DFID Project KaR R8018

TECHNICAL REPORT

RENEWABLE ENERGY FOR SUSTAINABLE RURAL LIVELIHOODS

RESURL

By Judith A. Cherni

Imperial College London
August 2004

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The author of this Report would like to thank the KaR department at DfID for its support and funding of project R8018, Renewable Energy for Sustainable Rural Livelihoods.

The project benefited from the support of the Cuban Ministry of Basic Industry who provided for the Cuban team and also participated in debates regarding the aims of the project. The participation of ITDG in Peru deserves particular mention for its expertise and commitment to the project. The progress of the project would not have been possible without the active and enthusiastic involvement of the National University of Colombia in Medellín and the Central University of Las Villas, Cuba. I am particularly grateful to Dr Smail Khennas for his timely and expert advice. The author would also like to thank Dr Rocio A Diaz-Chavez, Ahmad Aslam and Nita Cottle for their dedicated assistance during the preparation of this final draft.

The successful undertaking of this project would not have possible without the cooperation and assistance of regional and local leaders, experts and decision-makers who were so helpful in providing information and helping the team to reach remote locations. I am particularly grateful to those many anonymous farmers whose voices had now been registered in our surveys.

LIST OF TABLES AND FIGURES

EXECUTIVE SUMMARY

The project promotes clean and modern/sustainable energy technology for poverty reduction and environmental protection in remote rural areas. The aims of the Renewable Energy for Sustainable Rural Livelihoods (RESURL) project were to enhance the understanding of the relationship between access to energy and sustainable livelihoods, to *ex-post* evaluate existing energy technology development, to raise the benefits users accrue from current energy technology systems in remote rural areas of developing countries, and to develop methodologies to assist the process of promoting appropriate and effective clean energy solutions for poverty reduction. One motivation behind developing this study was evidence that performance had fallen short of expectations. Without detailed research into the state of the installations some time after being set up originally, any future renewable energy technology developments in these areas would be likely to fail in the long term.

The project has achieved both methodological and theoretical outputs as well as producing empirical results. It has impacted beneficiaries, agencies, academics, and the policy sector. RESURL has produced relevant information and analyses about the poorest groups among the 2 billion without electricity and those inappropriately supplied worldwide. The project's remit of poverty eradication is in line with the Millennium Development Goals (MDG) and corresponds with the key commitments of the 2002 Earth Summit at Johannesburg to promote renewable energy and improve access to affordable and environmentally sound energy services to achieve the MDG. The RESURL project has directly addressed this vital aspect of local infrastructure development revealing that a large potential for poverty reduction exists in promoting sustainable energy in remote areas. It has done so with innovative methods, a thorough approach and the piloted application has produced accountable outcomes.

RESURL built upon a partnership with the Cuban Ministry of Science, Technology and Environment; the Central University of Las Villas, Cuba; The National University of Colombia, at Medellín; the international NGO Intermediate Technology Development Group (ITDG), at Lima and Cajamarca, Peru; and specialist consultant from ITDG UK/Regional programme Sahel (PREDAS-CILSS) under the leadership of the Centre for Energy Policy and Technology at Imperial College London. RESURL draws on the experience and original studies carried out by us in rural Colombia, Cuba and Peru.

Post-Evaluation of energy development in isolated rural areas

The success and the actual performance state of energy installations in isolated rural areas were almost unknown in the three countries. Whereas most existent approaches to address these issues have focused on the technical and economic aspects of energy development, the methodology designed for this project is multidisciplinary, participatory and draws heavily on expert assessment. The ex-post evaluation addressed technical, non-technical and policy factors of failure and success of renewable energy technology (RET) in remote rural areas (RRA) and identified the barriers that interfere with effective RET for poverty mitigation. The ex-post assessment tool, *Post-Evaluation of Rural Energy (MAP-RESURL)* was applied in three large surveys in isolated areas of the three countries such as the jungle, high and lower mountain areas, inland and the coast. The results showed widespread dissatisfaction amongst users of existent energy provision systems. In addition, the

research procedure itself provided economic, technical, environmental and organisational information. Less evidence emerged on the economic impact of RET on rural livelihoods as, despite the huge potential of clean technology in this sphere, little has been officially established to exploit it. One primary factor for limited outcomes has been the short-life span of the technology that resulted as a consequence of the barriers that users encounter in rural remote areas. A significant barrier has been the lack of technical capability of local users to maintain modern equipment. This is a significant problem that emerges with photovoltaic installations in the Peruvian jungle, and compounded the difficulties they experienced already due to the defective quality of the batteries when bought. Intermittency and lack of reliability in the micro-hydro service for economic activity create further problems for users in mountainous areas in Cuba and in the Peruvian Andes. The yielding of such information was essential for explaining the lack of success of current systems. Making ex-post evaluation tools available within the current countries and to other nations would facilitate the chances of improvement of existing installations.

On the basis of this and additional knowledge, we were able to build new indicators and an analytical system for future decision-making in energy development in remote communities, as well as being able to design a capacity-building manual to assist direct beneficiaries in isolated communities to maximise the use of existent energy equipment. Lessons learnt during this stage of the project proved fundamental to the applicability of the multi-criteria model for appraising conditions and technology options.

Energy infrastructure for sustainable rural livelihoods

The knowledge acquired on the barriers and failures of installed energy equipments was instrumental in constructing new methodological tools to assess best technological options for isolated poor communities. From interviews with regional leaders we learnt that the current policy of expansion of renewable PV technology to rural areas for domestic use in Peru and Colombia is expected to significantly enhance the quality of life of people living in remote locations. However, distribution of PVs in developing countries is, by and large, going to be undertaken without an appropriate previous appraisal – which, to be useful, should address social, economic, environmental and technical dimensions of the real conditions of the communities and of prospective users.

The multi-criteria methodological package – which was built on the principles of social and environmental sustainability for poverty reduction, and on the combination of participatory as well as technical approach - aimed to collect first-hand information and provide analytical tools to assist decision-making of future rural infrastructure. The Sustainable Rural Energy Multi-Criteria Decision-Support System *(SURE)* is a software package that measures and models the trade-offs resulting from the planned application of possible energy solutions on the current assets of a community. The methodological package was tested in remote communities in Colombia, Cuba and Peru. The analytical system was applied to information from Colombia. It highlighted that decision-making that concerns future RET in rural areas must be undertaken not only after having taken full account of the technical potential and the costs details but also with users' demands and future sustainability in mind. Improvement of the tested survey techniques, the software and the technology matrixes will enable this methodology to be applied more widely and, consequently, goals of improving sustainable livelihoods in developing countries can be more closely achieved. This would respond to the interest already awakened by the project's work in the collaborating developing countries.

