance to focus on capacity building for the end users to ensure the correct use and therefore extend the maximum lifetime of the SHS components, as well as adding to the user's satisfaction.

Institutional factors

The process of electrification by SHS or other larger PV systems is not acquired over night. Significant information regarding the stages of preparation and execution of such electrification goals require additional expertise, besides the already well known grid extension method. Therefore institutional issues need to be considered to account for possible project failures and successes.

The IDTR electrification project along with its partners for executing the targeted amount of SHSs, need to have familiarity with photovoltaics as well as a standardized procedure, as it clearly deviates from the more traditional method of grid extension. Therefore it is necessary that the executing

entities have familiarity with photovoltaics and the whole chain from system design to installation be common practice, as recognized by Huacuz and Agredano (1998, P.392). Thus when executing a project of large magnitude, it is required that past experiences lead the way and the contracting of partners be guided by their expertise in this field to avoid possible hiccups which can put the project's sustainability at risk.

Photovoltaic parts are often imported, but relying on imports can jeopardize the availability and prices of the SHSs. Huacuz and Agredano (1998, P.392) consider a local support industry important for the project sustainability. It is therefore important that a local industry supply chain be in place to provide a large amount of the system components required. As an additional side effect, developing an internal industry for photovoltaic parts can create jobs and extra revenue by exporting such parts to other countries.

Economic factors

Economic factors are bound to always play a role, especially so in cases where the potential delivery of SHSs is on a large scale. This is the case of the IDTR. A sound financing scheme is necessary in order to reach those potential users, which often in the case of rural areas the people are unable to make high purchases in one go and can also not afford appliances to use with the electricity system (Huacuz & Agredano, 1998, P. 393). It is therefore necessary to offer some type of economic incentives to ease the purchasing process and also have a sound economic scheme on the projects behalf towards maintenance issues.

SHSs types and system design need careful consideration and should meet the needs of the targeted users. For that reason more than one system type should be offered in order to reach more customers with different needs. Pricing of each system is also crucial and should be adjusted so that as many people can be reached as possible.

How the SHS is made available to the people can be distinguished into four categories of modes of delivery, as recognized by Nieuwenhout et al (2001, P.460), namely; donations, cash sales, consumer credit and fee for service. Donations can mean that a system is fully subsidized for the user or that up to a certain amount is made available by means of a subsidy. It is often the case that donations are limited to the hardware and not the maintenance and service of the system (Nieuwenhout et al, 2001, P.462). Cash sales, as the name suggests, involves selling the whole system to the users and has the advantages of easy financing, low transaction costs as well as a high flexibility in consumer choice. Cash sales however do have some disadvantages as there is a tendency to opt for cheap, under-designed systems (Nieuwenhout et al, 2001, P.463). Credit programs are considered useful for widespread deployment. One of the main advantages is that the system cost in this case, is spread out by a couple of years increasing the affordability of the offered systems. This is also often preferred above renting schemes, as the people prefer to own the system than rent out its services (Nieuwenhout et al, 2001, P.464). For the end users, applying for credit might be difficult as they are rural inhabitants with little collateral and credit companies may be reluctant to supply credit to them. The last delivery mode mentioned is the fee-for-service. In this case public utilities are used to supply the service, whereby the users pay for the service of electricity and do not own the system. Main challenges posed by this mode of delivery is organizing the operation and maintenance of the

systems as well as providing a reliable fee collection system among the users (Nieuwenhout et al, 2001, P.464).

From the different delivery modes, the actual ownership of an SHS by the end users has been advocated by many as the way to ensure the good usage and sustainability of renewable energy projects (GEF/FAO, 2002, p.29).

Economic viability for the project also means that choices must be made whether certain groups who live in extremely isolated locations can be reached successfully with the program and not make any financial losses. Very remote and dispersed users can drive up the delivery costs of a SHS. It is thus questionable whether every potential customer can be serviced under current financial setup of the project at hand. These are bound to vary depending on the delivery mode opted for the SHS project.

Miscellaneous factors

Bolivia is a country which is heavily characterized with international migration. About a quarter of the total Bolivian population resides abroad (IBCE, 2008). Internal migration also plays a large role in Bolivia. Although migration may not be something which is directly linked to project sustainability, since the SHS project does not deal with it directly. When it comes to Bolivia, migration towards the cities and outside of the country has an important role to play, as it is a common strategy that people use in the chase for a better livelihood. If there is a significant outward migration in the areas of the project, in some cases an intervention made by a project may have little effect for people who are planning to migrate in the near future anyway. Making local migration tendencies a force to be reckoned with.

Environmental impact factors, although not dealing directly with the project's sustainability, do have a place within the project sustainability, as a decentralized renewable energy project is by definition meant to be sustainable environmentally speaking. In contrast to projects supplying energy by fossil fuels, which have adverse effects on the environment. These adverse effects, such as air contamination, are difficult to measure. Yet, simple on-site observations can give a general idea of the environmental impacts made by the SHSs implementation in these rural areas. Therefore, noted observations besides the already known benefits of renewable energy will be discussed in regards to the direct environment of the end user and the possible benefits or losses.

Projects concerning the provision of services such as electricity by SHSs have to work within provinces and communities inside the country. For this to work out, the cooperation of local authorities is indispensable. In places where there are political conflicts, the process of provision of services can be interrupted and thus play a role for the project sustainability. In other words it is necessary to take political situations into account in order to guarantee some kind of success rate of the project at hand.

2.3.4 Sustainability assessment

As outlined above, a combination of these sustainability indicators will be used in order to reach the project sustainability review. Not all the information for the sustainability indicators will be gathered in the same manner. Some of the information for these will come directly from the livelihood capitals assessment and some will come from personal observations as well as project documentation and interviews with key people involved in the IDTR project.

The research model in Figure 3 below, illustrates the path taken and the relative place of the livelihood capitals in the impact analysis for this investigation. It also shows how the different components may influence one another in reaching the final conclusion regarding what impact the rural electrification project has had as well as the review on project sustainability.

2.4 Research model

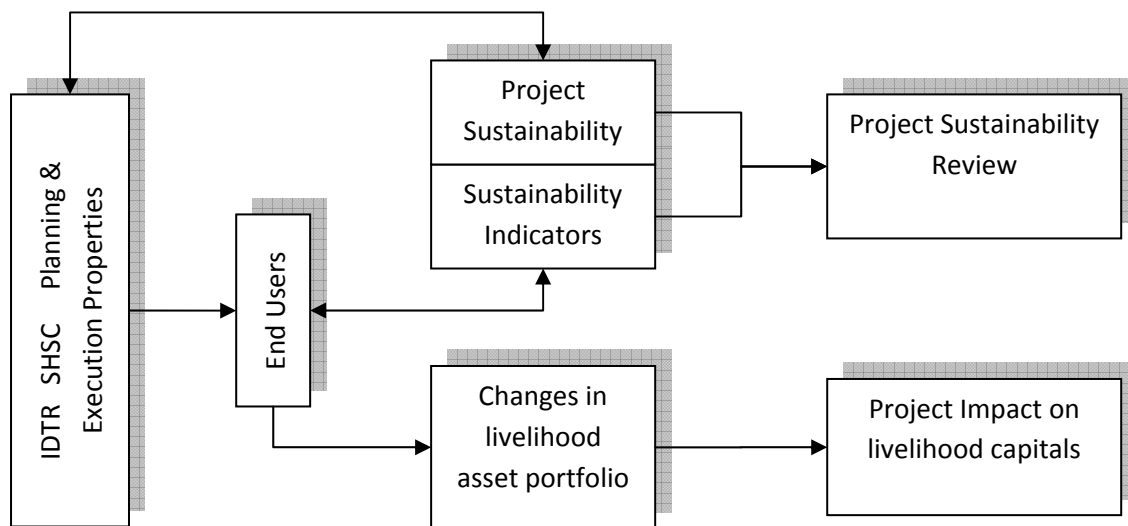


Figure 3: Research model

The purchase of a SHS in the rural household brings a new asset into the lives of the rural people. Rural electrification programs are adding new materials to the existing asset portfolio, namely electricity with the accompanied infrastructure (SHS with its accompanied system components). Whether this new asset is capable of aiding the people correctly is the question at hand. By assessing the impact on the other capitals by means of a new asset, a change can be traced in the livelihoods of the targeted people brought on by the rural electrification program. It then still remains to be seen whether this new asset has aided the people's livelihood strategies directly or changed other aspects and consequently have made people look elsewhere, where they have never looked before.

The figure shown above is a simplification of the research model which will be applied. As illustrated in this model, a renewable energy project location will be analyzed. Both the IDTR SHSC properties as well as the end users, form the main components of analysis. From these two components, changes in the livelihoods capitals in the asset portfolio will be traced and analyzed as well as the

changes impacting the project sustainability indicators. From the analysis of both the sustainability indicators and changes in the livelihood capitals, an assessment can be made on the project's sustainability and impact on the targeted population, which is ultimately the goal behind this research.

Taking these characteristics into account, the research model gives way to a hybrid approach which is of importance when studying livelihoods as highlighted by Scoones (1998, P.13). Scoones refers to this hybrid approach as an appropriate manner to explore the different questions posed, which are located in the different elements of the livelihood framework. In this case (see chapter 3), the methodology outlined will apply different qualitative and quantitative techniques to the different components of the investigation in order to construct a hybrid approach.

3 Empirical Framework

3.1 Introduction

In the following paragraphs, the research methodology will be explained as well as the other key research components. The respondent as well as the local context will also be taken into account. These are very determining factors as they aid and sometimes constraint the research at hand and thus consider a certain amount of attention. Before getting to the research methodology some background information will be provided on renewable energies in general and their applications, to give a better understanding of what the subject of discussion at hand is. Some information about Energética will also be given, the organization which aided this research by providing the opportunities to go into the field.

3.2 Renewable energy: a short review

Renewable energy as the name suggests, is energy which is harnessed through the use of resources that can be used over and over again without the depletion of the resource itself. Natural resources such as the wind, solar radiation, biomass, water (hydraulics) and geothermal are the most common when speaking of renewable energies. These resources can produce energy in the form of electricity, mechanical, heat or chemical energy (DOE, 2001, P.1). The greatest advantage in using these type of energies is that they are a cleaner type of energy in comparison to current use of fossil (non renewable) and that they are technically inexhaustible. These two qualities together have positive impacts on the environment, but just as important they have a significant impact in providing energy for people in isolated areas, with the aid of small scale decentralized systems.

The following paragraphs will provide an overview of the different types of renewable energy being applied in present day. Discussing the advantages and disadvantages these different types of energy have, as well as the significance these types of energy may have in impacting the livelihoods of isolated rural inhabitants. The technology behind solar photovoltaic energy will be elaborated upon with some more detail in comparison to the rest. This is to get a better idea of the working of solar home systems which form a part of the IDTR project in Bolivia.

3.2.1 Solar

Solar energy is one of the earth's most observable and abundant energy types. In nature the sunlight and the solar radiation provide heat and light-rays that are vital for the survival of the species inhabiting our planet. Turning sunlight into electricity is more often referred to as solar photovoltaic or solar PV. However sunlight or solar radiation can also be used to heat fluids or air (solar thermal) and to capture heat or redirect it for later use. Solar PV systems use solar panels to convert the sunlight directly into electricity, which can be used right away or later on by a residual charge stored in batteries. The main difference between solar PV and solar thermal is that solar thermal is used to generate heat in combination with fluids/air to generate electricity in a mechanical process, and solar PV converts the energy from the sun to direct current (DC) electricity. In solar PV, the sunlight strikes the silicon material of the solar cells, which upon contact with sunlight become electrically

charged⁶. For commercial purposes, solar thermal seems to be a better choice as it has the potential to generate large amounts of electricity and / or heat.

Currently, solar cells found in commercial solar panels have an average energy efficiency of about 15%. This means they effectively capture 1/6 of the sun's light rays⁷. But as technology continues to increase, so does the efficiency of solar cells. When solar cells were first invented in the 1950's the efficiency was only 4%. More recently in August of 2007, a solar cell capable of 42,8% efficiency had been developed by scientist at the University of Delaware in the United States⁸. With the current day continuous interest in renewable energy such leaps are bound to keep occurring, which will increase the position of solar PV energy in the renewable energies market.

Clearly solar energy has numerous advantages. To begin with that it is a renewable and thus inexhaustible source. Emission-wise it is a clean technology. Solar PV is also versatile; solar panels can be used in many types of applications, from powering your calculator to powering your house or even a water pump⁹. This gives solar PV an edge for implementation above other kinds of renewable energies, particularly for small scale decentralized use.

Solar PV in the form of SHSs are well suited for developing countries, by adding to the quality of life and supporting anti poverty initiatives. For households as well as communities, solar PV systems can provide benefits such as; powering communication equipment for schools, vaccine refrigeration and other general equipment for the community as a whole. Because solar PV systems are modular they have the advantage that they can be installed in single or multiple units. The fact that PV systems do not have moving parts, makes it a long lasting technology that requires little to minimal maintenance (El Bassam & Maegaard, 2004, P. 123).

Besides having advantages, solar power does have some downsides. With a recently achieved efficiency of 42,8% on the latest experimental solar cells, solar cells are still not as competitive with other forms of energy production, as actual commercial efficiency is around the 20%. In order to produce large amounts of electricity (e.g. commercial purposes) relatively large areas as a result are required, which means that the costs are high. The geographical location is also another important factor to consider, as a significant amount of sunlight hours is necessary to make it an attractive option for electricity generation. Although solar cells also function with lesser and indirect light, just less efficiently.

3.2.2 Wind

Wind power is one of the most used power sources in history. Man has used wind in the past to sail boats and used windmills to grind materials as well as to pump water. Nowadays windmills have evolved more technologically and can harness the airflow energy by converting it directly into electricity.

⁶ <http://www.solar4power.com/> - 10-11-2007

⁷ <http://www.renewableenergyaccess.com/> - 06-08-2007

⁸ <http://energie.vpro.nl/> - 06-08-2007

⁹ <http://library.thinkquest.org/> - 06-08-2007

Windmills today are capable of producing significant amounts of energy, ranging from small mills producing 50 kilowatts (kW) to large mills capable of producing 1 – 2 megawatts (MW). This has made windmill technology the most increasingly applied form of renewable energy since the 1990's. It has since then also seen an average increase of 25% per year (DOE, 2001, P.7).

Like solar power, wind has its advantages, such as being a clean type of energy and an inexhaustible resource. Wind energy also works well as a supplement to other types of energy. Geographical location is a very important factor for windmills. In order to be lucrative the areas suitable must have constant winds. Windmills have to be preferably placed in higher areas, free from obstruction, in order to maximize the airflow. Windmills also require maintenance and are relatively expensive for the amount of electricity they can produce¹⁰. Another downside to windmills is the noise they produce, which in concentration of several mills can reach high levels. Besides the noise, they are not always a wanted sight in the landscape and often form a visual complaint (El Bassam & Maegaard, 2004, P. 118). Besides the occasional bird collision with the windmill blades, impact on wildlife from windmills is minimal.

3.2.3 Water

Water for energy production is commonly referred to as hydroelectric power. It is a form of power which has been around for a while. Much like wind power, the power of streaming water was used (and still is in some places) to turn water mills for grinding grain and later mainly to generate electricity. This is achieved by using dams to retain water and releasing it to turn a turbine which consequently generates electricity. Dams are made to retain water to ensure the constant flow of water. In areas where flow is constant no dam, is necessary as a turbine in the water suffices. Hydroelectricity because of its early development and capacity to generate high amounts of electricity is the type of renewable energy that generates the most power around the world.

Depending on the size of the dam, the amount of electricity produced can vary significantly. Ranging from 1 kW to 12,600 MW, the latter being the most energy producing hydroelectricity dam in the world. This dam is known as the ITAIPU, a joint project of Brazil and Paraguay. In 1997 the dam supplied 26,4% of the total energy needs of Brazil and 79% of the total energy in Paraguay¹¹.

Being a renewable resource, hydroelectricity is clean, as it does not create CO₂ emissions into the atmosphere. It also has the potential to generate very significant amounts of electricity, such as the ITAIPU dam. It can be implemented around the world as long as there is enough water flow and significant relief differences. Although it is a clean energy source, hydroelectric dams, (especially large ones) can have unwanted ecological impacts as well. Because of the dam structure, river life is disturbed. One of these problems is for the fish, which cannot migrate upstream anymore as they are blocked from passing by the structure. Currently this problem has been dealt with by building fish ladders for the fish to swim past the dam structures (DOE, 2001, P.2). With large reservoirs needed by large dams, other problems do remain such as the rising temperature of the water

¹⁰ <http://library.thinkquest.org> - 08-08-2007

¹¹ <http://library.thinkquest.org> - 08-08-2007

downstream forcing decline in oxygen content, experience siltation, and gain in phosphorus and nitrogen content¹². In rural areas where people live of subsistence practices these effects may have a larger impact, as many rely heavily on the river to pursue any kind of livelihood.