Manual for energy systems' users in remote poor areas

Drawing on first-hand information gathered during the ex-post analysis, it was possible to design a manual that could answer people's needs in this area of difficulty. The objectives central to improving the expected outcome of energy technology to alleviate poverty in the long term are to reinforce users' and local decision-makers' familiarity with the equipment and to increase their technical capacity to deal with it so to ensure its sustained operation. For the most, users of PV equipment were found to lack basic information about how to maintain and repair it; in the case of micro-hydro plants, technical capacity was limited to very few individuals. No awareness of other technology options, or of the environmental impact of energy development was registered. Essential instructions that increase users' acquaintance with the technology and stimulate them to take a more participatory approach to energy development were designed for immediate application in the communities. The potential of the capacity-building manual to deliver technical and other information in the immediate future is huge, and there is evidence that this is a step that could contribute to poverty alleviation.

Modern energy and sustainable rural livelihoods

Over three years RESURL has produced an analysis of the barriers and successes of renewable energy development in remote areas of Colombia, Cuba and Perú. The analysis makes evident the fact that access to energy can significantly improve users' quality of life. However, unless a strong institutional and policy framework is supporting the energy programme, and technical skill is available, the gains are short-lived. A sustainable livelihoods approach proved a useful and powerful frame of reference to uncover issues related to poverty in rural communities. Further dimensions, such as users' demands and local organisation, were necessary however to cover the full gamut of components of the relationship between access to energy and poverty reduction. Lessons were learnt from the case of Cuba on political support mechanisms. The most significant improvements were found in health, life-style and education. Out of the RESURL study emerges the need to look into the electricity reform in developing countries as an important component of the policies that have influenced access to electricity by the poor. The insights and analyses drawn on this study must now be more widely disseminated within the English-speaking academic and policy-making world to better serve the MDG by promoting well-informed sustainable energy development in developing countries.

The way forward

Experience has taught us that energy expansion in remote rural areas that is dominated by technology drivers has neither the chance nor the reach to provide the reliability and long-term durability that users need to achieve sustainable livelihoods and fight poverty. Governments and development agencies in Latin America and the Caribbean have been providing the population with stand-alone energy systems and they have some interesting experiences to share. More of this valuable experience is now needed. Further analysis of the empirical information and an expansion in the dissemination of the findings are fundamental for these countries and others in the developing world that wish to enable independent and reliable provision of energy to remote populations (Table 1).

TABLE 1.

Issues studied	*Outputs and Findings*	*Future Activities*
Barriers that interfere with the success and sustainability of modern energy technology to improve rural livelihoods	• Post-Evaluation tool to assess energy development in isolated rural areas • Taking stock with modern energy development in rural areas is essential to improve chances of future success.	• Improvement of post-evaluation methodology: household questionnaire and semi-structured interviews. • Quantitative and qualitative data analysis
Energy infrastructure for sustainable rural livelihoods	• Lessons drawn on barriers to inform our new decision-making tool: technical skills, uses and priorities of energy. • A multi-criteria rural energy decision-making programme designed. Takes on board technology criteria, as well as community criteria. • New indicators that combine technology and community criteria. • Government and other agencies may promote future energy technology expansion without informed knowledge unless a tool like RESURL's is offered.	• Improvement of survey questionnaires, refinement of computer programme, indicators. , and the technology matrixes as part of the RESURL methodology to be applied more widely and, consequently, goals of improving sustainable livelihoods in developing countries can be more closely achieved. • Model application using data collected during RESURL second field-work • Dissemination of the programme with government, universities and practitioners and other agencies.
Building local capacity in remote rural areas	• Maintenance and information manual for users of modern energy systems in remote poor areas • Technical training and information on the environmental impact of the technologies is included. Short manual with illustrations	• To improve the potential of this capacity-building manual to assist in the selection of productive activities related to energy technologies • To distribute the manual. • The expand the manual purpose to poverty alleviation.
Modern energy and access by the poor	• Energy can contribute to improve the quality of rural livelihoods of the poor. • Policy and institutional frameworks need to support these programmes. • Indication that micro-studies are fundamental but energy development in rural areas also connected to macro-structural factors of national energy sector.	• To undertake literature review on the electricity reform in developing countries as an important component of the policies that have influenced access to electricity by the poor. • The promotion of well-informed sustainable energy development in developing countries.

Issues, outputs and findings, and future activities, RESURL, 2002

The contribution of the RESURL project is generic. Building up and adapting the *ex-post* and *ante* evaluation tools in ways that are appropriate to other developing countries – particularly by keeping the social and environmental goals of the MDG attainable – are vital. RESURL has awakened wider than expected interest from different parts of the developing world. This is an indication of the importance and also timely emergence of this type of work. RESURL has started to fill a significant gap in knowledge and in practical solutions. Technologies are now available to improve access to energy by the rural poor in remote areas. However, unless appropriate information is made available to users and to decision-makers, new developments will, no doubt, end up with the same flaws as previous schemes and will not succeed in reducing poverty in the longer-term.

The team has achieved its goals. There is a general sense among the project's members that valuable work has been done during the three years of intense, participatory and professional undertakings. However, it is also felt that the RESURL team has not completed or achieved its mission of poverty reduction in the developing world. Additional time and funds are now required to enable to accomplish the full potential of the project. The RESURL team is ready and willing to continue this process: to consolidate the outputs achieved, enhance direct benefit to users, effectively tighten up and promote the designed and tested evaluation methods in the government, academic and private sectors, to write-up and disseminate acquired knowledge, and to start exploring poverty reduction and sustainable energy in a wider frame of the utilities liberalisation process. Improvement of the computer model and the methodological packages will allow the team to offer them soon and openly to local, regional and national decision-makers. We have now submitted a proposal to DfID stating these points and our request to consolidate the outputs and scale up the results of the project.