3.2.4 Biomass

From all the mentioned renewable energy sources, biomass is the oldest in our energy production history. Biomass is simply defined as, “plant material, vegetation, or agricultural waste used as a fuel or energy source”¹³. The most common example is the use of firewood for cooking and other purposes. Up to now wood is still the most commonly used source of energy, especially in developing countries and in isolated regions. It is said that biomass still remains the main source of energy and provides half the world’s domestic energy needs, especially in the developing regions (El Bassam & Maegaard, 2004, P. 71). This is accomplished by wood fuels which play a significant role in the energy provision of rural households. In Latin America it is claimed that 10% of total energy is still met with wood fuels (El Bassam & Maegaard, 2004, P. 80).

Biomass can thus provide direct energy by burning material, but it can also be used to generate electricity. For that to happen, burning biomass material can heat up water into steam which then can turn an electrical motor to generate electricity. Biomass can also be turned into alcohol, which can be stored and used as a fuel later on. Biomass waste is also used to generate energy by means of anaerobic digestion. This is the process that releases methane gas from decomposing biomass, which is then collected and used as fuel and for other energy producing purposes¹⁴.

Biomass in theory, is an inexhaustible resource as plants grow back from the land, making it a renewable resource. Another advantage comes from fuels produced from biomass, such as alcohol, which are relatively clean burning. However when biomass is directly burned, it does contribute to global warming, as CO₂ is released. One way to combat this is by balancing the carbon cycle and replanting the used biomass which in return uses up CO₂ from the atmosphere. This means zero emissions as the CO₂ is cancelled out by an equivalent amount of new vegetation¹⁵. Unfortunately this is not always the case. Using biomass for fuel conversion often requires energy being put in to achieve this, making it inefficient.

Perhaps the strongest point of biomass as an energy source, is its worldwide availability. Except for those regions with harsh climates where little to no vegetation grows, biomass is generally readily available and does not cost anything, only the time spent in order to gather it for use. For poor rural households that cannot afford anything else, biomass and access to it is very crucial.

¹² <http://library.thinkquest.org> - 08-08-2007

¹³ <http://www.answers.com> – 08-08-2007

¹⁴ <http://library.thinkquest.org> - 09-08-2007

¹⁵ <http://www.renewableenergyaccess.com> - 09-08-2007

3.2.5 Miscellaneous

Besides the named types of renewable energy resources mentioned above, other resources exist, such as everyday fossil fuels and nuclear energy. These will not be discussed as the research at hand focuses only on renewable energy and small scale systems.

Geothermal is another type of renewable energy source which is at use today. Since it uses such a simple principal to acquire heat from the ground, it is a relatively cheap technology to use (in large applications). However the limitations for this energy type are too great. In comparison to the other renewable energy sources, only few places around the globe are suitable for geothermal energy and heat production (an example is Iceland). Besides the scarcity, the power generated by geothermal is also limited¹⁶.

3.2.6 Energy production Bolivia

In Bolivia, current electricity generation by renewable energy is lead by hydroelectric power. It has had a prominent part in the electricity generation of Bolivia since the 1970's up to present day. In 2004 the total energy production by hydroelectric surpassed the production of both oil and gas combined, making hydroelectric the most used renewable source in Bolivia with a share of 49%. The remainder of 2,1% is a mix of biomass and renewable waste¹⁷.

These figures however, are more of centralized renewable energy production for national use. In the case of decentralized renewable energy, projects for development in the rural areas have in the past used micro hydroelectric plants for enhancing rural production and in many cases solar PV has been applied in the form of SHSs similar to the IDTR.

The advantage of solar PV systems above that of micro hydro, as mentioned before, lays in the characteristics of these systems. Hydro is not always available in many of the areas in Bolivia. Another factor is that hydroelectricity is less versatile in terms of location. The location has to be nearby the households as you are extending the network from the micro hydro plant to the users. As Bolivia has favorable solar radiation values for solar energy, SHSs will have higher rate of penetration towards users, making it a good option. Very odd and remote locations can be reached this way and the energy produced is on site. As a result it does not require any further transportation and thus no extra electrical infrastructure.

3.2.7 Renewable energy and livelihoods

The focus of this research is to look at the impact that the SHS component of the IDTR project in the rural communities of Villazón (Bolivia) has had on the livelihood capitals of the end users. Taking into account the overview given of the different types of renewable energies, the impact analysis further on will focus on the energy service in the form of an extra asset to the livelihood portfolio. It is important to take this into account, as often people may think that renewable energy is only used to

¹⁶ <http://library.thinkquest.org> - 09-08-2007

¹⁷ <http://www.iea.org> – 20-08-2007

produce electricity (the most obvious energy form). But as described in the paragraphs above, renewable energy can also be used to produce heat or undergo a chemical process to generate fuels for storage and later use.

Although different types of renewable energy resources exist, they all share a common factor. That is that they have the ability to supply energy services to the people in the form of electricity. Renewable energy is more justified in development regions in comparison to regular main stream fossil fuel energy supply. This is because of the nature of renewable energy. That it is; anti monopolistic, more democratic and less amenable to centralized control. All in all making it very suitable for development regions and decentralized deployment (Bhagavan & Karekezi, 1990, P. XV).

Taking the context of Bolivia into account and the different types of renewable energies discussed above. In order to reach successfully those isolated areas, decentralized renewable energy systems are suitable to supply the people with energy services in the form of electricity. Primarily because of the fact that extending the national electric network is not viable for those isolated communities that are far away or find themselves in rugged terrain, which is characteristically the case on the Bolivian altiplano. This makes decentralized systems very suitable in aiding the livelihoods of the rural population.

3.3 Energética

In order to carry out this research, it was crucial to find the assistance of an organization dealing directly with renewable energy for development. In the case of Bolivia, there are several national organizations as well as international organizations dealing with renewable energy in development programs on different levels. The following research studied the case of the IDTR project, a nationwide government initiative to supply electricity to the rest of the nation lacking it. The exact details of the IDTR project will be discussed in chapter 4 along with the location description in which the investigation took place.

Energética is a Bolivian NGO located in Cochabamba. It is a multifaceted organization when it comes to renewable energy. Solar photo voltaic is only one of the many renewable energy forms being applied in their field of expertise. The organization is also well at home with many others renewable sources such as biomass, wind and hydro.

The main focus of Energética is to provide technical assistance, allowing the target groups to improve their access to energy. Since their startup, Energética now has more than 15 years of experience in this field. This is what made Energética one of the key executors of the solar home system component, contracted by the government for the IDTR SHSC project. They are also different thinkers when it comes to rural electrification and look beyond network expansion as the only method to supply electricity to rural areas. They are more experienced and convinced of the advantages decentralized electricity provision has to offer. As to what is the exact role of Energética in the IDTR SHSC is, will be further outlined in chapter 4 together with the other project details.

3.4 Research Methodology

For this thesis an ample amount of empirical data was gathered in order to answer the main and sub questions posed. The research methodology applied will be outlined in the paragraphs below. Several methods were used in order to form a well based opinion. In the beginning a literature study was conducted. The survey that followed was conducted with thirty nine end users of solar home systems taking part in the IDTR project and mainly consists of questions regarding the changes brought forward by their acquired SHS. While performing the questionnaires on site, the opportunity arose to make observations as well and carry out informal talks with the people to get a better idea of the context at hand and learn more about what might be missing or why people acted a certain way towards the survey questionnaire and other questions posed.

3.4.1 Literature study

Mainly in the preparatory stages of this research, a literature study was conducted. This was done in order to gain more insight into relative theories and background information concerning the topic of decentralized renewable energy and development. This gave basis to the research proposal and for the information being presented as the actual thesis. The livelihood framework which plays a role for the impact assessment, was derived and adapted for this research through the literature as well.

Other aspects, such as project details and general information in the field of renewable energy, were also gathered by means of literature research. This took place in The Netherlands as well as in Bolivia during the research period.

3.4.2 Survey

In order to measure the impact on the livelihood assets and capitals of the targeted population, a survey was chosen as the primary method. The survey aimed at tracking the changes among the different types of capitals in the livelihood asset portfolio of the end users. Thus focusing on what had changed in their personal situation in comparison to before the purchase of a SHS for their home.

For the survey an estimated amount of 50 households were selected within different villages of the same region, in order to achieve a representative group. In reality a total of 39 questionnaires among the end users were achieved. The reason for this was that the nature of the data that was being collected did not show too much variation towards the end. Since not much difference would have been evident, the decision was made to stop at 39. Also the nature of the answers by the respondents was a significant reason to halt at the 39 mark. The nature of the respondents in the research area turned out to be a limiting factor. What exactly is meant by this will be explained later on in chapter 4. Nevertheless the respondent group of 39 still provided a representative sample for the investigation.

The survey questionnaire was composed of a ninety nine questions of semi open and multiple choice nature, to categorize the changes in the different types of capitals. Each livelihood capital had its own set of questions within the questionnaire. However it must be noted that many of the questions

can overlap one another when it comes to judging the effect of that corresponding capital (this will be discussed further in chapter 5). Other general information was also gathered with the questionnaire, such as the household composition and geographical location.

Despite this limitation in the answers of the respondents enough surveys were still carried out for substantial data analysis of the different changes in the capitals.

Among the eight new installations in the community of Casira Chica an additional short semi open multiple choice questionnaire was conducted with the new users. The purpose behind this questionnaire was to ask about the expectations regarding the impact of the SHS was going to have on their lives. This served to compare the results taken from the main questionnaire among the users who already had a system and were being visited for maintenance¹⁸.

3.4.3 Interviews

The third but not least method used in this research for gathering relevant data were interviews. These interviews dealt mainly with the background information of the IDTR project itself and were conducted with the organizations dealing directly with the different aspects and stages of execution of the IDTR SHSC (Energética and the vice ministry of electricity and alternative energies. Through the interviews other insider type details were gathered on the IDTR SHSC.

3.4.4 Observations

Not falling directly under the interview category, but because of their informal nature, the talks with the people at the executing level were also a key part of the observations. They will therefore be categorized here under observations. Most of the observations took place during the survey period in the rural area of the surveyed communities. During these two weeks, time was spent travelling with two of the Energética technicians in order to carry out the planned maintenance and installation of the SHSs. During this maintenance run, the opportunity arose to carry out the questionnaires and witness the systems working at first hand. This of course gave way to observe the respondents in their natural everyday environment and the working method of the technicians, as they performed maintenance task as well as installations.

Two weeks in the isolated rural region of Villazón, meant sleeping at people's home and observing their customs and habits. Although the work schedule did not give too many opportunities for occasional conversations, the experience none the less was very educational for the noted personal observations.

¹⁸ See Annex A for this questionnaire and the responses

4 The IDTR and the local context

The IDTR is the project in question for this investigation. In the following paragraphs an overview of the project, together with the main goals, main actors and the SHSC will be given in order to gain a better understanding of the importance it has for the Bolivian rural. The SHSC will also be discussed in more detail in regards to what exactly is included in a SHS and how one is obtained by means of the IDTR.

A general description of the local context where the investigation took place and the people included in this research, will also be given in order to underline certain characteristics and background information encountered during the research. Characteristics which need to be considered due to their influential nature for the research results will be discussed later on.

4.1 The IDTR project

4.1.1 Introduction

The initiative for a nationwide electrification project seems to be a very logical move for a government which is promoting development and greater levels of equality among its people. When the project officially started, only an inadequate 65% of the Bolivian population had electricity. Most of the people who had access to electricity were living in urban areas (an estimated 89,5%). In the mean time, their rural counterparts had to settle for unreliable sources of electricity and only 24.5% of the rural population had electricity (Terrazas Vásquez, 2007, P.16). At present, other projects are also running parallel to the IDTR in order to tackle the energy provision and efficiency problems across the country. One of these for example, is a government effort to get consumers to switch from incandescent bulbs to energy saving bulbs, in order to improve efficiency and cut down on energy consumption.

Electricity and access to electric services is often mentioned as a catalyst for development. Without it people are at a clear disadvantage over those that do have access. Mainly because with electricity and light you can live a life with higher standards and with dignity, as the Bolivian government puts it. The IDTR and its SHSC, give the opportunity for the rural poor to feel a bit more dignified, as they are given the possibility to access electricity and no longer feel marginalized in that respect compared to the rest of the urban population, who because of their relative geographical concentration have a heads up on access to amenities.

Although the SHSC is very important in the IDTR, there are other objectives besides the SHSC goal. In order to reach the goals proposed, not only is it necessary to use decentralized renewable systems such as the SHSC, but also to apply densification of the current electric network for those who are able to access it in a viable manner.

Shortly summarized, the main objectives of the IDTR project include ¹⁹:

- The support for the national strategy for rural infrastructure (which includes electricity and telecommunications)
- Expand the coverage of the electric services and telecommunications in the rural areas.
- Promote the productive and social usages of electricity and telecommunications

The SHSC falls into the second category named above, which is the expansion of the coverage of electric services in the rural area. In paragraph 4.1.3, the SHSC will be described in more detail.

4.1.2 Actors

Since its launch in 2003, the IDTR was launched by the Bolivian government, represented by the vice ministry of electricity and alternative energies. The project was setup by the government with the aid of past experiences made with similar electrification efforts. Efforts were assisted by other aid organizations such as the small grants program of the United Nations, which launched several renewable energy projects in the country (Rodriguez Ortiz, 2008). These past experiences have helped to systematize and institutionalize the processes needed to carry out an electrification project in the scale of the IDTR.

A large scale project such as the IDTR requires a significant amount of funding. For the planned 17,775 SHS installations, the government of Bolivia is providing 9,9 million US dollars for the first phase (Paz Vargas, 2007, P.8). The goal is to provide SHSs to end users at an affordable price. In order to achieve this goal, the World Bank has extended a credit for the Bolivian government. The credit fits well into the World Bank's policy of aiding development projects which can benefit the poorest groups. With this credit the government has setup the SHSC so that the total price for the system is subsidized by 60% on the government's behalf. This 40% of the system price is left over for the end users to pay, either directly if they can afford it or by means of a micro credit for those who cannot. Since the World Bank is the key financier, there are certain regulations and demands made by the World Bank which the government of Bolivia has to comply by.

In order to carry out the project, the government itself works as the main contractor and manager of the process. The actual work is contracted by means of a medium term service contract (MSC) and is carried out by the organizations working in the field of energy. These organizations at the beginning of the project made proposals for the work to be done and the government assigned the workload accordingly by means of the MSC's (World Bank, 2007). For this specific case, the aid of Energética and Isofoton was contracted as the two main executing organizations for the IDTR SHSC.

Energética (see paragraph 3.3) is the NGO which collaborated with this investigation, they aided by providing me with the possibility to go in to the field and carry out the surveys and talks with the end users. Isofoton is of importance as well, since Energética is working closely with them to carry out the project. This close relation is mainly because Isofoton has sub-contracted Energética to carry out part of their workload, 1500 SHS installations to be more precise.

¹⁹ <http://www.idtr.gov.bo>

The 'Asociación Nacional EcuMénica de Desarrollo' (ANED) is another key actor involved in the execution of the project. Through Energética and Isofoton, ANED is the financial nonprofit organization which has been subcontracted to manage the micro credit applications for the people wishing to obtain a SHS as part of the IDTR project. ANED has local offices in various urban centers across the country and thus have a basic infrastructure in place for the people that wish to get involved in the project, as well as the expertise in handling credit with the rural population. Financing is a very crucial component, as it is the credit organization which will be the first to come into contact with the end users. In order for ANED to sign up a user for a SHS, a simple credit check needs to be done and some basic requirements need to be fulfilled on the user's behalf.

At the moment, the SHSs being installed are receiving a 60% subsidy of the total price on behalf of the central government. However Energética is doing its best to get extra subsidies on the systems when entering new areas for installation. These new subsidies can come from the municipalities or other levels of local government. With the extra subsidies the penetration level into the rural areas can be widened, as a drop in price makes the SHS a lot more attractive for those who are currently being left out (Terrazas Vásquez, 2008).

4.1.3 The solar home system component

The SHSC of the IDTR is composed of a total installation of 17,775 solar home systems. This is the main target which has been set at the beginning phase of the project. As mentioned before, organizations bid for the installation of these systems and these have gone respectively to Isofoton and Energética. From the initial total of 17,775 SHS to be installed, Isofoton at the start got the bid to install 13,775 SHS and Energética 4,000.

Energética being a Bolivian NGO working in the field of renewable Energy for the past 15 years has had the edge from the beginning over Isofoton, which is a Spanish organization and manufacturer of the solar panels being used in the project area. Because of their relative little experience working in the Bolivian rural areas, Isofoton had some setbacks in the early stages of the project startup and therefore had to subcontract Energética to install part of their SHSs (Terrazas Vasquez, 2008). In the region of Villazón this is also the case, Energética was carrying out the installation procedure and maintenance originally assigned to Isofoton.

The Solar Home Systems

The solar home systems are available in four different capacities to the end users, these are; 22Wp, 36Wp, 55Wp, 75Wp. The four different types of systems are named in relationship to the generation capacity of the solar panel. The table below summarizes the main differences per system according to their capacity. All of the systems offered (regardless of their capacity) are given a four year warranty period and a once per year maintenance visit. In contrast to the other components of the system, the solar panel (which is the main component) is covered by a warranty period of 20 years by the manufacturer.

System type	Solar panel capacity in Watt peak	Battery capacity in Ah	Number of light points	System price in US Dollars
SFD-1	22Wp	70	2	205
SFD-2	36Wp	70	2	270
SFD-3	55Wp	100	3	390
SFD-4	75Wp	150	3	590

Figure 4: SHS differentiation table

All of the SHSs also include the following;

- 1 system charge regulator
- 1 voltage converter
- 1 cell phone charge point
- 1 set of cables and accessories
- Installation and transportation
- 4 years warranty and yearly maintenance during the 4 years
- 1 instructional poster for simple maintenance and cleaning
- Capacity building in use and maintenance

The terms for this warranty are that the user during the first four years does not interrupt any of the system components. Such as disconnecting the battery to charge another one, or opening up the charge regulator. To insure that this does not happen all of these systems are sealed at crucial points which will let the technicians know if people have interrupted the system in any way. Pictures of each system are also taken during the visits to verify their status.

Capacity building in maintenance tasks is given to the end users after the installation of their system, as well as during the yearly maintenance visit. Edgar Terrazas Vásquez (Terrazas Vásquez, 2008), stresses that the second capacity effort is necessary to reinforce the knowledge of the users because they tend to quickly forget and do not like to read the instruction booklet provided to them. Also because very often during the installation some of the family members are not present. For that reason, every time people can be re-capacitated the maximum amount of household members are instructed to be present so that in the case one forgets, they can help one another other in filling in the knowledge gaps.

Process for obtaining a SHS

In order to obtain a SHS, the area has to be destined for the installation of the SHSs. However not every area is put on the project. Basic economics on the price of the systems and the budgets available means that first an area is entered by the organization and then the local demand by the rural population is measured. The aim is to have at least 250 users in a relatively concentrated area that wish to take part in the SHS project. This is because of the immensely dispersed character of the

Bolivian rural population, which makes it economically non viable to travel a hundred kilometers into the mountains for just 1 or 2 users (Terrazas Vásquez, 2008).

This kind of rural marketing for the systems is carried out by Energética (this was the case for the communities in Villazón). A spokesman from the organization goes into these areas and speak first with the corresponding level of local government and then talks directly with the targeted population by setting up community meetings in order to explain the benefits of the systems and the possibilities for purchasing one. Afterwards the process of enrollment for a SHS is handled by ANED. If the end users meet the credit criteria, they can buy a SHS through ANED and choose their payment plan accordingly to their financial situation. Figure 5 depicts the information leaflet as given by ANED, for the user to get an idea of what they can get for their money and what payment possibilities are available. It also sums up the requirements which need to be met when signing up for a SHS. These are; a photocopy of a valid ID card, a credit solicitation form, the down payment and 25 Bolivian pesos for administration costs.

¿Que necesitas para solicitar el credito?

- Fotocopia C.I. vigente
- Formulario de Solicitud de Crédito
- Cuota de adelanto
- Pagar 25 Bs. por Gastos Administrativos

¿Bajo que condiciones?

- Aporte Inicial:** \$us. 50, 80 ó 100
- Plazo de pago:** 1 a 3 Años
- Tasa de interés:** 18 % anual
- Cuotas de Pago:** Mensual, bimensual, trimestral, personalizado
- Garantía:** El mismo Panel Solar

Cálculo de cuotas de crédito en dólares (Sus.)
* Los precios incluyen el ITF

Sistema	Precio al contado	Cuota Inicial	Crédito
SFD - 1 (22 Wp)	205	50	155
SFD - 2 (36 Wp)	270	50	220
SFD - 3 (55 Wp)	390	80	310
SFD - 4 (75 Wp)	590	100	490

Si paga en 1 año:

Sistema	Cada Mes	Cada 2 Meses	Cada 3 Meses
SFD - 1 (22 Wp)	14.24	28.66	43.27
SFD - 2 (36 Wp)	20.21	40.68	61.42
SFD - 3 (55 Wp)	28.46	57.32	86.54
SFD - 4 (75 Wp)	45.00	90.60	136.79

Si paga en 2 años:

Sistema	Cada Mes	Cada 2 Meses	Cada 3 Meses
SFD - 1 (22 Wp)	7.75	15.59	23.54
SFD - 2 (36 Wp)	11.01	22.14	33.41
SFD - 3 (55 Wp)	15.50	31.20	47.07
SFD - 4 (75 Wp)	24.51	49.30	74.40

NOTA: Por cada pago que realice exija su factura (Papeleta Amarilla)

ISO FOTON en alianza con la Asociación Nacional EcuMénica de Desarrollo (ANED) financian paneles solares destinados a cambiar tu vida, brindándote Instalación a domicilio, capacitación en uso y mantenimiento, 1 visita de mantenimiento por año, durante 4 años.

SANTA CRUZ Comarapa: Calle Martín Claire No. 237, telf: 39462031 • **Vallegrande:** Plaza 26 de enero No.27 telf: 39422202 **COCHABAMBA Quillacollo:** Calle General Pando No. 136 telf: 44364565 • **Totora:** Calle Mercado casi esq. Rodolfo Soriano **POTOSÍ:** Calle Santa Cruz esquina Mercado Uyuni S/N telf: 26262666 • **Puna:** Plaza 16 de Julio S/N, telf: 26138312 • **Betanzos:** Av. Linares No. 12, telf: 26136209 • **Tupiza:** Av. Chichas N° 244, telf: 26944717 • **Cotagaita:** Calle 1° de mayo s/n casi esq. Panamericana **LA PAZ Oficina Central** Calle Rosendo Gutiérrez 679, Sopocachi Telf: 2418643 – 2418716 Fax: 2419505 • e-mail www.aned.org

Figure 5: ANED SHS information leaflet

Source: ANED office, Tupiza - Bolivia

4.2 Area of Villazón

The following paragraphs are meant to give an overview of the local context characteristics, such as the location in which the research took place, in order to get an idea and a better understanding of the environment in which the research respondents live. This investigation took place in the south western Bolivian altiplano department of Potosí. More precisely so, in the municipality of Villazón that borders with Argentina (see Figure 6). Potosí is one of the nine departments across the country in which the IDTR is being implemented.

Because of Villazón's border position with Argentina, many people migrate to Argentina, either for seasonal work or permanently. In the survey region, almost all of the respondents had relatives residing in Argentina. All other economic activity of the communities is strongly tied with the border town of Villazón, which is the trading center for goods across the border.

Most people practice subsistence farming and sometimes produce crops for export to the local market. The remoteness and rugged landscape in this area does not allow for large scale agricultural production and there are few who have the amount of land to practice it. In the communities where the survey took place all 39 households also sold small pottery goods to Argentine traders for extra income. All families had livestock as most of the terrain does lend itself for goat and llama herding.

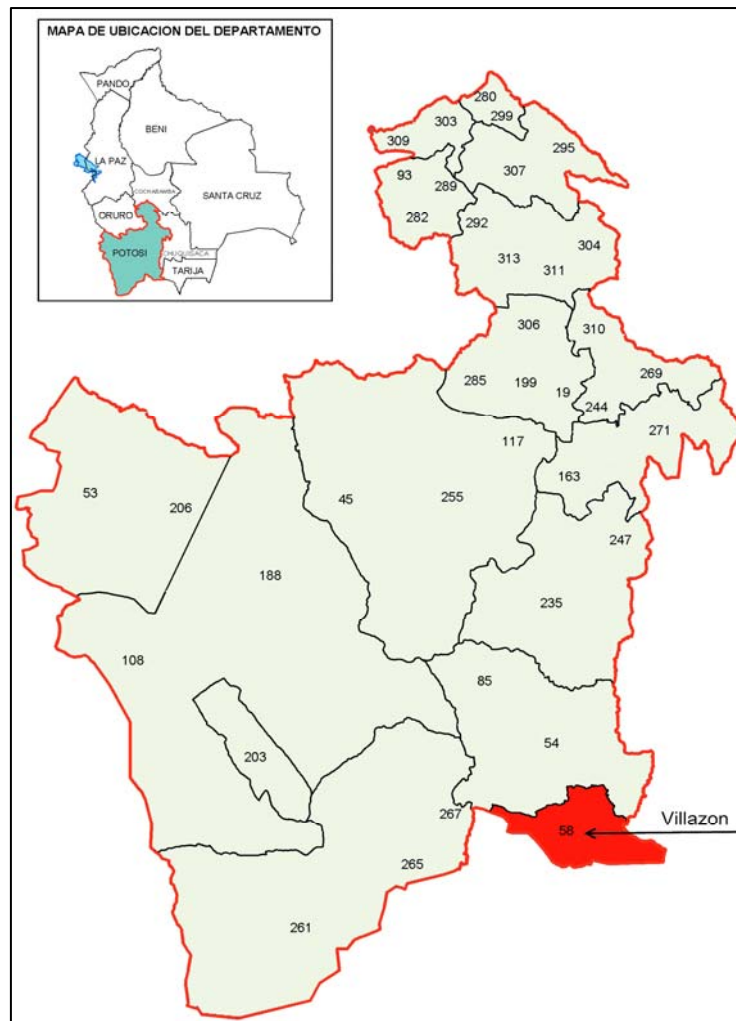


Figure 6: Relative geographical position of Villazón (red) Bolivia
Source: <http://idh.pnud.bo>

4.3 The respondents; difficulties and challenges experienced

This paragraph describes certain characteristics which were encountered while working with the Bolivian respondents, which for this research posed some limitations. It is thus vital to get an idea how the people responded and why, as it can clarify certain doubts on the validity of the answers given mainly in the research survey phase by the end users.

As mentioned before, conducting the surveys took place in the isolated rural communities of Villazón. This location determines the first characteristic of the respondents; that they live in a rural setting and their occupation is primarily subsistence farming. Before entering the rural area of Villazón I was already accustomed to the traditional way of life of some urban people in Bolivia, namely in Sucre as I spent most of my days residing there. Normally there is always a difference to be expected between the degrees of conservative nature of the people coming from the city and those coming from rural areas.

The people in the communities in which the survey took place, indeed turned out to be more conservative but also more closed and not as interested as their urban counterparts. This was easily noticeable by the answers people gave and their mistrust towards the intention of the survey. This mistrust however, would have been even worse under different circumstances. Since I was travelling with two technicians working for Energética, the people perceived me as part of the project team and were thus willing to take part in the survey. Without this advantage, another person would have most likely stood in front of many closed doors.

When talking with the technicians and others about this aspect of mistrust, it became clear that the good hearted people of the rural areas were often victims of scams. Scams schemed up by con artists from the city. These scams often promised them a fictive product or service while collecting the money and later never to be seen again. In fact the problem was that they were too trusting in their good nature. When they do trust, as it was the case for us (the local technicians and I), people were willing to give you a lot if it was necessary. In my particular case some people often thought I was from the credit company which arranges the micro credit for purchasing the SHSs. Because of this some people were willing to give me their due payments for their own SHS or for signing themselves up for a new one.

The mistrust together with a low level of interest and difficulty in comprehending simple questions, was the most challenging. This meant that certain questions in the survey turned out to be very difficult (even though these were formulated in several different ways), which often lead to an insufficient or not thought through answer by the respondent. Reformulating an already very basic question was a difficult task, particularly as to not lead the respondent towards an answer. This was noticeable in some questions where they had to choose from examples, in which a lot of the times people answered with the first example given and could not think of anything else by themselves.

The lack of interest was also noted as the surveys took place in their homes. While asking the questions certain observations were made which could be related to questions on the questionnaire. This meant that it was noticeable when people were lying on certain questions or where they were not doing their best to come up with an answer. It was understandable that people had to carry their daily tasks and many of the respondents were busy at the time of questioning. This meant taking time off their current activity to answer some questions. There was also a noticeable difference between the manner of answering between women and men. Most women were less articulate in their answers than the men, when answering similar questions. This also has a lot to do with their traditional gender roles in the household, where women do not get too involved in technical things, financial matters and other important decisions within the household.

Due to the short window of opportunity in entering the project area and to weather conditions at the time of the year (April), the survey could only be carried out once with the end users. On a second opportunity, it is arguable whether the respondents would have answered any differently as they did the first time. With the known limitations and in order to increase the validity, a more in depth and time consuming relation with the end users would have to be achieved in order to understand and observe their lifestyle better and the changes which have been made to their livelihood capitals due to their SHS. However, with the time available, weather conditions and the busy maintenance schedule, the latter was not an option nor would it have suited the nature of this research. On this note I would like to make clear that the best was done to make the respondents understand the survey properly and to not go as far as to influence the answer possibilities of the respondents themselves.

4.4 Geographical representation of the four communities surveyed

The following map was created using the coordinates of each household which was surveyed during the visit into the area, acquired with a GPS device. The map provides a geographical representation of the area and it also provides an idea on the disperse nature of the settlements and user households.

The figure below illustrates the relative position of the communities; Quichina (in yellow), Chaquicocha (in green), Tica Cancha (in purple) and Casira Chica (in orange).

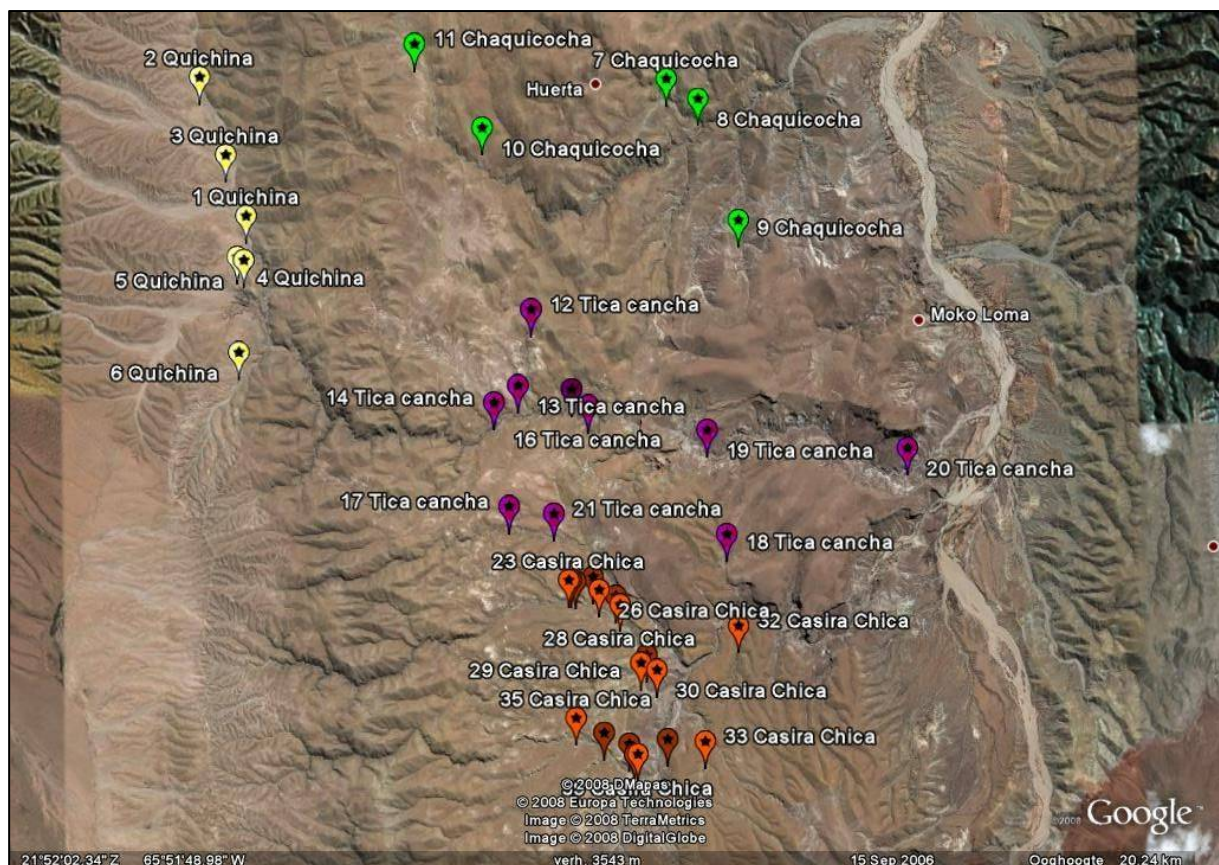


Figure 7: Geographical locations of Quichina, Chaquicocha, Tica Cancha and Casira Chica

Source: Google Earth overlaid with respondents household coordinates

As seen on the map, Casira Chica was the community with the most SHS installations as well as the biggest of all four. Quichina on the contrary was the smallest of all with only six SHS installations. At the time of the survey, an additional eight users in Casira Chica were having SHSs installed in their house. Along with the location of the solar home systems, the rugged nature of the areas can be seen on the satellite image being presented above. Some areas where respondents lived were very rugged indeed. Very often this meant that we had to travel along the river beds and park the vehicle on a hill top and continue walking for an hour in order to reach a house on the maintenance list. It is this lack of infrastructure which makes these areas difficult to reach. Entering these areas can only be done during certain times of the year. Period of rains for example, makes it impossible for the team of technicians to enter successfully with vehicles, as paths are often destroyed.