CHAPTER 1
INTRODUCTION

1.1 Purpose and Objectives

The project promotes clean and modern/sustainable energy technology for poverty reduction and environmental protection in remote rural areas of developing countries. The purpose of the Renewable Energy for Sustainable Rural Livelihoods (RESURL) project were to analyse the relationship between access to energy, poverty reduction and environmental sustainability in three developing countries, as well as to design methodologies to both *ex-post* evaluate energy development and to assist future decision-making for appropriate clean energy technology options. The overall aim was to raise the benefits users may accrue from both installed and future energy systems in remote rural areas.

The project's remit of poverty eradication is in line with the Millennium Development Goals (MDG) and corresponds with the key commitments of the 2002 Earth Summit at Johannesburg to promote renewable energy and improve access to affordable and environmentally sound energy services. RESURL's purpose reflects the findings of the latest UNCTAD Report on the need for better use of technology to improve the conditions of the world poorest. RESURL is built upon a partnership with the Cuban Ministry of Science, Technology and Environment; the Central University of Las Villas, Cuba; the National University of Colombia, in Medellín; the international NGO Intermediate Technology Development Group (ITDG), in Lima and Cajamarca, Peru; and specialist consultant from ITDG UK/Regional programme Sahel (PREDAS-CILSS), and under the leadership of the Centre for Energy Policy and Technology at Imperial College London.

In detail, the five objectives of the project were

1. To develop/enhance the understanding of the relationship between off-grid energy technologies and poor rural communities and to step up the sustainable livelihoods thinking as a conceptual and practical framework for promoting informed poverty reduction policy.
2. To design two subsequent post-evaluation and then decision-making methodologies to examine the many barriers and opportunities for energy provision as they play out on the tortuous way to sustainable livelihoods in rural communities. The methodologies would take into account their social, economic, environmental and political dimensions, so as to avoid the many mistakes of the past that may result into technology malfunctioning, wasted potential and limited access.
3. To test the two assessment tools in a comparative manner in remote rural settlements located in different geographical regions in three countries via a series of 62 case studies, and to train all the research teams to be competent in handling these methodologies.
4. To design a capacity-building tool that could both smooth the progress of local users to become competently self reliant in the maintenance and repair of energy equipment and increase their information of the environmental and technical characteristics of the available full-modern-energy menu, as well as to distribute the tool in 10 communities in a developing country.
5. To introduce local, regional and national decision-makers in the collaborating countries to the work initiated by RESURL, in order to explore the suitability, future improvement and possibilities of integration of these methodologies in their poverty reduction and sustainable development strategic policy.

Chapter 2 in this Report focuses on Outputs 1,2 and 3 as per Logical Framework, and the focal point of Chapter 3 is Outputs 3 and 4.

1.2 Methodology

The method of enquiry was both deductive and analytical.

New knowledge building on the role of energy provision - particularly from renewable technology – for reducing poverty and enhancing environmental protection in rural communities took place based on valuable studies of energy technology applications, outcomes and problems worldwide, on the patterns of methodological responses to rural poverty and its alleviation, and on the changing and also rising preoccupation for environmental protection and the meaning this has for human well-being. The key to knowledge building was to recognise that there are technical but also non-technical barriers that interfere with a more successful involvement of modern energy technologies for poverty reduction, that decision-making to implement energy solutions has been undertaken without previous consultation with actual users and also with development agencies omitting systematic and rigorous assessment of reigning conditions. Another assumption was that technological solutions to generate off-grid electricity in remote rural areas have already ripened and been tested for their potential to improve living conditions. Knowledge building made reference to the full-energy menu consisting of solar, diesel, micro-hydroelectricity, biogas, firewood, wind and even grid-connection. Central to knowledge structure was the identification of the role of financial, physical, natural, human and social assets found in a community and the notion that professional experts and community users need a method that facilitates the pooling of different expertise to improve livelihoods.

The analytical mode of inquiry involved evaluating what representative samples of entire communities reported about living conditions and energy technology status, including energy priorities, barriers and prospect. The focus of the national case studies was deliberately regional rather than country-aggregated and within each nation the case study in at least two different geographic regions, i.e., in the mountains, jungle, coast, inland higher-mountains, in order to determine how people in various different geo-physical areas, as well as different socio, economic and organisational groups, react to energy development. These variations were examined through a comprehensive enquiry that addressed dimensions that affected the performance of existing energy equipment and the conditions for future development and energy improvement.

Another decisively important aspect of the project methodology was to survey and visit each location during the course of the project, and to conduct semi-structured and structured interviews with key actors, representatives of community leaders, local government, mayors, officials, professionals, and administrative groups that collect electricity fees. This experience enabled the research team in each country and the project field-work managers to be more familiar with the technology and environment dynamics of local poverty as they connected through different economic levels and group organisation. It was unfeasible to travel to remote villages in Colombia, so the team in that country succeeded in bringing local leaders from these areas to the cities instead and contracting local students to undertake the surveys.

The research teams acted both as observers and participants in the battle against poverty. For example, the regional radio and television of the District of Cajamarca, Peru, carried out interviews with members of the RESURL project from Peru, Cuba and the UK. The media asked about the project's mission and activities in the country. The national teams were also instrumental in providing practical and

immediate advice to local administrative groups and to interest groups. For example, interviews in Peru with local government representatives in La Pacha, brought up the important issue of legalisation of the micro-hydro plant; the visit to the waterfall in the village of Liclic inspired ideas about alternative natural options to the use of a beauty spot. In both cases, our top ITDG specialists provided immediate advice to the local population.

Furthermore, the team helped to create a unique participatory and scientific approach to the research design. This involved not only the use of every circumstance to search for proper evidence and significant interactions and to enlighten these through statistical packages, but also the use of methodical and systematic disciplines, e.g., Mathematics in the design of the decision-making computer programme for rural infrastructure. Where long-term sustainability and livelihoods improvement was such an important component of the analysis, it was essential to incorporate these sciences to increase the capability of the computer programme that the team designed.

There was need to reflect on the use of the term 'sustainable'. The team preferred to think of 'sustainable' as an integrated concept that applied not only to environmental, but also to social, economic, and technological dimensions of energy solutions. This is the conceptual frame that guides our design of the multi-criteria decision-support system when the model measures trade-offs and impacts of technology options.

The project is aimed to scientifically promote renewable, clean, modern energy technology and therefore found it inappropriate to focus on too narrow a range of technological options, e.g., solar and micro-hydroelectricity, to exclude polluting, but widely employed, alternatives, e.g., diesel and kerosene, or to discard the possibility of grid connection as a possible solution. Therefore, the 'full-energy menu' was included in this study.

Finally, knowledge transfer amongst the four national research teams was a creative component in evolving and improving the research design. Apart from training all the developing countries' research teams in the management of the methodologies and data codification, knowledge transfer from south to south, north to south, and south to north was an invaluable element that reverberated on the multidisciplinary and empathetic research design and in the learning and application of interview techniques.

1.3 Main Achievements

Over three years, RESURL has contributed to generate new *knowledge* on the state of alternative renewable energy installations in remote rural areas of three different countries; on life improvement and poverty reduction; and on policy issues. The project in addition has achieved a range of theoretical, methodological and empirical *outputs* in relation to technical and non-technical aspects of energy development.

Knowledge

- Analysis of 35 remote rural communities in three countries (Cuba, Peru and Colombia) shows that four types of decentralised energy systems are more dominant in remote areas, i.e., micro-hydro plants, solar panels, traditional firewood and hybrid systems. Also, not every technology is equally satisfactory, and maintenance barriers in particular have prevented long-term sustainability of the systems.
    i. In Cuba, farmers in the mountains use mainly traditional (i.e., fuel-wood) energy sources (42%), followed by hybrid (40%), micro-hydro (12%) and finally solar panels (6%) systems (particularly in schools and health clinics)

ii. In Peru, we found that main clean energy technology in the Andes is micro-hydro plants (40%), followed by solar panels (33%) but particularly in remote locations in the Amazon rain forest. The use of traditional fuel-wood (26%) was also found and finally hybrid systems (1%) are also an option.
iii. In Colombia, residents in the coast and also in the rain forest used mainly traditional systems (49%), followed by micro-hydro (31%), solar panels (12%) and finally, hybrid systems (8%).
iv. The state of the systems and users' degree of satisfaction with clean energy systems was related to the type of technology. In the three countries, micro-hydro was the most reliable local energy generator while solar panels were not delivering as expected due to maintenance deficiency.
v. Lack of technical skills among local users as well as high costs involved in maintenance are the main and most often difficulty preventing sustainable systems.

- The beneficial potential of energy emerged on two fronts: livelihoods improvement, and economic poverty reduction.
  i. By providing essential service for basic health-care installations, primary schooling, and entertainment reducing excessive drinking particularly among men and the youth;
  ii. By enabling the possibility of new and old agricultural activities such as coffee-grain drying. This possibility is generally not materialised due to defective energy equipment.
- In order that energy technology can fulfil its potential to improve livelihoods and reduce poverty national policy mechanism must promote sustainable development in remote areas including the use of indigenous energy sources. Equally important is to create local institutional networks that support and also builds upon energy services.

Outputs

1. Knowledge and enhanced understanding of the relationship between the provision of modern energy technology, rural livelihoods and poverty reduction, through the collection of new information on some of the poorest groups that constitute the 2 billion people without electricity and those inappropriately supplied world-wide.
2. The establishment of fundamental methodological guides for both, post-evaluation and future decision-making for more sustainable energy development in poor and remote rural areas:
3. A tested methodological package that uses technical and non-technical indicators to evaluate the performance and effectiveness of stand-alone modern energy technology schemes that had been previously installed in remote rural areas (MAP-RESURL), so as to illuminate the different barriers that stand on the way to achieve sustainable livelihoods.
4. An advanced computer multi-criteria decision-making system, the Sustainable Rural Energy Multi-criteria Decision-Support - *SURE* - that optimises off-grid and grid-connected options for developing sustainable energy infrastructure and reducing poverty in remote rural community. Different from other systems, *SURE* calculates the assets of a community, it evaluates technology, costs and resource availability of power combinations within a full-energy-menu, and significantly, its algorithms measure the trade-off that particular energy configurations may cause on the physical, financial, natural, social and human community's assets. *SURE* is a methodological package. The team designed new 'hybrid' indicators for multi-criteria analysis that draw on the intersection of technical characteristics and the sustainable livelihoods features. The package now requires useful improvements before its wider dissemination.

5. Two different data sets originated from testing the post-evaluation study, and the *SURE* model respectively, containing primary and comparative information from representative surveys in 76 rural poor communities in isolated locations in Colombia, Cuba and Peru.
6. A manual for local users and regional authorities in the form of an illustrated two-double page leaflet. It shows step-by-step how to maintain and repair photovoltaic and micro-hydro systems, and highlights environmental advantages and impacts of these two systems and of wind and biogas installations. The team distributed the manual, which is in Spanish, to farmers of 10 remote communities in Cuba.
7. Discussion of the project's aims with government representatives in Cuba, Peru, Colombia and Ecuador (which voluntarily joint the project). In Cuba, Colombia and Ecuador there have been clear expressions of direct interest to continue supporting and co-funding the project until its output is properly completed. Connections with the Peru's government have been initiated.

The principal **implications** of the findings for achieving the objectives of the project are the following:

I. Knowledge from scientific and participatory sources is no longer an optional requirement for sustainable and effective energy provision if poverty reduction and environmental protection is to be achieved in developing countries. In fact, systematic information is vital to improve the chances of success of installed or to-be-installed energy technology in poor areas. A multidisciplinary approach, such as the one developed during the project, is most appropriate to promote poverty reduction and sustainability. This study has contributed to an area that has huge potential to reduce worldwide poverty.

II. Energy supply, particularly from renewable technology, is an important modern driving force for improving living conditions in rural areas. Sustainable development is a concept that regional policy-makers and key actors start to incorporate in their political lexicon. It brings a ray of hope to local poverty reduction, and prompts visions of how sustainable development should be. This may also mean a sense of connection of socially excluded and geographically isolated communities to the world's efforts to protect the natural environment. Energy provision is necessary to improve the collective well-being, e.g., for clinics and schools, to enable individual households to attain basic services, water pumping, lighting and radio, and to promote productive activities, e.g., coffee-drying.

III. Barriers and opportunities for effective sustainable livelihoods in rural poor areas play out in many forms. The equipment must be of good quality in order to last. It is important to know how to manage technical equipment and also to have the financial means to maintain it or to buy replacement parts. Importantly, policy should support every effort made by users of renewable systems in order to count with stronger chance of success.