5 Impact assessment

In this chapter, the main empirically gathered information of this investigation will be discussed in order to try to answer the sub questions and the main question (regarding the impact on livelihood capitals), of this investigation. The livelihood capitals data gathered by means of the survey questionnaire with the end users of the IDTR project in the four communities visited, together with personal observations, will form the main source for this analysis. The analysis will be discussed per capital as set out in the actual survey.

The survey was established using the five livelihood capitals as illustrated in the sustainable livelihood framework (see chapter 2) in the livelihood assets component. For each type of capital, a question block was formed in the survey questionnaire. With this differentiation in the survey questionnaire, the empirical data per capital could be identified. For the questions discussed here in the results, it is important to note that every question was related to changes since the acquirement of the SHS and not before that or generally speaking. In the communities surveyed, the SHSs installed were in use for about 1 to 1.5 years.

5.1 Natural capital

By natural capital, it is understood that it refers to the direct resource stocks and environment which the people can use for their livelihoods. Natural resources such as water, air and soil are the basic elements (Scoones, 1998, P.7) that constitute such resources, which the people can use in order to grow food or build from and to structure any possible kind of livelihood.

It is thus questionable to what extent the SHS has influenced these natural resource stocks. With the addition of electricity to the asset portfolio, several possible intervention scenarios can be imagined as one would benefit from the energy provided to boost any type of activity which is directly linked to production by natural resource stocks such, as soil, water and air. As well as the replacement of current techniques by the new technology of the SHS.

In the survey, the natural capital dimension was split

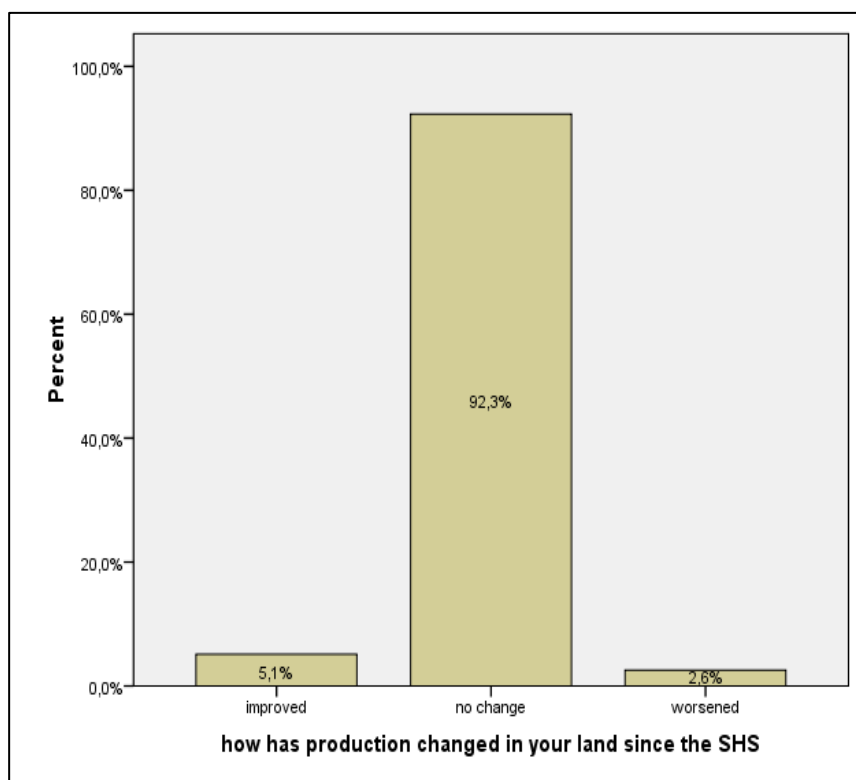


Figure 8: Bar displaying changes in the users land production since the SHS

into three levels of indication. Namely the impact on the production of their land, the impact on the air quality as experienced by the users and the impact on their water resources for consumption and production.

For production land, the people of all four communities questioned did not achieve any significant change in their production. The majority (92%) experienced no change in the production of their land since they have a SHS. When there was a change in the production, such as an improvement or worsening, this was due to the rains and ice respectively.

The quality of the air is another key indicator for natural capital. The aim with these questions was to reach an understanding of how the people cooked in their households and what methods they used for cooking. With the arrival of the SHS, no change was made in the way things were cooked, which means that no renewable energy method is used for cooking purposes. All of the respondents cooked with the locally available wood and many also used gas for indoor cooking. About 74.4% of the respondents said they cooked indoors as well as outdoors. Only a few (15.4%) cooked explicitly outdoors. These were the people with no kitchen room as part of their home. Even a smaller percentage said they solely cooked indoors.

From Table 1 below, it can be seen that there was no change in the fuel choice for cooking since the SHS was acquired. The greater part of the users still continue to use gas for cooking indoors and continue to use wood for cooking outside the home. Logically so, as wood is found nearby and has no additional cost. In this case no impact was noted due to the SHS intervention.

Table 1: Cooking environment and the corresponding fuel of choice

		where do you usually cook		
		only indoors	only outdoors	indoors & outdoors
		Count	Count	Count
with what do you cook now indoors	Wood	0	0	2
	Gas	0	0	25
	Wood & gas	4	0	2
with what did you cook before indoors	Wood	0	0	2
	Gas	0	0	25
	Wood & gas	4	0	2
with what do you cook now outdoors	Wood	0	6	29
with what did you cook before outdoors	Wood	0	6	29

Table 2: Changes in air quality and reductions in smoke produced by lighting sources

		Count	Table N %
has the quality of the air changed inside since SHS	improved	6	15,4%
	worsened	0	,0%
	no change	33	84,6%
has the quality of the air changed outside since SHS	improved	0	,0%
	worsened	0	,0%
	no change	39	100,0%
what do you use that produces smoke, but in less amounts now	fuel generator	0	,0%
	candles / oil / gas lamps	39	100,0%
	other	0	,0%
	still use but in less amounts	0	,0%

Table 2 above describes the perspective of the end users on the air quality change since the SHS acquirement. Quality of air outside the house is a difficult thing to notice. It is also for these people out in the rural area certainly not a priority and they often care little about inhaling direct smoke as they cook outside. It is therefore not surprising that every respondent noticed no change in the air quality outside the home. Indoors, a change was also not noticed that much by people. Only 15,4% of the respondents recognized a change in the air quality. An air quality improvement is one of the things which is to be expected when a household acquires a SHS. This is because old forms of lighting such as candles and oil/gas lamps will be replaced by the lighting of the system. 100% of the users answered that they had cut down on candles and oil/gas lamps. This would again suggest an improvement in air quality indoors. However as shown above, 84.6% of the respondents did not seem to make this link between the reduction in smoke and the improvement in air quality.

In the mountainous region in which these communities are located, runoff water was scarce at the time, since it was the dry season and smaller streams were running dry. However most of the household are strategically located along the river valleys for the access to river water. Table 3 shows that in 82,1% of the cases people relied on the river for their drinking water. This has changed very little since the SHSs installment. It means that in this particular aspect the SHS has had also no impact for the way water is being accessed and in 94,5% of cases it also had no effect on the quantity available to them. Few people used manual water pumps to access drinking water. In Quichina and Chaquicocha, the village nuclei had access to tapped water from the nearby hill and in Chaquicocha from a windmill pump (as part of another development effort from the local municipality). For the rest, the people relied on the river and other conventional methods to acquire water. No kind of photovoltaic powered pump was being used by any of the respondents to gain access to ground water.

Table 3: Change in access to and quantity of drinking water

		Count	Table N %
how do you access drinking water now	river / pond	32	82,1%
	communal piped tap	1	2,6%
	manual water pump	2	5,1%
	water well	1	2,6%
	other	3	7,7%
how did you access drinking water before the SHS	river / pond	31	79,5%
	communal piped tap	1	2,6%
	manual water pump	3	7,7%
	water well	1	2,6%
	other	3	7,7%
has the water quantity changed since the SHS	more	2	5,1%
	the same	37	94,9%

5.2 Financial capital

The economic or financial capital forms a very important asset in the livelihood portfolio. Under this capital, the main cash, credit or debt, savings and any other main economic assets in the form of equipment or infrastructure, all have an impact on the financial capital (Scoones, 1998, P.7). The financial capital like other types of capitals, can determine the pursuit of any type of livelihood strategy as well as being a livelihood goal itself.

As mentioned earlier, the rural population is not the most trusting and open about the information they give. When it comes to finances the level of weariness is at its highest. The respondents were not always as motivated to provide an answer in this category. This was to be expected and so questions regarding their actual income were not directly asked, but rather indirectly on how the SHS has impacted the household financial properties such as savings and debt as well as purchases made.

The first indicator to look at is the credit and debt developed by taking part in the project. As stated in the IDTR description, part of the service is to offer the people a micro credit in order for them to pay the system in a gradual manner. Taking the purchase price of these systems in to consideration, it is most likely that people will have used the credit option to purchase the SHS besides a few exceptions of wealthier families.

In Table 4 below, almost everyone (74,4%) responded 'yes' to taking a credit for the payment of their SHS. A surprising 25,6% answered no nonetheless. Along with the credit it is important to know

whether the SHS indirectly has put stress on the financial resources of the households. In this case all people who said yes to the credit also reported as having no difficulties as a result of it. The remainder 25,6% did not apply because they stated as not having to take out credit for the SHS.

Table 4: Credit takers and financial difficulties

		Count	Table N %
did you take a credit loan for the project	yes	29	74,4%
	no	10	25,6%
has the credit brought difficulties	no	29	74,4%
	yes	0	,0%
	not applicable	10	25,6%

With the SHS, people in comparison to before do get better quality light and use less to none in candles and other traditional forms of indoor lighting. With this in mind it is to be expected that people can save money on candles and other things when it comes to lighting, as they now have light bulbs powered by the SHS for night time use as well as for day time use if necessary. In Table 5, when asked about the possibilities to earn money as an effect of having the SHS, the majority responded no (61,5%) and the rest responded yes. The users which were convinced about earning more money, stated that the main reason for this was the increased productivity which the light provided. This increased productivity was due to the longer working hours at night time, making the pottery works in which all of the communities in this region are involved (see Figure 9). Only one user stated that he could save more money with the SHS and thus keep more earnings.



Figure 9: Photo of pottery works as often found outside respondents homes

Even though not everyone acknowledged the earning possibilities, 61,5% of the respondents did see an increase in their savings since the acquirement of the SHS. According to them, this was due to the decrease in expenditures related to old fashioned lighting, such as candles, oil lamps and gas lamps, which are the most common for these people. No change in the savings was also a significant response by 33,3% of all respondents and only one user declared that his savings had decreased since the purchase of the SHS. Despite the better light and less use of candles, people maintained their current activity of pottery making in order to earn money. All of the respondents stated not having changed their income generating activity as a result of the SHS.

Table 5: Earnings and savings related to the SHS

		Count	Table N %
Have the SHS help you earn more money	yes	15	38,5%
	no	24	61,5%
if yes how	increased productivity by working at night	14	35,9%
	I can save more money	1	2,6%
	not applicable	24	61,5%
do you earn money differently since purchasing the SHS	no	39	100,0%
do you save	yes	38	97,4%
	some times	1	2,6%
if yes, how have your savings changed since the SHS	more because of extra productivity	1	2,6%
	less	1	2,6%
	the same	13	33,3%
	more because of less expenditures	24	61,5%

It is clear that when the people decide to purchase a SHS, some kind of savings will be required to make the down payment and the rest can be can paid by means of the micro credit made available to them by the credit organization. Therefore some kind of temporary capital injection is expected for them to acquire the system. The SHS in the aspect does seem to have a positive impact on the financial resources of the users, as they still save money by decreased costs in previous lighting fuels and earn more due to the increased productivity in their pottery making in the night hours. Table 6, displaying the fuel expenditures, backs up this assumption. On average people used to spend 74 Bolivian pesos per month on fuels for lighting and other purposes. Now they have cut down these expenses by more than half and are only spending on average 28 Bolivian pesos per month. This adds up to a total savings of 552 Bolivian pesos per year or, in other words, ±52 Euros. From Table 6 it is also noticeable that the majority of the people still continue to buy gas for cooking as well as candles and batteries. Many did say that the expenses of batteries and candles had gone down immensely as they now use lighting from the SHS. Although, every now and then candles are needed, especially for those households that have more than 2 or 3 rooms and their SHS does not provide enough lighting points for all of these areas.

Table 6: Types of fuels bought and the related savings since the SHS

		Count	Table N %	Mean
do you still buy additional form of fuels	yes, candles	2	5,1%	
	yes, gas & candles	10	25,6%	
	yes, candles & batteries	1	2,6%	
	yes, candles, batteries & gas	24	61,5%	
	yes, gas, batteries & fuel	2	5,1%	
how much did you spend on fuels before the SHS per month in Bolivian pesos				74
how much do you spend now on additional fuels per month in Bolivian pesos				28

Another aspect of the financial capital, is the so called financial infrastructure. The SHS and all of its components are without a doubt an infrastructural gain for the end users. The fact that the systems can be purchased at a subsidized price is already an automatic financial gain for the people. Once they have fully paid the system, they are free to do what they want with it. If someone was to resell his system in the market, it is estimated that he would barely lose his investment as the solar panel itself is already worth the price for the whole system that the users have paid. Although it is not technically a promotion point of the project, many user do recognize this possibility for any future plans. A case scenario in which this will pay off is when certain rural communities get connected to the main stream network and thus find their SHS as being obsolete. If this was to happen the users could recuperate a large part of their investment by reselling their system in the local market.

Beside this direct gain in the form of the SHS itself, other gains are the electric equipment that the users will have purchased after the acquirement of their SHS. From Table 7 one can see that only 17,9% of the respondents said to have purchased additional electric equipment since the SHS. The main reasoning behind this was the electricity which the system provided. The remainder (82,1%) did not purchase any additional equipment and still used the same as before (mainly radios). From the few which did buy something new, it was mainly for entertainment purposes, such as a radio or a television with DVD. Only one respondent had bought an appliance which could be used directly for their work activity. When asked about the meaning of the electric equipment for them, 79,5% responded that it was mainly for music and news, which means that their most used electronic devices were radios. Only two respondents recognized the use of their equipment as beneficial for the children's education and the rest had other remarks.

Table 7: Electric equipment and uses for it

		Count	Table N %
how has the quantity changed in electric equipment since SHS	more because of electricity	7	17,9%
	the same	32	82,1%
if more, what type of equipment have you purchased	entertainment equipment	6	15,4%
	work equipment	1	2,6%
	not applicable	32	82,1%
what does the use of this mean for you	listen to music & news	31	79,5%
	educational for the children	2	5,1%
	other	6	15,4%

5.3 Physical capital

The physical capital is in this case strongly tied to the financial capital discussed in the previous section. When talking about physical capital, the basic infrastructure needed to support the livelihood is the essential factor. Clean and affordable energy is recognized as being a key factor in the infrastructure component to achieve a sustainable livelihood (DFID, 1999, section 2.3.4). Other indicators, such as the water supply, also form part of the basic infrastructure but will not be discussed in this section, as water supply has been overlapped by the natural capital asset.

With this in mind, besides the obvious SHS which delivers in this case clean and affordable energy for the users who have signed up for the project. The communications and related electronic equipment dimensions will be analyzed as they too form part of the infrastructure dimension. Table 8 below, shows that the majority (74,4%) of the users did not have any kind of electricity generating device or electric network connection. The remaining 25,6% did have electricity although not constant, by means of car batteries, fuel generation and others. Now with the SHS in their homes, most of the respondents (92,3%) only use the SHS and no other additional means to generate electricity. Only four respondents kept using additional means for electricity generation. Their explanation for the usage of these, besides the current SHS, is because they either had it already or because they wished to watch television²⁰. Two of them had panels already connected directly to a battery and the other two respondents had generators which they had bought before.