IV. It is not sufficient to install modern energy equipment in poor areas to improve livelihoods. Mal-functioning, non-operational – in the case of photovoltaics - or technology unable to generate sufficient power to supply demand requirements (e.g., due to micro-hydro intermittency in Manantiales, Cuba) reduces or even cancels the benefits that people expect to gain from the systems. Many users in the remote surveyed areas of Colombia, Cuba and Peru only benefited for short time because the energy schemes had been poorly planned. Yet, people got to

know in this way what it means to have electricity and they wish to have access to it.

V. The reasons for current failure were lack of local technical capacity for maintenance, defective equipment when bought, and elevated equipment repayment costs. In addition, excess electricity generated was not being advantageously used. A fast acceptance and interest of governments and others to expand off-grid solutions to rural areas has not been a guarantee of its success. Progress in planning and development of rural energy assessment methods remains slower than decision-taking and actual expansion.

VI. Indications emerged of impending conflicts between local, regional and national government in relation to tariffs and repayments, responsibility for the equipment and micro-hydro plants, and the potential for revenue when excess electricity could be produced. The privatisation of the energy sector in the non-centralised economies emerged as a shadowy element that may or may not dictate the future characteristics of the administration of existing services.

VII. Farmers in general knew little about the advantages and disadvantages of different clean technology to generate electricity even when they have the use of solar panels. Energy, however, is a priority in most cases even when other necessities, such as roads and potable water, emerged as a most urgent priority.

VIII. The project has been of significant benefit to the collaborating partners and their institutions by improving their capacity, in some cases, significantly, to assess the state of rural energy development through new methods as part of national interests in promoting sustainable development in rural poor areas. Moreover, it has introduced the teams to the concepts of sustainable livelihoods and these had been now incorporated within their academic and developmental practice.

1.4 Scientific Interest and Novelty

The research interest in this project was to develop a systematic method for tackling and dealing with the complex relationships between poverty reduction and infrastructure improvement, and for identifying how best to benefit or enhance each of the five of the community's assets through energy provision. The research was interested to measure trade-offs between the impact of energy technology and a community's current capitals, that were not framed as isolated concepts but which together allowed multiple changes to be achieved in order to alleviate poverty and strengthen sustainable livelihoods in rural areas. The scientific analysis is based on the multi-criteria method of Compromise Programming and Technology Matrix, and new hybrid indicators and mathematical functions to model changes to local capitals. The *SURE* software processes the information with the **Compromise Programming Multi-Criteria Method**. The method, created by Yu (1973) and Zeleny (1973).

Bringing social and technical scientific expertise together to solve a common problem created very productive ground from which a new approach to sustainability and poverty reduction can emerge. The research project revealed that social science approaches to technical solutions provide an important window on how communities and other stakeholders recognise barriers and opportunities, define priorities, and interpret technological and political trends, so as to illuminate the mistakes of the past and to make better use of existing technology. The team recognised that effective and lasting energy provision in rural poor areas required, however, the vital

input of engineers and other technical professions. If these requirements are not captured by an appropriate research team who knows how to work with them, the conflicts and problems may not find a durable solution.

The team carried out many activities during the project's three years. Two large field-work programmes in three developing countries, expansion work at local universities, presentations at international conferences, meetings with regional and also national policy-makers in collaborating countries and one additional nation (Ecuador), and wide exposure to the private and public sectors, have resulted in positioning the RESURL project within worldwide efforts to tackle poverty and environmental degradation through its concentrated focus on infrastructure development and renewable energy provision. Specific work is now needed to scale up the work and improve the methods, to implement the outputs and consolidate the results.

1.5 The way forward

Technologies are now available to improve access to energy by the rural poor in remote areas. However, unless appropriate information is made available to users and to decision-makers, new developments will, no doubt, end up with the same flaws as previous schemes and will not succeed in reducing poverty in the longer-term.

There is a general sense among the project's members that valuable work has been done during the three years of intense, participatory and professional undertakings. However, it is also felt that the RESURL team has not completed or achieved its mission of poverty reduction in the developing world. Additional time and funds are now required to enable to accomplish the full potential of the project. The RESURL team is ready and willing to continue this process: to consolidate the outputs achieved, enhance direct benefit to users, effectively tighten up and promote the designed and tested evaluation methods in the government, academic and private sectors, to write-up and disseminate acquired knowledge, and to start exploring poverty reduction and sustainable energy in a wider frame of utilities liberalisation process. Improvement of the computer model and the methodological packages will allow the team to offer them soon and openly to local, regional and national decision-makers. We have now submitted a proposal to DfID stating these points and our request to consolidate the outputs and scale up the results of the project (see Annex I).

CHAPTER 2
EVALUATING EXPERIENCE AND IMPROVING TECHNICAL SKILLS IN REMOTE RURAL AREAS OF DEVELOPING COUNTRIES

2.1 Introduction

Chapters 2 and 3 analyse outputs 1 to 5 as stated in the Logical Framework. Chapter 2 focuses on Outputs 1 to 3. Output 1 was to improve the knowledge on the practice and the theory of renewable energy technology (RET) for achieving sustainable livelihoods and poverty reduction by looking at the barriers and also the opportunities for effective energy operation. Output 2 was to design methodology tools to evaluate the technical, non-technical and policy factors of failure and success of RET in remote rural areas (RRA), so as to measure the impact of RETs on poverty mitigation. The output of this objective is the Post-Evaluation Tool applied in the three collaborating developing countries. Output 3 set to make a practical tool for women and men living in remote rural communities to rise their capacities optimise energy systems, currently installed or future systems, and to promote local decision making as to future energy development.

The aim of outputs 1 and 2 was to identify primary and secondary information that would be useful to incorporate in the survey for future energy development as stated in chapter 3, and to produce the capacity-building tool that would respond to real community needs. The post-evaluation survey aimed to learn what are the main technical and non-technical barriers of existing developments and what is the current functional status of energy equipment, particularly modern technology.

The tables below in each of the three sub-sections summarise the outputs, its measurable indicators, their impact in terms of the project outreach, and the final column indicates the annex number where more information can be found.

2.2 The relationship between poverty reduction and renewable energy technology (Output 1)

Table 2.1 shows the output that relates to the research that the team undertook to enhance the understanding of the relationship between poverty reduction and energy provision in remote rural areas in particular. Multidisciplinary sources were consulted and lessons drawn on the barriers and opportunities for promoting successful renewable energy technology for establishing sustainable livelihoods. Further understanding of a Sustainable Livelihoods framework and its applicability as conceptual and also practical guidance was produced and discussed at the first International RESURL Workshop in Cuba in November 2001 and at the Network for Energy and Sustainable Livelihoods (NESLI) UK workshops convened at Imperial College London.