This new access to electricity is by no doubt one of the biggest impacts on the end users. With the SHS they are able to cut down the usage of old generation methods all together or diminish the use

²⁰ Although watching television is technically possible on all the SHS types, it will drain the system battery fairly quickly on the smaller types of systems. It is therefore recommended to the users to only use small (14 inches or smaller) black and white screens to cut consumption of such devices and to use them preferably with the larger two systems of 55Wp and 75Wp, as these are equipped with larger capacity batteries.

of it for some, providing the basic infrastructure to carry out more activities and with relative ease in comparison to the old methods.

Table 8: Change in access to electricity, relative power and usage

		Count	Table N %
did you have access to electricity prior to the project	no	29	74,4%
	fuel generator	3	7,7%
	car battery	6	15,4%
	other	1	2,6%
and now only by SHS or also additional ways	only SHS	35	89,7%
	fuel generator	2	5,1%
	car battery + solar panel	2	5,1%
if yes, in comparison to before how much electricity do you have now	more	10	25,6%
	not applicable	29	74,4%
why do you use other additional methods	I had it already	2	5,1%
	to watch TV	2	5,1%
	not applicable	35	89,7%

Table 9 below provides an idea of the type of communication equipment that the people have in these areas. The most basic is the radio. Every household spoken to had a radio and sometimes even more than one. Many radios had CD players or DVD players incorporated and some even had a small television screen to watch movies on. However, the amount and usage of these had not changed significantly. Only 15,4% mentioned an increase in the usage of such electric equipment and the rest remarked no change. Surprisingly so, as the radios can now be connected to the SHS and do not require any batteries to operate²¹.

Another surprising result, is that the majority (66,7%) remarked the radio as being important for carrying out their work. Not so much because of the news or weather forecasts, but to listen to something while working inside making pottery in the late hours. When asked about communications equipment, only a minority of 7,7% used some form of public phone in a nearby town for communicating directly with someone. The usage of this since the SHS had not changed much (all four respondents remarked no change), as the electricity being supplied by the system was not being put to use for any kind of two way communication equipment²².

²¹ With the SHS, a converter is supplied for altering the voltage of one outlet. This gives the users the opportunity to connect different sized radios with different voltages ranging from 3 volts to 12 volts.

²² The SHS is also supplied with a special outlet to connect a cell phone through a car charger which operates at 12 volts. It is thus possible that in other regions closer to GSM phone networks, that the users then will have bought a mobile phone for communication purposes.

Table 9: Change in electric equipment usage and communication tools usage

		Count	Table N %
what type of electric equipment do you own	radio	21	53,8%
	radio cd player	4	10,3%
	radio cd and dvd player	4	10,3%
	radio & TV	9	23,1%
	radio & stringing machine	1	2,6%
do you now use more electric equipment since SHS	yes	6	15,4%
	same	33	84,6%
is the use of electric equipment necessary for your work, if so how	no	13	33,3%
	yes, for listening to music and news	26	66,7%
did you use communication equipment before the project	no	36	92,3%
	public phone	3	7,7%
do you use communication equipment now	no	35	89,7%
	public phone	3	7,7%
	community radio	1	2,6%
if yes, how has the use of this equipment changed since the project	same	4	10,3%
	not applicable	35	89,7%

5.4 Human capital

When referring to human capital, it is (as the name suggests) the resources of the person as they are, mentally and physically. What abilities a person possesses such as education or skills and knowledge, as well as their capabilities are determining factors in a person's life in order to achieve and or pursue certain livelihood goals (DFID, 1999, section 2.3.1).

Table 10: Relation between SHS as facilitator for new and current activities and objectives

		Count	Table N %
has the SHS helped you pursue new activities or objectives	no	23	59,0%
	new activities	1	2,6%
	don't know	15	38,5%
since SHS can you do your activities more easily	yes	19	48,7%
	no	10	25,6%
	don't know	10	25,6%

if yes what do you think facilitates this	electric light	19	48,7%
	not applicable	20	51,3%

Taking the complexity of this characteristics into hand, querying about new skills and capabilities proved to be difficult at times for the respondents to comprehend. In Table 10 above, the results for abilities pursue new objectives or activities shows that a large amount of the respondents (38,5%), did not know or did not understand what was meant by it. When asked about if they could carry out their current activities more easily, a little less than half answered yes and referred to the electric light as the facilitator for this. Once again, many respondents (25,6%) did not know the answer and the rest (25,6%) stated that it had not been made any easier.

From Table 11, it is clear that from the 69,2% children that spend time at night for studying purposes, 61,5% are spending more time on the educational activities due to the light provided by the SHS. So the main benefits from the SHS provided light are being expressed on the children's time spent for their educational activities at home. For children it is an investment in human capital which will pay out in the longer term. About 10,3% of the adults also said to be involved in some kind of educational reading and they too benefited from the light, yet none acknowledge any kind of relation to their new skills or knowledge for developing new work opportunities as a result of their reading and or studying activities.

Table 11: Changes in education time and available knowledge and skills

		Count	Table N %
do the children study at night	no	11	28,2%
	yes	27	69,2%
	not applicable	1	2,6%
if yes, how much time do they spend studying at night since the SHS	more time due to light	24	61,5%
	same	3	7,7%
	not applicable	12	30,8%
do you (adults) use light for education purposes	yes	4	10,3%
	no	35	89,7%
have your new abilities or knowledge give you any new opportunities for work	no	4	10,3%
	not applicable	35	89,7%

The health factor is another key element in human capital. One of the most direct effects of a SHS is the cut back in candles and other smoke producing fuels which are used indoors for lighting and can have an adverse effect on the general health. The air quality indoors factor has already being looked at in the natural capital paragraph. It was clear that many did not recognize a change in this. In Table 12, when asked about their health condition since the SHS, almost 80% of the respondents acknowledge no change in their health condition. Only 17,9% remarked an improvement and 5,1%

of these related that improvement to a reduction in smoke by candles. The rest related other reasons and medication to the improvement in their health situation.

Table 12: Change in health related to SHS

		Count	Table N %
how has your health changed since SHS	improved	7	17,9%
	worsened	1	2,6%
	the same	31	79,5%
if improved, why do you think	less smoke from candles	2	5,1%
	medication	1	2,6%
	other	4	10,3%
	not applicable	32	82,1%
if worsened, why do you think	not related to SHS	1	2,6%
	not applicable	38	97,4%

5.5 Social capital

With social capital the main units of analysis become the social resources which people rely upon in order to pursue their livelihood objectives. Available networks, social claims, social relations, affiliations and associations, form such resources that constitute social capital (DFID, 1999, section 2.3.2). Social inclusion fits into the social capital as well, especially when dealing with isolated rural communities who have lacked help in comparison to their urban counterparts. With this in mind, it is necessary thus to get an idea on what the SHS can affect, that will add or take from the existing networks and social relations that the people in the communities rely upon.

As discussed in the physical capital section, the usage of communication equipment is an important tool to satisfy communication needs in social networks. With regards to physical capital, two way communication equipment was evaluated (such as phones), however other equipment such as television and radio are also effective means of communication, but usually it is one way. In Table 13 below, it is clear that the most common tool used is the radio (by 89,7%). About 7,7% of the users had also begun using a TV since the SHS. One user had also used a telephone or mobile although the usage of this took place somewhere else, as their own communities have no effective mobile coverage. The significant change in usage of this type of equipment did change since the acquirement of the SHS. 71,8% of the respondents signaled an increase and the remaining 28,2% used them equally much as before. No one said that they were using them less. With the extra usage of radio and TV it can be said that people are better informed about news in their area. Only two of the respondents had made use of a telephone and internet, yet the use of these took place outside their community and thus on a very limited basis.

Table 13: Change in usage of different communication means since SHS

		Count	Table N %
what communication means do you use since the SHS	telephone / mobile	1	2,6%
	radio	35	89,7%
	TV	3	7,7%
did you use these as well before the SHS	telephone / mobile	1	2,6%
	Internet in town	1	2,6%
	radio	36	92,3%
	TV	1	2,6%
how has the use of these changed since SHS	more use	28	71,8%
	same use	11	28,2%

Table 14: Change in social contacts and opinion on change

		Count	Table N %
how have your social contacts changed since the SHS	more contacts	5	12,8%
	the same	34	87,2%
what consequences does this have for you	its good	3	7,7%
	I don't know	36	92,3%

From Table 14 above, one can see that the amount of social contacts had increased for only five of the respondents. The remaining 34 remarked no change in the amount of contacts which they have since the SHS. When asked about the consequences of these extra or same contacts, few could express any consequence. Only three respondents regarded it as being good and the rest did not know what it meant for them. Taking the results from Table 13 on the usage of communication means, although a majority expressed an increase in the use of their communication equipment such as radio, the one way nature of these devices clearly show that there was no relation between the increase in use and the increase in social contacts. The results from Table 15, aggregates to this. Only 25,6% of the respondents participated on a regular basis in night activities. Most of these activities were simply meeting with the neighbors and (sometimes in the case of 1 respondent) bible meetings. The light from the SHS was given as a reason for the increase in the participation of these activities by 10,3% of all respondents. Another 15,4% mentioned no change in the participation in such like activities since the SHS. When asked about the consequences of increased participation, people again were not able to place any links to this. In response to the nearest neighbor with a SHS, 43,6% mentioned that their neighbors had a SHS and 53,8% mentioned that some neighbors had a SHS. Only one respondent stated no. It must be taken into account that when speaking of the nearest neighbor, for some households in these areas the nearest neighbor can sometimes be five

kilometers further down the path. Fourteen respondents answered yes to a relationship change between them and their neighbors without a SHS. It was remarked as positive, in the sense that they came over more often to visit, showing interest in the system (20,5%), sometimes it was remarked as negative, as they expressed some kind of jealousy and enviousness (10,3%) towards the users who had already purchased a system.

All in all, it can be said that the social capital dimensions being discussed were not so deeply impacted. The amount of contacts for the people which have a potential to increase their social network reach did not grow because of the SHS. The use of two way communication technologies, which can bring the people in contact with others outside their own community and increase their reach in information gathering, was also not there. Mainly one way communication technology is being applied and it serves primarily for entertainment purposes.

Table 15: Changes in social activities, consequences and relation to the SHS

		Count	Table N %
do you take part in social activities at night	yes	10	25,6%
	no	29	74,4%
if yes what type of activities are these	neighbors visiting	7	17,9%
	bible meetings	1	2,6%
	other	2	5,1%
	not applicable	29	74,4%
participation change since SHS with activities	more activity because of light	4	10,3%
	the same	6	15,4%
	not applicable	29	74,4%
what consequences does this have for you	none	10	25,6%
	its good	5	12,8%
	not applicable	24	61,5%
do your neighbors have SHS	yes	17	43,6%
	no	1	2,6%
	some	21	53,8%
did your relation with your neighbors without SHS change	no	25	64,1%
	yes, they were jealous	4	10,3%
	yes, visit more often	8	20,5%
	more friendships	1	2,6%
	other	1	2,6%
if yes, do you think it was because of the SHS	yes	14	35,9%
	not applicable	25	64,1%

In the following Table 16 below, several answers regarding the concept of social inclusion were given. When asked about their connectedness to the rest of the world since their SHS, the majority felt that they were indeed more connected (84,6%). From these users that felt more connected and included, 53,8% thought it was because they now had proper lighting. The light and its superiority to the traditional candle light was also the main response (48,5%) for the users feeling an advantage above the other neighbors or users which did not have a SHS. Others felt their advantage was due to a combination of light and appliance use and the ability to work at night. Working at night is in this strongly tied with the lighting quality given off by the SHS. One user related his advantage to less expenses as a result of owning a SHS.

Table 16: SHS advantages and social inclusion

		Count	Table N %
now that you have SHS, do you	yes	33	84,6%
feel more connected to the rest of the country and world	no	1	2,6%
	same	5	12,8%
if yes, why do you think so	I can listen to radio	7	17,9%
	I have light	21	53,8%
	other	4	10,3%
	I don't know	1	2,6%
	not applicable	6	15,4%
do you think you have an advantage above your neighbors without SHS	no	8	20,5%
	yes because I can work at night	4	10,3%
	yes because the light is better	19	48,7%
	yes, because of the light & work appliances	1	2,6%
	yes, because of the light & appliances	6	15,4%
	yes, because of less expenses	1	2,6%

The fact that the IDTR SHS project component has been designed to reach those in isolated communities, meant for the users that they were being taken into consideration by the government to provide them with better services, which most rural people have lacked in the past. Many users quoted the slogan behind this initiative which is 'electricity to live with dignity'. For them, being involved in this program and having proper lighting was thus seen as a form of inclusion with the rest of the population in the country. Something in which they as rural indigenous people have been excluded from in the past, characteristically so in Bolivia's history.

5.6 Expectation of new SHS users

The following paragraphs contain the results from the questions gathered with those users which were having a SHS installed during the same period of maintenance throughout the communities. Consequently all of the eight new installations were being placed in the community of Casira Chica. These installation consisted of 2 x 55Wp, 3 x 22Wp, 3 x 36Wp systems among the eight users, almost a perfect distribution if one more 55Wp had been installed. None of the new users however, opted for the 75Wp system.

The questions for the new users of a SHS being installed, complement the question of the regular survey for the impact analysis. Although not as extensive in nature, the questions for the new users provide an idea on what the people expect to use the SHS for and how their household may benefit from it.

In table A (see appendix A). One can see that, when asked about what they expected to change in their household as a result of their SHS, the majority (5 of 8 users) expected their change to be work related. Four out of the five said it would benefit their work at night time for making their pottery and that it would also benefit their children's education by helping them do their homework at night. One respondent said it would benefit his working hours. The remaining three respondents had mixed ideas on what was likely to change. One user, who was actually blind, mentioned in his case that the SHS would benefit his elderly mother of 79 years of age. Another user expressed that there would be more 'joy' and he would make less expenses with the SHS. The other mentioned that it would be good for the homework of the children as well as being less dangerous for them since they would not be using candles anymore. When asked about their productivity change, not surprisingly 7 of the 8 expected it to increase their working hours by making the pottery at night with the light. The other 1 did not, as the members of his/her household did not work at night.

When asked about their health change as a result of the SHS, 7 of 8 users responded that they expected change. Four accredited this to the decrease in air contamination by candles and other burning light sources. Two related the health benefit by being able to make more money and thus afford more medicines in the future. One user accredited the future health gain with the decline in use of candles as he stated that it was dangerous and also that they could now live 'more at ease'.

This relation between better health due to less air contamination is made evident by the responses given in the actual impact survey and the question regarding what they would stop using after the SHS. All of the eight respondents in this case responded to stop using candles and batteries. Among other reductions in use were car batteries and gas lamps.

Asking more specifically on the mentioned benefits for the children's education, four respondents linked the benefit to the homework activities of their children, one for the homework and safety as well. The other two, claimed benefits for their education, because of the TV and DVD equipment which in their cases could be used for educational videos and instruction material. The remaining 1 user did not have any children and thus did not apply for this question.

From the eight, five users mentioned that they would like to use their new SHS to power; radio, TV and DVD equipment. Two radio and TV and only one wished to keep only using his radio. From previous results it was also made clear by the respondents who already had a SHS that the majority purchased additional equipment for entertainment use (see Table 9).

From the social capital dimension, it was noted that the relationship with the neighbors did not change significantly when the SHS was purchased. When the new users were asked about a possible change in the relation with the neighbors, 7 of the 8 thought that it would not change in any way and one respondent answered that it the installment of his SHS would persuade the neighbors that do not have a SHS, into purchasing one.

6 Project sustainability review

The following paragraphs will review the sustainability of the IDTR SHSC, with the information gathered from the previous paragraphs on the impact assessment of the capitals acquired through the surveys conducted in the four different communities. Other important factors from general information, such as the project setup and personal observations as well as the interviews conducted, will provide important insights into the project's categorical criteria for sustainability as mentioned in chapter 2. These include; human factors, institutional factors, economic factors and the miscellaneous factors which will guide the assessment to come.

6.1 Human factors

Four year service plan

One of the main components behind the solar home systems being installed and what distinguishes this project, is the 4 year warranty program which is provided to the end users (as explained in paragraph 4.1). In the first four years the end users must restrict themselves from intervening with any system components. This hands off approach on the users side is important in order for the project organization to pass on the manufacturer's warranty to the end users. Within these terms, if anything fails, it will be replaced.

The main advantage of incorporating such a warranty period is that it promotes the success of the project. When people encounter a problem or a component breaks down, they have someone to go to in such situations. If the opposite was true, many people would get discouraged in purchasing a SHS if they knew from their neighbors that the system broke down and no one came to repair it.

In order to prolong the best operation of the SHS for the time to come, on site capacity building is crucial. This too is accomplished with the IDTR during the installation phase and reinforced once again during the maintenance visits by the technicians. By instructing the users, people know what to do when something goes wrong and they also learn what not to do in order to remain in warranty and not damage any of the system components.

One example (see Figure 10) of warranty violation is connecting an additional battery to the SHS. This is seen as a major violation, as it affects the solar battery which is a very important component of the system. During the maintenance done in the area, two users were encountered who had committed such a violation with their systems by connecting additional batteries. They will be reported and it is most likely that they will lose their warranty and thereby also their eligibility for the yearly maintenance.

From experience, Energética recognizes that in order to tackle these kinds of problems, the first maintenance visit should preferably be planned in the first 4 to 8 months after the installation has been made. This is so the SHS, if breached, can still be saved from further damage on time. This also reinforces the capacity building for the users, as it is often after the installation that users begin to

ask questions about their SHS (Terrazas Vásquez, 2008). So an earlier visit can work as a preventive measure and reinforce the knowledge of the system for the end user.

Once again; the whole component of warranty, maintenance and capacity building in the first four years, prolongs the success of the SHSC of the project. Besides the initial four years, the main component is the solar panel, which comes from manufacturer Isofoton in Spain. The panel comes with a twenty five year warranty, as that is the expected shelf life of the panel. People who are not easily convinced, reconsider under the favorable terms which the SHS has to offer, thus adding to the total amount of people willing to purchase a SHS. With all of these traits in mind, the lasting appeal increases, which is very important for the SHSC sustainability.



Figure 10: Photo illustrating a SHS warranty breach

The final objective of the four year service plan is to train a local person to work as a technician after the first year. Therefore when the project organization officially leaves the zone, a local person will be put in charge of the maintenance and repair duties in that area for the corresponding SHSs. This local technician will also (after four years) function as a supplier of spare parts for the people that have a SHS, creating a local supply chain. With this idea in mind, people in the future will not have to travel far in case they require spare parts or a repair service by the local technician. This aspect is also crucial, adding to the sustainability of the project. With a local technician and local parts distribution, people can rely on supplies ensuring that their systems remain operational and do not get discouraged in their usage, making the SHS a long lasting solution for their energy needs as well as a sound investment.

Participation

From the end users' perspective, participation on a design level has not played a significant role. Since the IDTR SHSC has been setup already to provide the mechanisms for electricity access to the masses. Participation does not occur every single time a community is entered for installations, but rather the potential new users participate in information gatherings in what they are going to receive if they take part in the project. Another perspective in participation is more present with the local levels of government, which are now being increasingly involved in the project in order to come to agreements about extra financial subsidies for the end users. This is good as it lowers the price and increases the reach of the project. It also informs the local level of government about the initiative, so that there will not be too many communication problems for future electrification plans. Current coordination problems are being experienced, which are slowing down the provisioning of the services made available by the IDTR SHSC (Rodriguez Ortiz, 2008). Participation at a higher level increases the sustainability of the project in the sense of its effectiveness to reach the most users in the future.

The technicians

As mentioned earlier, the users receive instructions on the functioning of their system, so that they can carry out simple maintenance tasks and know what to do in case something fails. The local technicians doing the installations and giving instructions form an important human factor for the project sustainability. In the four communities entered, the technicians came well prepared with enough tools and materials. This is important, as the end users are located in very isolated regions and the SHSs have to be installed under difficult circumstances. The adobe brick houses encountered throughout the region are one such difficulty. Systems components have to be put in place but the adobe material makes this often a difficult task to attach anything properly to the inner surfaces of the houses. The technicians had good experience with working in these conditions and had no major setbacks.

6.2 Economic factors

Costs and potential reach of the project

Seeing how this project is directed at a low income group and is destined for development purposes, a micro credit scheme is of essence. Up to now, the current scheme is that the government subsidizes 60 percent of the SHS costs and the remaining 40 percent is left to the end users. This is made possible through ANED, which allows users to choose a payment scheme that suits their situation. This has to be done in order to make the prices of the SHS affordable and realistic.

Readjustments to the financing scheme are still being made. This is because, according to Energética (Terrazas Vásquez, 2008), the target group for this system has shifted since the project study phase. During the period of 2002 -2004 a study phase was conducted and the price for the systems was thought up with another target group in mind. The problem is that the target groups being reached now have less to spend than originally calculated. This has happened because in 2005, the country went through a nationalization process of mining activities and natural resource exploitation. This led to more financial resources by the 'prefecturas' (departmental government) which in some cases (Potosí & Oruro), meant that the departmental government opted for rural electrification by means of network grid extension (Terrazas Vásquez, 2008).

The problem faced by Energética as an executing organization of the SHSC, is that small communities (of sometimes six families) close to the network were now being connected with the electric grid. This was obviously not viable, because of the small consumption of these families (15 to 20 Bolivian pesos per month), but in many cases it was done for political reasons. For Energética this meant that they had to go deeper into the rural isolated areas where people are even more dispersed and had less to spend. This required more resources and people were less enthusiastic because of the high price, regardless of the 60% subsidy (Terrazas Vásquez, 2008).

From a study conducted by Energética (Terrazas Vásquez, 2008), the people being left out are those who can only afford to give out a maximum of 50 to 100 dollars on a SHS with spread out payments. For these groups even the smallest SHS is out of reach, even though annually they may be giving out 30 dollars on candles. Besides the costs of candles, the expenses happen 1 Bolivian peso at a time,

which means that a down payment for a SHS and monthly deposits are too great of an economic shock for a household with a tight budget.

The affordability issue brings about another problem. If there are some who can afford it but the majority cannot then the organization will not enter that area to install, as it is not economically viable to do so for a handful of systems which are spatially dispersed. For this reason Energética tries beforehand to acquire extra funds through the local municipalities and governments in order to lower the price of the systems and thus increase their potential demand in a future area, making it viable to setup shop in these locations (Terrazas Vásquez, 2008).

With these difficulties in mind, readjustments are indeed necessary to increase the reach of the SHSC to those users who are being left out by the original pricing and subsidy scheme. These adjustments can only add to the project sustainability as it aims to cater for lower income groups and also to aid the development process in the rural areas.

Owning a SHS

As mentioned in chapter 4, the IDTR uses a credit component managed by ANED as the main delivery mode of the SHSC. This means that the end users are the owners of these systems at the end of all payments. Undeniably so if the costs of the SHS are lowered, more people can be reached with the project. Yet, it is questionable if the system was to be free of costs to what extent this would be sustainable. At the moment like it is now, people have to invest in a SHS and are careful with their SHS because it is of value to them. As a matter of fact, while the systems were being maintained, extra theft preventing measures were being taken by sealing all the bolt screws on the solar panel extension tube. It was a common concern shared among the users that their system could possibly be stolen when they were not home. So in the case of system ownership, the people are interested in doing their best as to not damage it. This in return adds to the general sustainability of the project as it increases the lifetime of the system and interest by the end users. It does however, bring a dilemma for future applications, as to whether it is better to give it away for free or to supply it at a minimal costs with more subsidy from the local levels of government.

6.3 Institutional factors

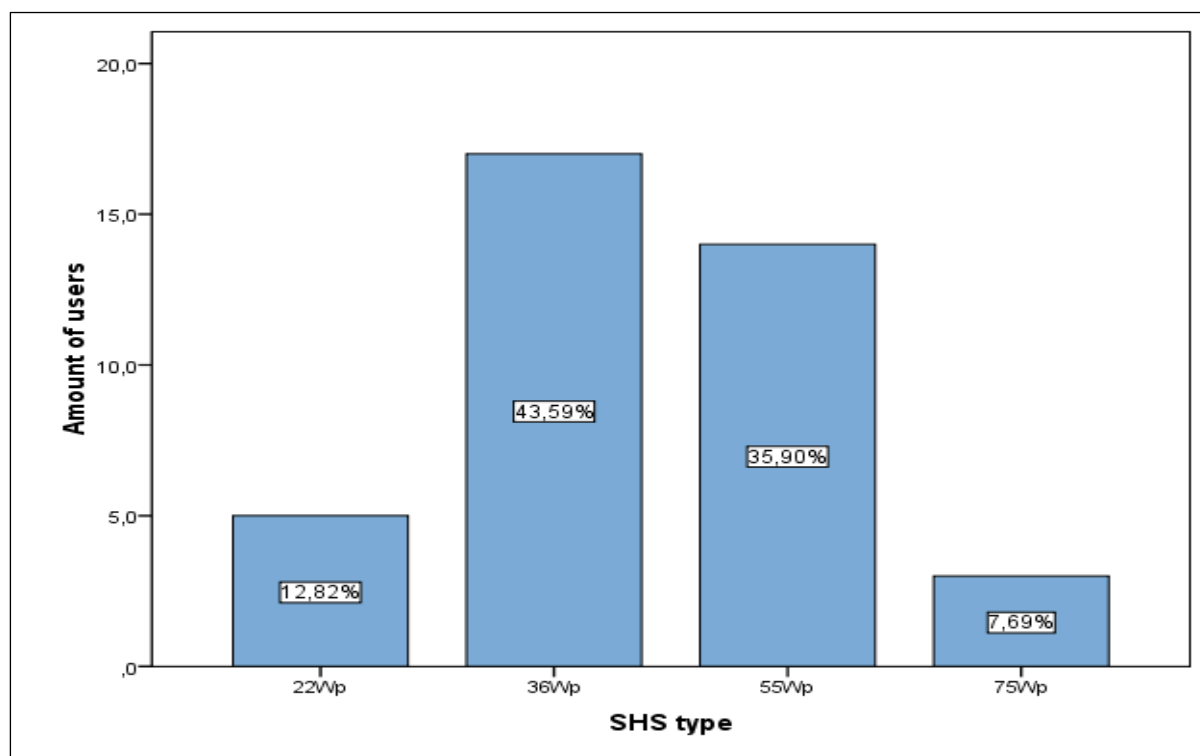


Figure 11: Types of SHSs installed in Casira Chica

SHS types

Figure 11 displays the type of SHSs installed in the community of Casira Chica and what the most popular SHS was. In this case the majority of the people chose the 36Wp. The 55Wp came a close second.

It also shows that the systems being provided are in good range of what the needs are of these users. Energética (Terrazas Vásquez, 2008) has also seen this trend, which sees a majority of users purchasing the 55Wp SHS. This is because most rural households have a main sleeping room, a kitchen room and often a storage room as well. In that case a system with three lighting points is the best solution. The 55Wp comes with three light points and the 36Wp with two. The 36Wp does have the capacity to add an extra light point (if purchased from the organization) which is important for the future of users wishing to expand their houses. From this point of view, it factors well for the project's sustainability that the people are offered systems well suited for their energy needs (which are not high). In the case of the communities surveyed, people were paying the original SHS prices, no extra subsidies had been arranged. If it were so, the 55Wp system would have been the most chosen one, as it comes with the extra light point and a bit more capacity for extra appliances.

Local PV industry and parts availability

As mentioned previously in chapter 4 the SHS is composed of several components, the solar PV panel being the most important one of all. After the four years of the official warranty, the

organization will leave someone in charge as a local technician and a parts distributor. Availability of the system components in the local market are also thus essential in making the project sustainable. If the end users have to rely on too many imported components, it can be of concern for future availability. In the case of these systems being surveyed, the only imported part was the solar panel, which came directly from Isofoton in Spain. Other system components are available from the Bolivian market. Some components, such as the energy saving bulbs and charge regulators, are from a foreign company but are assembled in Bolivia by their local branch. As a matter of fact Bolivia exports some of these parts to other countries in Latin America such as Peru (Terrazas Vásquez, 2008).

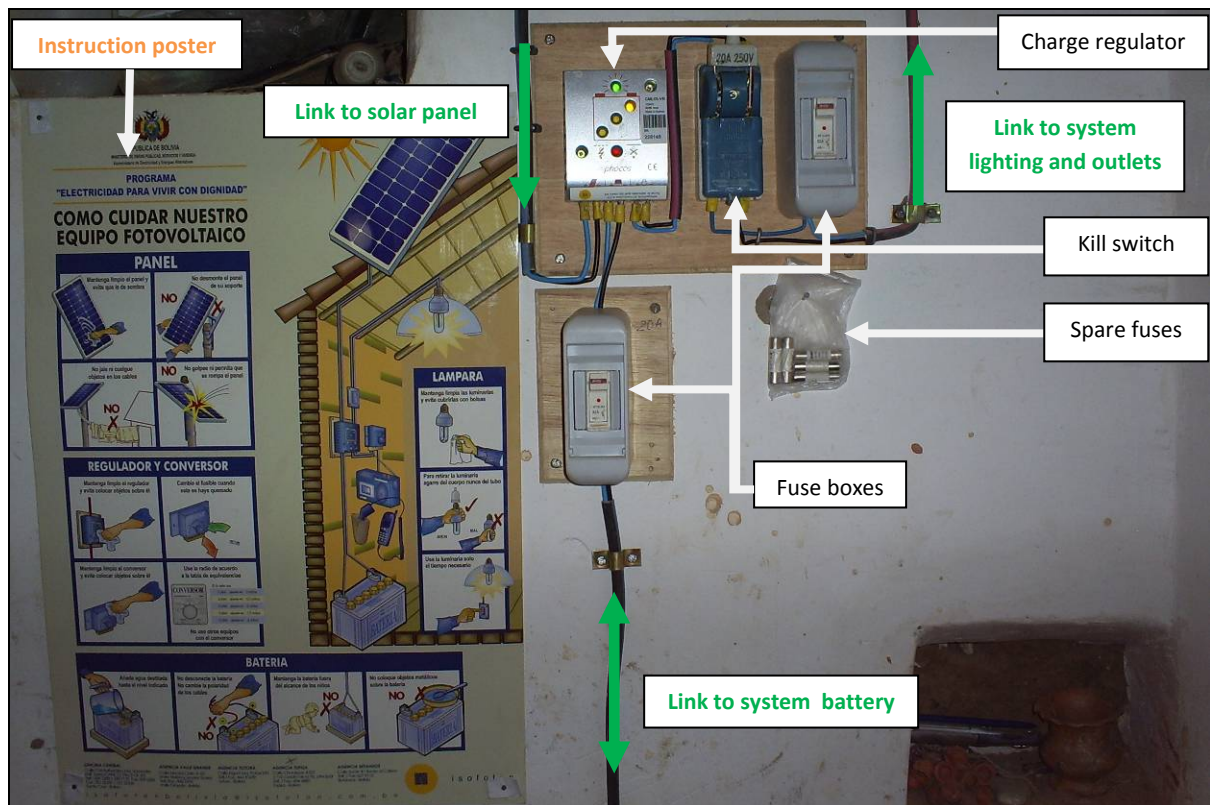


Figure 12: Photo displaying system components and instruction poster inside the users house

One of the components which users receive additionally are the spare fuses for the fuse boxes which are meant to prevent accidental damage to the system's battery and charge regulator (see Figure 12). How the SHS works is essentially the same for both the executing organizations. One of the differences between Energética and Isofoton, (the two respective organizations doing SHS installations) is that Isofoton opted in this case for a tubular fuse. This type of fuse however is not available everywhere, which makes it difficult for the users to replace them when they run out. From the viewpoint of Energética this is a design flaw, as they opted to use a very common 12 volt car fuse type, which is easily available across the country (Terrazas Vásquez, 2008). The users do receive 4 spare fuses during the installation. Luckily so, because during the maintenance most of the users had blown almost all of their spare fuses as they are just getting to grips with the system and do a little more experimenting on their own during the first year.

6.4 Miscellaneous factors

Environmental observations

One of the main impacts discussed in chapter 5 and shown by the response given by the users, was the reduction made by the users on typical types of fuels for lighting such as; batteries, candles and gas lamps.

A reduction in batteries not only has an economic advantage for the household but also ecological side effects. In the rural areas, every single household had old corroding batteries lying around in the direct vicinity of their land. This is due mainly to people disposing of batteries by throwing them away as there isn't any kind of recycle plan and the people lack knowledge of the environmental and health risks related to this. By cutting down the usage of batteries, indirectly the environment is being positively influenced. Less batteries are being disposed of in the direct vicinity of the house, reducing health risk to the people and toxic contamination on the land.



Figure 13: Photo of battery disposal at a surveyed household

The reduction from gas lamps and candles use also have an impact on the health of the people, although from the survey not everyone recognized these direct benefits. Using candles inside does produce smoke which is inhaled. Gas lamps form also a health risk, as these are mentioned to be harsh on the eye sight.