TABLE 2.1

OUTPUTS 1	MEASURABLE INDICATORS	OUTREACH	ANNEX I
1. Enhanced understanding of the relationship between poverty reduction and energy provision, and provided knowledge from multidisciplinary lessons on barriers and opportunities for renewable energy technology for enhancing sustainable livelihoods.	• Paper submitted to *World Development Journal* • 7 published articles in Spanish refereed Journals • International RESURL Workshop, Santa Clara, Cuba, November 2001 • *Memo* on the sustainable livelihoods approach (SLA): principles and limitations • 10 Presentations in International Conferences in Europe, Africa, Latin America and the Caribbean • *3* MSc theses Imperial College London (ICL). • 2 NESLI national Workshops	• Universities, practitioners and ministry, and electricity providers in Colombia, Cuba and Peru interested in the project. • Practitioners, NGOs, private sector, government and academics participated in NESLI. • Capacity-Building: SLA introduced to post-graduates at ICL, and the National University in Colombia and Central University in Cuba • Wide and varied public exposed to the objectives and work by RESURL during 3 field-works	• List of Publications • Conference Papers: • Msc Theses • NESLI Participants list

RESURL Outputs 1 The relationship between clean energy and poverty reduction

The wasted potential of energy technology to reduce poverty

A pragmatic approach has dominated national and regional decision-making at all levels in developing countries as well as national and international development agencies when addressing poverty reduction and rural energy provision. Large infrastructure developments in rural areas, particularly in the electrification sector, have been achieved in the developing world in the last decades. Off-grid solutions have been included in many cases. However, the results have been mostly disappointing. Millions of people, particularly in poor rural areas, still remain without access to clean and modern sources of energy.

The advantages of stand-alone technologies indicate that they could offer ideal solutions to populations living in difficult-to-access areas, poor people, and to areas where relevant natural resources are abundant and where the natural surroundings and quality could be preserved rather than be spoilt by other systems (e.g., diesel). For people living in poverty, the most pressing priority is the satisfaction of basic human needs, which includes access to food, shelter, water supply and sanitation and other services that will improve their standard of living, such as health care, education, and better transport. Problems of poverty in all its dimensions can be addressed with the improved provision of energy services (World Bank, 2004; World Energy Council and Food and Agriculture Organisation of the United Nations, 1999; UNDP, 1999). Energy provision to rural areas, particularly through off-grid

renewable energy systems, represents an important step for reducing the electricity gap in rural parts of the developing world (Byrne et al., 1998).

Given a fast acceptance of renewable energy technologies for rural areas, as well as an increasing interest by governments and others in the developing world to promote off-grid solutions (e.g., DEP, 2202), progress in planning and development to maximise their application remained slower than decision-making and actual expansion. In India, for example, renewables were promoted as a panacea to the energy problems. Doing too much too soon resulted in unrealistic expectations leading to failures like poor technology selection which led to equipment malfunction. After more than twenty years of electricity expansion in rural areas is time to take stock with the conditions that indicate un-intended discrepancies between the aims of energy technology and the final outcomes in terms of the expected effects on poor communities. The RESURL project addressed this overall inconsistency between technology potential and actual impact on livelihoods by learning about the barriers that had interfered with the success of energy schemes in remote areas so as to create effective means to deal with these problems.

2.3 Post-Evaluation of Barriers and Success of Renewable Energy Development in Remote Rural Areas –MAP- RESURL (Output 2)

Reliance of the poor on their natural surroundings indicated that any step towards poverty alleviation should incorporate environmental and economic sustainability as a priority for enhancing sustainable livelihoods. Drawing on conclusions from the literature review and learning from the experience of the team members, we sought a multidimensional approach that would enable the technical and non-technical aspects of energy development to be embraced in our analysis for future development of energy design for rural poor areas. We knew that the degree of success and failure of energy system development depended upon factors that did not circumscribe to technology and economic risks, albeit these are of great importance. In order to promote energy solutions in remote poor areas, these must be sustainable in the long term. It was essential not to fall prey to past mistakes. The team learnt about the barriers through the literature and importantly, through extensive field-works in remote areas in Colombia, Cuba and Peru.

Knowledge was needed on the main barriers that stood on the way of more sustainable energy development applications in rural areas. However, a comprehensive method that would focus on technical as well as non-technical factors was not readily available. Therefore, the main output of the first stage of the project is the design of a methodology to help evaluate the current performing state of energy schemes installed in remote rural areas in the developing world. The project designed MAP-RESURL, a Multi-criteria Approach for Post-Evaluation of Renewable Energy for Sustainable Rural Livelihoods. MAP-RESURL is a participatory and also expert tool that guides the assessment of current energy technology in places where energy schemes have been implemented.

The output of the application of MAP-RESURL in Colombia, Cuba and Peru is first hand information from 33 remote communities and 900 interviews in total. We took on the sustainable livelihoods approach and explored its applicability to issues of rural poverty and energy technology. Three baseline data sets were obtained for each country. The quantitative analysis of the survey information was done in Excel and also partly in SPSS. The information uncovered some of the barriers that most often interfered with effective provision of energy in these regions. Table 2.2 summarises the outputs that refers to Outputs 2 in the Logical Framework

TABLE 2.2

OUTPUTS 2	MEASURABLE INDICATORS	OUTREACH	ANNEX II
2. Designed criteria, indicators and methodology to assess barriers and to evaluate the impact of stand-alone energy systems on poverty mitigation in remote areas.	1 MAP-RESURL post-evaluation methodology - Guidance and questionnaire in English and Spanish 1 International RESURL Workshop in London, October 2002. Tested and applied MAP-RESURL in remote rural areas in Colombia, Cuba and Peru 900 household interviews in 33 communities in various geographical regions. 3 first-hand data sets 12 interviews with community leaders and regional policy-makers	2. The tool reached local and regional government in 2 Provinces in Peru, 1 in Cuba, and 3 in Colombia. MAP-RESURL is supported by the Ministry of Industry in Cuba and well known to the Ministry of Science, Technology and Environment. Interest in Cuba to improve and apply MAP-RESURL in other parts of the country Interest from MSc students (from Oxford and Brunel Universities) to apply method in China and India studies.	Post-Evaluation Domestic Questionnaire Example of Interviews Transcript Example of Photographic documentation

RESURL Outputs 2 - Post-Evaluation of energy development and testing out of the methodology

The Survey

The survey addressed households, commercial and non-commercial community premises, the local environment, and local leaders. The survey was designed by RESURL and it addressed four aspects of the energy development in isolated rural areas: technology, economy and society, the environment, and institutions and local organisations. The indicators in the four dimensions enable identification of key factors that might contribute to the barriers that preclude effective electricity generation, financial viability and continued maintenance. The indicators correspond to technical and non-technical aspects of decentralised energy technology and the variables are multidisciplinary. The research scheme is shown in Figure (2.1).