From an ecology point of view the project sustainability is being positively reinforced. Through the economic dimension that people are now able to save more money by reducing the consumption of candles, batteries and other fuels for lighting. As illustrated by the photo above, the reduction of these will benefit the direct environment of the users.

Migration

One of many livelihood strategies is migration. In the municipality of Villazón, migration plays an important role. Many of the people in the surveyed communities had already migrated in the past to do seasonal work abroad in Argentina and others to closer by locations for mining work. This provides the people with an extra income opportunity, as intensive farming is not an option because of the rugged terrain and little land available. In the surveyed area, users mentioned that there was no change in the amount of people migrating out of these communities since the SHS. There was no change with the youth, who are the ones that often leave the rural communities in search of more income generating activities. It is important to take this into account when speaking of the project sustainability. The project is suppose to increase the development in these areas, but to what extent is it necessary can be argued, if the younger population is still abandoning the area. In the case of these communities, extra income is still being generated on a daily basis by the pottery making activities that everyone does. In other areas of Bolivia it might be arguable to what degree the project is reasonable when outward migration is very high. Not so much as an electrification effort, but more as a significant means for development.

Political instability

Bolivia in the past year has seen some political turmoil with acting president Evo Morales and his governing party of MAS (Movimiento al Socialismo). This has put the central government in a bad light with the majority of the departments and prefectures of Bolivia. This too has had some implications for the SHSC. As mentioned before with the price scheme, some users are still being left out because they cannot afford a SHS. In order to accomplish this Energética has talked with local levels of governments for extra subsidies on the SHS price for the end user. In some cases lately, prefectures have refused to make any kind of deals in that respect (Terrazas Vásquez, 2008). Ivan Rodriguez (Rodriguez Ortiz, 2008) also acknowledges this as a major problem. He states that they are currently busy with straightening out these coordination problems with the local governments, in order to acquire more subsidies for the end users. This coordination problem is not only a subsidy matter but also an identification matter. Without the proper coordination, the central government and the organizations working in the SHSC execution cannot properly define the zones for potential users. This is because prefecturas can have their own electrification plans and sometimes withholding this information only gets in the way of the process. Removing this coordination problem can speed up the service to a lot of people and is seen as a central task to ensure the success of the IDTR program and therefore also the sustainability of the project itself (Rodriguez Ortiz, 2008).

6.5 Previous experiences with renewable energy in Bolivia

Although the IDTR project and its SHS component are new in Bolivia, in the way that it is setup to provide these services to the masses (Rodriguez Ortiz, 2008), there have also been some past experiences by other organizations, such as the small donations program of the United Nations Development Program in Bolivia. They have carried out pilots projects in the past, with different sorts of renewable energies for different types of needs.

Something which is clear from the impact measured on the capitals of the people in the four communities surveyed, is that the SHS has mostly impacted the financial capitals and that these changes are most noticed in domestic activities. The main reason for this has to do with the capacity shortage of the SHS for any type of large scale productive use. This implies that, in order to put the SHS to serious productive use, the solar panels being installed need preferable a stronger watt peak value than what is being offered now. However a stronger PV system comes at a higher price.

As mentioned earlier in chapter 3, taking price and electricity generation capacity into account, hydroelectricity or wind power are better suited for industrial or commercial usage in productivity gains. However, the poorest of the poorest in this case cannot afford such systems and do not require them either unless they are directly involved in large scale production of some kind. Previous lessons from the small grants program (P.P.D., 2006, P.82) confirm these findings. For example that, a SHS and small hydro are mainly good for domestic activities, such as homework activities of children at night. Furthermore they have positive implications for productive activities, but only as a support mechanism rather than a actual tool. Meaning that it is best used for supporting activities such as, lighting for small shops, lighting for handicrafts work and operating small electric equipment.

It is also recognized that the regional development, particularly in its existing production transformations, play a role in how far the benefits will be due to a SHS. If the transformations in the scale of production are being undertaken in a region, than these SHSs permit qualitative advantages on the short term to optimize the production transformation (P.P.D., 2006, P.83). This means that without a larger regional initiative for up scaling production, the users and the SHSs alone will not likely benefit beyond a direct gain in household activities and if they do benefit it will be at a very slow pace in the longer term.

7 Conclusion

This research dealt with a two part central question. The following will give an answer to these questions based on the results gathered from the analyses made and all other relevant information presented in this report.

What is the impact of the new electric services provided by the solar home system component (SHSC) of the IDTR project on the livelihood assets of the end users?

The primary focus of the first question dealt with the electric services that the SHSC provided to the end users. In this case, the services came in the form of a solar home system which is able to provide lighting and electricity for simple equipment, with usage limitations per different type of system. How this has changed their livelihood asset portfolio since the users have purchased the SHS, was the main focus of the survey used in the analysis, by looking into the changes of different livelihood capitals. All of the five capitals mentioned in this study were impacted, yet some more explicitly than others. This impact on the livelihood capitals which form the livelihood asset portfolio as explained in the theory, constitutes a very important part of the sustainable livelihood framework in influencing livelihood choices and strategies. During the impact analysis it was also noticed that the changes in capitals often overlap one another.

Air, water and land were the most basic elements available to the end users of the SHS in the rural locations surveyed. These form the basis for the natural capital dimension. The SHS and its services in this case however, have had little to no impact on the natural capital. This is because no significant changes were made to the production of the land the people have or to the water resources available to them. This was to be expected, as the power generated from the SHS is not sufficient enough for land applications such as irrigation or water pumping. What was to be expected is the difference in quality of the air indoors. This is mainly because users were now using electric light instead of candles or other lighting fuels, meaning a reduction in smoke. However, no changes were reported by the users. In the human capital this would also play a role for health issues, but once again no change was identified nor a link made between the reduction in indoors smoke levels and positive changes in health. Therefore, no impact was noted on the natural capital dimension since the use of the SHS. Even though, a potential positive impact was expected by future users of a SHS. These new users, questioned during the installation of the SHS, were convinced that it would help their health situation. Yet, the link to air quality was not the explicit reason for this. It is clear that the air quality for the rural users was a dimension which was difficult to grasp. Most certainly because of the lack of awareness that exists regarding this topic in the rural context.

One of the most significantly impacted capitals in the asset portfolio was the financial capital. With an investment such as the purchase of a SHS, financial capital is always going to be affected. The way the project has been setup, with a micro credit plan made available to the users, serves to lessen the financial shock that the purchase of a SHS has under normal buying circumstances. Because of this, the people who make use of this credit had reported no extra financial difficulties for their household as a result of the purchase. On the upside, savings had gone up for most people, as they were able to cut on expenses from candles, batteries and gas for lamps. This of course is limited in the first year as the purchase price has to be compensated but after some years running the cost of

the system and the savings made on candles, gas and batteries weigh each other out. Another positive impact was the increase in productivity, not from the land as mentioned in the natural capital, but from their other income generating activity which in this region is pottery making. All of the respondents were involved in this activity and many gained from it by being able to work longer hours at night thanks to the better quality light provided by the SHS. From this point of view, the SHS for these households engaged in pottery works provides a healthy investment to gain more financial resources, which then could be used to supplement other types of capitals within their asset portfolio. This financial gain was also an expectation by the new users having a SHS installed. They too expressed their expectations of an increase in the working hours at night. Pottery work is often done at night. The reason for this is that during the day people are conducting their daily duties on the fields and with their livestock.

The physical capital was one of the capitals which was not significantly impacted. This dealt directly with the tangible infrastructure that the people had to support their livelihood. When purchasing a SHS, this meant an addition to the current infrastructure available to them. People now have electric infrastructure in place at their home, to generate electricity and power simple devices as well as electric lighting. This new addition to the infrastructure in the physical form of the SHS, often meant, (but not for everyone) that new equipment was purchased primarily for entertainment. For some users additional power sources were now also not necessary as a result of the SHS, such as car batteries, only some continue to use these additional power sources, for extra applications such as a television set. In reality the SHS had a very limited impact on the physical capital besides the direct gain from the system itself.

Future new users gave an indication of how their human capital would be impacted. Education benefits for the children were high on the expectation list for them. From the current users, it was confirmed that the majority of the households witnessed an increase in the study time by the children at night, thanks to the electric light. As mentioned in the natural capital dimension, health benefits from cleaner air were not quickly indentified. These are relevant for human capital as health can impact the abilities people have to do their daily activities. From the SHS point of view, indoor smoke reduction is one of the direct links, yet people did not see how they could benefit from this health wise.

The social relations, bonds and networks available to the people are what constituted the social capital indicator. With a SHS new opportunities can arise to increase the level of communication by means of communication equipment and social ties can be strengthened by the common factor of owning a SHS. These aspects however, did not significantly change since the purchase of a SHS. The usage of two way communication devices such as the telephone or mobile phone was not an issue in this case, simply because the infrastructure for these devices is lacking in the research area. Communication equipment use for the time being is limited to one way devices such as the radio and television. From a national point of view, users did express that they felt more connected to the rest of the country as they were now being more included. This inclusion has to do with the different politics of the country and in relationship to the project, people felt more involved by having the possibility to access electric services and live a more dignified life. This aside, the social capital was still only impacted on a very limited basis. No major signs were given, that would indicate improvement of their social networks or relations since the SHS.

The livelihood capitals mentioned above all build up the livelihood asset portfolio. The livelihood capitals have been positively impacted in different manners. By this, it is meant that some capitals are experiencing more positive changes than others. Most importantly however, is that the people are benefiting from their SHS, as the capitals mentioned above together with other aspects form the resource base for their daily lives. Although it might be early in the project phase to recognize more significant livelihood capital changes, the fact is that it has primarily brought a positive change to their asset portfolio and has added new capabilities for their livelihood, even though it might still be too early for the end users to be aware of all the possibilities.

How sustainable is the IDTR SHSC project until now based on the impact assessment and the project sustainability review?

Was the second question posed on the IDTR's project sustainability. Based on the impact and the project sustainability factors the following was found.

Sustainability, as mentioned earlier in this thesis is a broad, term. In the context of this investigation and the project being studied, the sustainability of the project was reviewed in terms of its lasting appeal for current and future users.

One of the main advantages behind the IDTR SHSC is the four year warranty and maintenance plan, as well as its micro credit plan for purchasing. The additional properties of local technical support and distribution of system component parts as planned after each project area is exited by the project organization. These help to form key factors to ensure the lasting appeal of the project and the installed SHSs.

First, it guarantees service and repairs for the end users within the first four years. This is a strong selling point for rural clients, which might doubt the sincerity of the project. This is generally a result of the fact that rural inhabitants are often victims of scams. Secondly, the micro credit makes it possible for a higher range of people to afford a SHS without having to pay for the whole system at once. Thirdly, once the organization officially leaves the area, a qualified local technician will be in place to service the systems and function as a local distributor for spare parts.

The capacity building aspect is also of importance, as it deals directly with the human factor of the untrained rural user. Information is provided once the SHS is installed and again during the maintenance visits. This way people's knowledge in usage and maintenance of the system is reinforced. It of course increases the chance of correct use and maintenance on the user's behalf, which can increase the components' lifetime. As well as the users satisfaction in the correct care and proper use of their SHS.

From a project perspective, it is good to reach as many people as possible so they can all benefit from the electric services of a SHS. However, there are still hiccups in this matter, which are influencing the overall project sustainability. Simply because not as many people are being reached as could be and cooperation levels between different levels of government are low at the time of research.

The costs of the SHS are a main issue and the poorest groups are still out of reach from owning a SHS. The political situation inside the country is also not stable which means difficulties for cooperation and coordination with lower levels of government have come up. These aspects need re-adjusting in order to increase the reach of the project and making it more sustainable. In other words, things can always be improved. The IDTR SHSC with the positive impacts witnessed from the livelihood asset portfolio and the way it has been setup, makes it a serious initiative for future users.

The IDTR being a new type of project as it is setup to provide electric services to the masses is bound to face some difficulties. The impacts mentioned here are good for the people living in rural communities who have for a long time lacked very basic services, but electric services from the SHS cannot be labeled as a silver bullet for development. The systems at hand do contribute a lot to the improvement of domestic tasks as well as to the overall quality of life, but are still too limited in power to be put into any large scale productivity gains. For this, simply more is required in forms of regional production development plans. In the case of the people surveyed, SHSs form a precise tool to offer electric services through a decentralized system. People in these areas and their relative simple lifestyle do not require much beyond what a SHS can give to them. More effort should be put in to supplying the poorest with such systems instead of extending networks were the usage of it will not be economically viable. For the same investment, people could be receiving SHS systems practically free of charge.

Up to now the IDTR SHSC and how it is being executed, has displayed strong human, economic and institutional factors which have shown that the project has a strong basis for a successful implementation. Nevertheless, the shortcomings in the economic factors of pricing should be addressed in order to push beyond the successful running of a program, towards a strong rural development initiative.

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Appendixes

A Table of survey questionnaire with new users

Table A

		Count
how were you informed about the SHS project	visit from Energética	4
	through an installation of a neighbor	4
what convinced you to purchase a SHS	the costs savings	1
	I could pay with credit	1
	it's more like regular electricity and the quality is good	1
	others had it and I didn't	2
	my neighbors	1
	I couldn't afford it, but now I can	1
	the light for my mother and visitors	1
	more power for greater use	1
why this SHS and not another type	don't know	1
	because it is slightly bigger than the smallest system	1
	by mistake, I wanted a bigger one	1
	because of the price	2
	this one has more energy for future uses	1
	for the usage, small one is enough	1
	better for working at night	1
	better for working at night & for children's education	4
now that you have the SHS, what do you think will change in your household	more joy and less expenses	1
	good for homework & less dangerous than candles	1
	it will help my elderly mother a lot	1
	yes by working more at night making pottery	7
	no, we don't work at night	1
do you think you'll be more productive and how	yes, it's good for persuading those without panel	1
	no, it will stay the same	7
do you think your relation with the neighbors will change	yes, less air contamination	4
	I don't know	1
	yes, more money for medical costs	2
	yes, live more at ease & candles are dangerous	1
	as long as possible	8
do you think your health will change now that you own a SHS		
how long do think the SHS will last you		

if you get main stream electricity later, will you continue using the panel	yes, I don't think I will get mainstream electricity	6
	yes, I will move it to another location	2
what type of equipment do you wish to use with your system	radio	1
	radio & TV	2
	radio & TV & DVD	5
what type of fuels will you now use less or not at all	candles & batteries & gas for lamp	4
	candles & batteries & gas for lamp & car battery	2
	candles & batteries & car battery	2
what do you think will change with the education of the children	TV & DVD good for education and light for homework	2
	light for homework	4
	light for homework & less dangerous than candles	1
	not applicable	1

B Survey questionnaire taken among the existing with a SHS

Encuesta Sistemas Fotovoltaicos – proyecto IDTR

Comunidad: Municipio:

Encuestado: No. Encuesta:

Fecha: Tipo de SFV:

1 - 20 Wp	2 - 30 Wp	3 - 50 Wp	4 - 75 Wp
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A) El hogar (características)

No. Pers.	Posición en el hogar Papa – mama – hijo/a – primo – abuelo/a – amigo -	Sexo M – F	Edad	Nivel de Educación Ningún – primaria – secundaria – técnico – universidad - otro: (P) parcial
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

B) Capital Natural

Tierra

1. Como ha cambiado la producción en su tierra desde que tiene panel.
 - a. Mejorado
 - b. Empeorado
 - c. No hubo cambio
2. Si mejoro, por que.
 - a. Riego FV/ bombas de agua FV
 - b. Propia inversión (compre tierra extra, maquinaria, abono, etc.)
 - c. Lluvias
 - d. Otra razón:
3. Si fue propia inversión o otra razón, que le facilito esto
 - a. Ganancias gracias al uso de SFV
 - b. Otra razón:
4. Si ha empeorado, especifique por que:

Aire

5. Usted cocina adentro o afuera de su casa.
 - a. Adentro
 - b. Afuera
 - c. Adentro y afuera
6. Con que tipo de combustible cocina usted adentro de su casa.
 - a. Kerosene
 - b. Madera / Biomasa
 - c. Desechos de animales
 - d. Energía renovable
 - e. Gas (GLP)
 - f. Cocina solar
 - g. Otro:
 - h. Madera & Gas
7. Con que tipo de combustible cocina usted afuera de su casa.
 - a. Keroseno
 - b. Madera / Biomasa
 - c. Desechos de animales
 - d. Energía renovable
 - e. Gas (GLP)
 - f. Cocina solar
 - g. Otro:
 - h. Madera & Gas
8. Con que tipo de combustible cocinaba usted antes del proyecto adentro de su casa.
 - a. Keroseno
 - b. Madera / Biomasa
 - c. Desechos de animales
 - d. Energía renovable
 - e. Gas (GLP)
 - f. Cocina solar
 - g. Otro:

- h. Madera & Gas
- 9. Con que tipo de combustible cocinaba usted antes del proyecto afuera de su casa.
 - a. Keroseno
 - b. Madera / Biomasa
 - c. Desechos de animales
 - d. Energía renovable
 - e. Gas (GLP)
 - f. Cocina solar
 - g. Otro:
 - h. Madera & Gas
- 10. El proyecto de SFV's le facilito otra manera para cocinar.
- 11. Como ha cambiado la calidad del aire adentro de su casa desde el comienzo del proyecto.
 - a. Mejorado por que:
 - b. Empeorado por que:
 - c. No hubo cambio
- 12. Que significa este cambio en la calidad del aire para usted
 - a. Sentirse mejor
 - b. Sentirse peor
 - c. Sentirse igual
 - d. No se
 - e. Otra razón:
- 13. Como ha cambiado la calidad del aire afuera de su casa desde el comienzo del proyecto.
 - a. Mejorado por que:
 - b. Empeorado por que:
 - c. No hubo cambio
- 14. Que aparatos utilizaba antes que producían humo que ahora utiliza menos
 - a. Generador de combustible
 - b. Velas / mecheros
 - c. Otro:
 - d. Sigo utilizando aparatos que produzcan humo pero menos

Agua Potable

- 15. Tiene usted acceso a agua potable.
- 16. Como tiene acceso usted al agua potable.
 - a. Trayendo del rio
 - b. Por tubería comunal
 - c. Con bomba de agua manual
 - d. Con bomba de agua (de energía renovable del proyecto)
 - e. Comprando
 - f. De un pozo de agua
 - g. Otra manera:
- 17. Tenía usted acceso a agua potable antes del proyecto.
- 18. Si tenia, como tenia usted acceso al agua potable antes.
 - a. Trayendo del rio o un pozo
 - b. Por tubería comunal
 - c. Con bomba de agua manual
 - d. Comprando
 - e. De un pozo de agua
 - f. Otra manera:
- 19. Como ha cambiado la cantidad del agua potable desde el comienzo del proyecto.