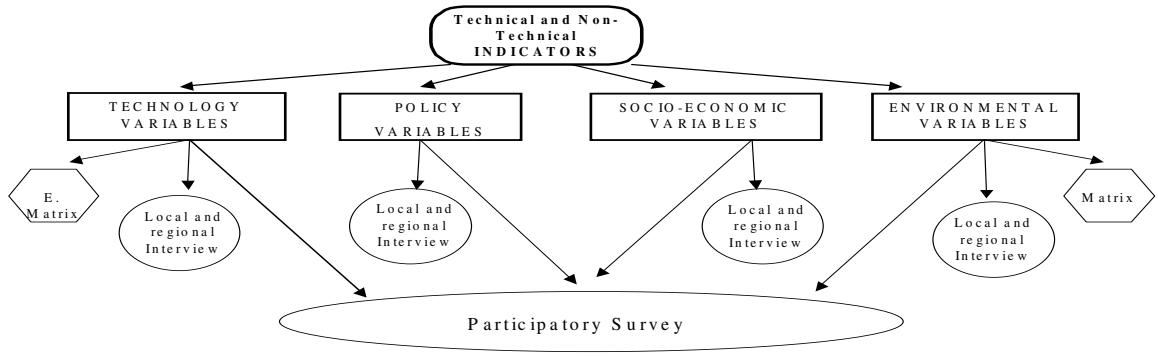


Figure 2.1 Methodological strategy used for assessing barriers of decentralised technology performance, RESURL 2002

Application of MAP-RESURL in three countries

Apart from its methodological purpose, the application of the questionnaire in three countries generated useful information. MAP-RESURL was tested in Cuba, Peru and Colombia. The study took place in the Escambray mountains in Santa Clara, Cuba; In Peru, in the Andes Province of Cajamarca and the jungle Province of Ucayali; in Colombia, the Chocó on the Colombian Pacific coast, and the Andean district of Antioquia. In each country, 300 households were surveyed in communities located in remote areas with very difficult access. Additional information was gathered from experts who looked after the installations, from leaders and other significant premises. The findings of the application of MAP-RESURL are summarised in Table 2.3.

TABLE 2.3

Evaluation	Cuba		Peru		Colombia	
• Number of villages/ communities	14		7		14	
• Total households	300		300		300	
• RETs in other premises	Schools, clinics		Clinics, shops		Clinics, shops	
• Remote locations	Mountains		Andes, Rain forest		Coast, Rain forest	
• Decentralised energy systems found	Micro-hydro	40	Micro-hydro	120	Micro hydro	94
	Solar Panels	18	Solar Panels	100	Solar Panels	35
	Traditional	132	Traditional	80	Traditional	147
	Hybrid	124	Hybrid	2	Hybrid	23

Evaluation survey of energy systems in remote locations of three developing countries, RESURL, 2002

The data gathered from the results of the application of the questionnaires is still under statistical analysis. The final results will be reported during the Phase 2 of the

RESURL project. Nevertheless a qualitative analysis of the preliminary main results is presented in Table 2.4.

TABLE 2.4

Post-Evaluation assessment	Case studies		
Energy system, performance, participation, and costs	***Cuba***	***Peru***	***Colombia***
• *Energy system (in order of importance) used for cooking*	Traditional (44%): Firewood Grid	Traditional (27%): Firewood and kerosene And gas	Micro hydro (31%) Traditional (49%): Firewood and kerosene
• *Main reason for lack of modern systems, or deficient energy services*	Need of technical maintenance	Lack of administration	Lack of both, support from authorities and economic resources
• *Users' degree of satisfaction (grid and off-grid if present)*	Satisfactory (60%)	Satisfactory (40%)	Mainly unsatisfactory (< 40%)
• *Existing local technical skills*	Low	Low	Low
• *Participation in energy-related decision-making*	Yes, through community leaders	Yes, through Municipal authorities and families (as consumers)	Yes, through community leaders
• *Women participation in energy decision-making*	Yes, considered very important	Just as family members	Just as family members
• *Average monthly cost of energy services*	$10 - 20 Cuban pesos (£0.50 approx)	$25 Soles £4.06 aprox	$10,000 – 25,000 Colombian pesos £2.28 – 5.67 aprox

Main qualitative and few quantitative findings of MAP-RESURL household survey in three countries (n=300 per country), RESURL, 2002.

2.4 Increasing Local Users' Capacities to Understand and Maintain Modern Energy Systems (Output 3)

The findings from the post-evaluation MAP-RESURL surveys in Colombia, Cuba and Peru indicated to us that lack of technical capacity among the direct beneficiaries was a considerable barrier that stood against a more effective and sustainable energy solution. Villagers were very keen on owning and operating renewable energy installations but often reported great disappointment at the unexpected technical problems that they needed to face and for which not solutions were ready available.

To help overcome this barrier, the team designed a small manual for men and women. The objective of the manual was to optimise existing energy systems, to provide essential and technical information to users, and to promote local decision-making. The manual starts by indicating the basic differences between centralised and decentralised electricity systems, and focuses on the general advantages and environmental impacts on the landscape of renewable energy technology. The manual concentrates on micro-hydro, solar, biogas and wind systems. Step-by-step, and with illustrations, it explains how to maintain and repair solar equipment and micro-hydro turbines. It is written in Spanish.

A main aim of the manual was to provide farmers and other users with a direct and immediate tool, in order to promote some degree of technical independence by developing their basic skills to resolve problems on-site. Energy technicians and engineers who have installed the equipment do rarely live nearby remote communities. The manual was distributed in 8 remote communities in Cuba. With this manual, the project launched its activities aimed at boosting the farmers' technical capacities and knowledge. Providing these to users is thought to be an essential element of technology transfer for the long-term success of clean energy technology in remote poor communities and for poverty reduction.