- a. Mas agua, gracias a:
- b. Menos agua, por que:
- c. Igual
- d. Mas

Agua normal (agua para lavar o para la tierra y animales)

- 20. Que tipo de agua utiliza para la producción en su tierra o animales o para lavar/limpiar
 - a. No utilizo
 - b. Si, agua de lluvias para: producción – animales – lavar/limpiar
 - c. Si, agua de un rio o poso para: producción – animales – lavar/limpiar
 - d. Si, aguas de lluvia y del rio para ambos
 - e. Si, otra agua para:
- 21. Como ha cambiado la cantidad de agua normal desde que empezó el proyecto
 - a. Mas agua, por que:
 - b. Menos agua, por que:
 - c. Igual

C) Capital Financiero

Dinero / Deudas / Ahorros

- 22. Ha tomado el crédito de ANED para tener acceso al proyecto de SFV.
- 23. Ha tenido dificultades económicas en su casa a causa del crédito.
 - a. No
 - b. Si
- 24. Si es (SI), que significa estas dificultades para usted
 - a. Menos dinero para comida
 - b. Menos dinero para educación
 - c. Menos dinero para ahorrar
 - d. Otra:
- 25. Los servicios eléctricos del proyecto le han ayudado a ganar más dinero.
- 26. Si es así, como ha ganado dinero con los servicios eléctricos que el proyecto le ha facilitado.
 - a. Trabajando de noche
 - b. Ahorrando más dinero
 - c. Vendiendo electricidad
 - d. Otra razón:
- 27. Usted gana su dinero de otra manera desde que empezó el proyecto.
- 28. Si es (SI), de que manera ha cambiado la forma en que gana su dinero.
 - a. La misma actividad pero más eficientemente, gracias a:
 - b. Nueva actividad que antes: y ahora:
 - c. Otra manera:
- 29. Usted ahorra.
 - a. No, por que:
 - b. Si
 - c. A veces
- 30. Si ahorra, como ha cambiado los ahorros desde el comienzo del proyecto.

- a. Mas ahorro, porque mejoro la productividad
- b. Menos ahorro, por que:
- c. No hubo cambio
- d. Mas, porque hay menos gastos

Tecnologías & equipos de producción

- 31. Como ha cambiado la cantidad de aparatos electrónicos desde el inicio del proyecto.
 - a. Más, porque tenemos electricidad
 - b. Menos, por que:
 - c. Igual
- 32. Si es más, que tipo de aparatos a comprado.
 - a. Aparatos para comunicación
 - b. Aparatos para entretenimiento
 - c. Aparatos para trabajar
 - d. Otros:
- 33. Que significa el uso de estos aparatos para usted.
 - a. Poder escuchar música y noticias
 - b. Mas contacto con familiares afuera de la comunidad
 - c. Nuevas ideas para el futuro
 - d. Educativo para los niños
 - e. Otras:
- 34. El proyecto le ha proporcionado nuevas tecnologías (excluyendo el SFV mismo).
 - a. No
 - b. Bombas de agua FV
 - c. Sistema s de riego
 - d. Salas de video
 - e. Estación de recarga para baterías
 - f. Otras:
- 35. Usted es propietario de estas tecnologías o es compartido con otros usuarios.
 - a. Propio dueño
 - b. Propietarios compartidos
- 36. Estas nuevas tecnologías / equipos le ayudan ha ser mas productivo, como.
 - a. Tiempo de trabajo extendido, gracias a:
 - b. Automatización de procesos de producción
 - c. Nuevas actividades para generar ingresos
 - d. Otras:

D) Capital Físico

Infraestructura

- 37. Tenía acceso a electricidad antes de este proyecto, especifique como.
 - a. No
 - b. Generador de combustible
 - c. Electricidad por la red
 - d. Otro sistema de generación con energía renovable:
 - e. Batería
 - f. Otra manera:

38. Y ahora solo con panel FV o con otros métodos adicionales.
- Solo SFV
 - Generador de combustible
 - Electricidad por la red
 - Otro sistema de generación con energía renovable
 - Batería & Panel FV
 - Otra manera:
39. Si es así, en comparación con antes cuanta electricidad tiene ahora con uso de panel FV.
- Mas
 - Menos
 - igual
40. Qué tipo de aparatos eléctricos tiene?
- Radio
 - Radio CD
 - Radio CD & DVD
 - Radio & TV
 - Radio & otro: ...
41. Utiliza usted ahora más aparatos eléctricos que antes del proyecto.
- Si
 - No
 - Igual
42. El uso de estos aparatos es necesario para su trabajo.
- No, por que:
 - Si, para escuchar radio durante el trabajo
43. Usted utilizaba aparatos de comunicación antes del proyecto.
- No
 - Si, teléfono publico
 - Si, teléfono propio
 - Si, teléfono celular
 - Si, radio de comunicación comunal
44. Utiliza aparatos de comunicación ahora.
- No
 - Si, teléfono publico
 - Si, teléfono propio
 - Si, teléfono celular
 - Si, radio de comunicación comunal
45. Si es así, como ha cambiado el uso de este aparato de comunicación desde que empezó el proyecto.
- Mas uso, por que:
 - Menos uso, por que:
 - Igual
46. Cerca de su casa o en su comunidad hay luz en las calles.
47. Como ha cambiado este desde que empezó el proyecto.
- Más luz, gracias a:
 - Menos luz, por que:
 - Igual
48. Usted utiliza otros medios para generar electricidad fuera de lo que proyecto le ha proporcionado.
- No (continué con #50)
 - Si, con batería
 - Si, con generador

- d. Si, con otro:
- 49. Porque utiliza otros medios adicionales.
 - a. El SFV nos es lo suficientemente potente
 - b. Crecimiento de usos con electricidad
 - c. Porque ya lo tenia
 - d. Otra razón:
 - e. Para ver TV

E) Capital Humano

Educación/habilidades/conocimiento

- 50. El proyecto de SFV les ha dado habilidades extra para perseguir nuevos objetivos o hacer sus actividades mejor.
 - a. No
 - b. Si, nuevos objetivos como:
 - c. Si, nuevas actividades como:
 - d. No se
- 51. Cree desde que empezó el proyecto puede hacer sus actividades más fácilmente.
 - a. Si
 - b. No
 - c. No se
- 52. Si es así, que cree que le ha facilitado esto.
 - a. Luz eléctrica
 - b. Aparatos eléctricos
 - c. La salud
 - d. Educación
 - e. Otra razón:
- 53. Como ha cambiado el tiempo que puede gastar para propósitos educativos desde que empezó el proyecto.
 - a. Mas tiempo, por que:
 - b. Menos tiempo, por que:
 - c. Igual
- 54. Los niños estudian por la noche.
 - a. No, (continué con # 56)
 - b. Si
- 55. Cuanto tiempo se gastan los niños estudiando en la noche desde que empezó el proyecto.
 - a. Más tiempo, por que:
 - b. Menos tiempo, por que:
 - c. Igual
- 56. Ustedes utilizan luz proporcionada por el proyecto para estas actividades de educación.
 - a. Si
 - b. No
 - c. Otra:
- 57. Sus nuevas habilidades o conocimientos le han brindado nuevas oportunidades de empleo o actividades para generar ingresos.
 - a. Si, por que:
 - b. No, por que:

Salud

58. Como ha cambiado su salud desde que empezó el proyecto.
 - a. Mejorado
 - b. Empeorado
 - c. Igual
59. Si ha mejorado, porque piensa que ha sido.
 - a. Menos esfuerzo de trabajo gracias a:
 - b. Estufas limpias
 - c. No se cocina adentro
 - d. No se queman velas adentro entonces no hay humo
 - e. Medicación
 - f. Otra razón:
60. Si ha empeorado porque piensa que ha sido.
 - a. Relacionado al SFV, por que:
 - b. No relacionado al SFV, por que:
61. El proyecto de SFV le enseñó sobre los peligros para la salud de cocinar con biomasa (madera etc.).
62. La casa o la comunidad ha adquirido algún refrigerador para vacunas (medicinas) después que comenzó el proyecto SFV.
63. Si es así, porque se ha comprado un refrigerador de vacunas.
 - a. Por que hay electricidad de SFV
 - b. Por otra razón:

F) Capital Social

Redes

64. Que medios de comunicación utiliza usted desde que empezó el proyecto.
 - a. Teléfono / Celular
 - b. Internet
 - c. Radio
 - d. TV
 - e. Otro:
65. Utilizaba estos tipos de comunicaciones antes del proyecto, cuales.
 - a. No
 - b. Teléfono / Celular
 - c. Internet
 - d. Radio
 - e. TV
 - f. Otro:
66. Como a cambiado el uso de estos medios desde que empezó el proyecto.
 - a. Mas uso, por que:
 - b. Menos uso, por que:
 - c. Uso Igual

Relaciones sociales

67. Tiene más o menos contactos sociales con gente de su comunidad o afuera de su comunidad desde que empezó el proyecto.
 - a. Más por que:

- b. Menos por que:
 - c. Igual
68. Que consecuencias tiene es esto para usted(es), especifique:
- a. Es bueno
 - b. No se
 - c. Otra: ...
69. Todavía tiene contacto con las agencias del proyecto.
70. Si es así, que tipo de contacto tiene con ellos.
- a. Mantenimiento del sistema
 - b. Contacto financiero & mantenimiento
 - c. Contacto financiero & mantenimiento & Entrenamientos (capacitación)
 - d. Otro tipo:
71. Usted toma parte de actividades sociales por la noche.
72. Que tipo de actividades son estas, especifique:
- a. Visita de vecinos
 - b. Grupo de biblia
 - c. Otra: ...
73. Como ha cambiado la participación en estas actividades sociales nocturnas desde que comenzó el proyecto.
- a. Más actividad por que: ...
 - b. Menos por que: ...
 - c. Igual
74. Que son las consecuencias de estas actividades para usted, especifique:
- a. Nada
 - b. Es bueno
 - c. Otras: ...
75. Sus vecinos también tienen electricidad por SFV's.
- a. Si
 - b. No
 - c. Algunos
76. Su relación con sus vecinos sin electricidad cambio desde que tiene SFV.
- a. No
 - b. Si, vecinos son celosos
 - c. Si, vecinos no me respetan
 - d. Sí, me visitan mas
 - e. Sí, tengo más amistades
 - f. Otra: ...
77. Si cambio, piensa que es por el proyecto de SFV.

Asociaciones / Afiliaciones

78. Forma usted parte de algún grupo o asociación relacionada al proyecto SFV.
79. Que significa esto para usted.
- a. Mas relaciones sociales
 - b. Mas contactos
 - c. Mas comunicación
 - d. Mas intercambio de información
 - e. Otro:
80. Formaba usted parte de un grupo similar antes de que empezara el proyecto.
- a. Si,
 - b. No

Inclusión (social)

81. Ahora que tiene electricidad por SFV, se siente más conectado al resto del mundo.
- Si
 - No
 - Igual
82. Si se siente mas conectado, porque piensa que es.
- Poder ver televisión
 - Poder escuchar radio
 - Poder usar el teléfono
 - Tener luz por la noche
 - Por nuevas actividades productivas con electricidad
 - Por otra razón:
 - No se
83. Piensa usted que tiene una gran ventaja sobre sus vecinos sin electricidad.
- No
 - Si, para trabajar de noche
 - Si, la luz es mejor
 - Si, la luz y los aparatos de trabajo
 - Si, la luz y los aparatos
 - Si, menos gastos
 - Si, otra

G) Misceláneos

Gastos de combustible

84. Cuantos bolivianos se gastaba a mes antes del proyecto SFV en combustibles. (velas, kerosene, diesel etc.)
- 00 – 20 Bs
 - 20 – 40 Bs
 - 40 – 60 Bs
 - 60 – 80 Bs
 - 80 – 100 Bs
 - 100+ Bs
 - Otra cantidad:Bs
85. Todavía compro formas adicionales de energía.
- No
 - Si, velas
 - Si, kerosene
 - Si, velas & Gas
 - Si, velas & pilas
 - Si, velas & pilas & gas
 - Si, velas & combustible & pilas
86. Cuanto gasta ahora en formas adicionales de energía.
- 00 – 20 Bs
 - 20 – 40 Bs
 - 40 – 60 Bs
 - 60 – 80 Bs
 - 80 – 100 Bs

- f. 100+ Bs
- g. Otra cantidad:Bs

Migración

- 87. Antes del proyecto SFV, alguien en su hogar tenía planes de migrar.
 - a. Si, por que:
 - b. No, por que:
 - c. No se
- 88. La personas con planes de migrar ya se fue de la comunidad.
 - a. Si
 - b. No
- 89. La gente que migro después del proyecto, porque decidió migrar a otro sitio.
 - a. Nuevas ambiciones gracias a:
 - b. Más servicios como:
 - c. Mejor trabajo
 - d. Mejor pago
 - e. Mejor pago & trabajo
 - f. Familia
 - g. Otra razón, es decir:
- 90. Ha notado usted menos o mas migración saliendo de la comunidad desde que empezó el proyecto SFV.
 - a. Menos, por que:
 - b. Más, por que:
 - c. No hay cambio

SFV especifico

- 91. Estaba claro lo que usted podía usar (aparatos y aplicaciones) con el SFV que escogió.
 - a. Si
 - b. No
 - c. Mas o menos
- 92. Esta contento con su SFV.
 - a. Sí, porque tenemos luz
 - b. No, por que:
 - c. Sí, porque hay menos gastos de velas & pilas
 - d. Sí, porque hay luz y más comodidad
- 93. Cree que la energía que le da el panel es suficiente.
 - a. Si
 - b. No
- 94. Si no, por que razón piensa que no es suficiente.
 - a. Queremos usar mas aparatos que antes
 - b. Otra razón:
 - c. No es suficiente para propósitos comerciales
 - d. Quiero más puntos de luz
- 95. Como le pareció adquirir el SFV para su casa.
 - a. Fácil
 - b. Difícil
 - c. Normal
- 96. Que piensa del precio para adquirir el SFV.
 - a. Es muy caro

- b. Barato
 - c. Precio esta bien
97. Como le parece hacer el mantenimiento del SFV (limpieza y otras cosas sencillas).
- a. Fácil
 - b. Difícil
 - c. No se
98. Sabe usted exactamente como funciona su SFV.
- a. Si
 - b. No
 - c. Solo lo básico
 - d. No me interesa el funcionamiento
 - e. Otra: ...
 - f. No, se me olvido
99. Desea comprar un SFV adicional o más potente en el futuro.
- a. No, porque este es suficiente
 - b. Si, para tener más luz
 - c. Si, para mas aparatos
 - d. No se
 - e. Si, para una estancia adicional
 - f. Si, para tener más luz y mas aparatos
 - g. Sí, porque la red no nos va a llegar