TABLE 2.5

OUTPUTS 3	MEASURABLE INDICATORS	OUTREACH	ANNEX II
Drew lessons from MAP-RESURL and literature and designed tool to tackle lack of capacities in remote places	• Manual for Users of Renewable Energy Technology in Rural Areas. With illustrations and clear Technical and Environmental Information • 100 leaflets distributed in 8 remote communities in Cuba	• Manual reached the remote communities of: Mingui, Cueva La Vieja, La Lima, CanCan, Manantiales, Sabanitas, Romilio and Guayanara. • The manual has been shown at international conference (Cuba, Nov'2003)	Illustrated Manual for beneficiaries (Spanish and English)

RESURL Outputs 3 - Improving technical skills and knowledge of local users of modern energy technology

References

Byrne, John, Shen, Bo and Wallace, William (1998) 'The economics of sustainable energy for rural development: A study of renewable energy in rural China', Energy Policy, 26, 1, pp. 45-54

DEP, Dirección Ejecutiva de Proyectos, Ministerio de Energía y Minas del Estado Peruano, Law No. 27744, 31st May 2002 (Spanish). www.dep.mem.gob.pe Accessed August 2002

UNDP, 21/7/1999 http://www.undp.org/seed/pei/publication/energy.PDF - Accessed 2002

World Bank, 2004 World Development Report 2004: Making Services Work for Poor People

World Energy Council and Food and Agriculture Organisation of the United Nations, 1999 The Challenge of Rural Energy Poverty in Developing Countries, WEC and FAO

Yu, P.L. 1973. A class of solutions for group decisions problems. Management Science. 19:936-946.

Zeleny M. 1973. Compromise programming. In: Multiple criteria decision making. Ed J. L. Cochrane and M. Zeleny. University of South Carolina Press, Columbia

CHAPTER 3
A DECISION-SUPPORT SYSTEM FOR INFRASTRUCTURE DEVELOPMENT IN RURAL AREAS

3.1 Introduction

The final chapter summarises Outputs 4 and 5 of the Logical Framework. It explains a central output of the project, i.e., the multi-criteria decision-support system (DSS) computer model. The project focuses on energy provision for alleviating rural poverty and promoting sustainable livelihoods. However, the characteristics of the model are such that it can be adapted to other infrastructure development needs of rural poor communities. We call the model *SURE*, Sustainable Rural Energy Multi-Criteria Decision-Support System. *SURE* is an advanced methodological package that contains a programme to evaluate off-grid and on-grid power schemes as well as offering the tools to collect the inputs necessary for the evaluation model. Apart from the inputs provided by energy technology specialists, the model requires the participation of local and regional stakeholders. The team tested the validity of the methodological package in Colombia, Cuba and Peru and surveyed 44 remote communities in total. We designed analytical codes in order to standardise the collected data from the participatory surveys and run-tested the model employing the primary and secondary data obtained from one community.

The next section explains in more detail what the method is while the last section of the chapter graphically explains the approach of the methodology, the structure of the programme and the expected outcomes of its application. Table 3.1 below summarises the measurable indicators that refer to Outputs 4 and 5, the dissemination achieved and the annex where more information is found. In Annex III, we report the results of the pilot application of *SURE*. The case study is a remote community in Colombia.

TABLE 3.1

OUTPUTS 4 & 5	MEASURABLE INDICATORS	OUTREACH	ANNEX
4. A new stakeholders survey tool to assess demands, risk, barriers, future benefits community 5. Advanced multicriteria methodological decision-making package for energy provision in remote poor areas.	4. and 5. • An advanced computer programme, Sustainable Rural Energy Multi-Criteria Decision-Making System-(*SURE*), that evaluates power systems options and models trade-offs and demand • Hybrid Indicators and logarithm • New Tools to obtain Inputs for Model: Participatory Stakeholders Survey and • Technology Matrix • Three sets of original data from 43 remote communities without or with very little electricity in Colombia, Cuba and Peru • A test of *SURE* in	• Model presented at international conferences • Countries outside the project interested in the methodology. • Ecuador interested to contribute to model improvement and applications. • Students from other UK universities interested in the methods. • A master thesis is being developed In Cuba on the Technology Matrix	• List of Publications: I. • List of Conference Papers: I. • List of Master Theses: I. • *SURE*: Household • Questionnaire: III • *SURE*: Findings: III. • International expressions

	Colombia • Publications in progress • Initial discussions with government representatives in Cuba, Peru, Colombia and Ecuador (which voluntarily joint the project).	• Further applications of the model started to be considered by Colombian team • In Cuba, Colombia and Ecuador there is interest to continue supporting and co-funding the project to maximise current outputs.	of support: l.

RESURL Outputs 4 & 5 - Decision making for future and sustainable rural energy systems

3.2 Methods to Evaluate Energy Solutions for Enhancing Rural Livelihoods

SURE is a systematic method that tackles the intricate interactions between poverty reduction and energy infrastructure improvement by simplifying the task of evaluating solutions in a comprehensive manner. It identifies the most appropriate energy system configurations for a poor community; it calculates what is the state of each of the existing capitals of a community; and it finally provides technology options that will also look at how best to benefit or enhance these assets through energy provision. The computer model assesses the trade-offs by measuring changes to capitals when a particular energy solution might be applied. The model enables the team to 'see' the changes that can be done to the sustainable livelihoods 'pentagon' or a community's baseline. The multi-criteria analysis is based on Compromise Programming; new indicators draw on our Technology Matrix and indicators for the five capitals, and the designed algorithms are used are used to model changes to the five capitals.

Rationale

SURE built into the experience and findings of the post-evaluation phase of the RESURL project (see Chapter 2). For rural energisation to be technologically sustainable, it must engage with technical as much as non-technical knowledge. A model for assisting decision-making requires that every technical criterion unfold into combined indicators that can indicate community as well as technological success. By using genuine information and then modelling the outcome, RESURL encourages decisions that improve sustainability and effectiveness of modern energy installations as measured by changes that take place at the level of livelihoods indicators.

However, unless we know the initial conditions, and the community's demands, the calculations of the effects of the technology on a community would be inaccurate. The methodology enables users' actual priorities to be taken into consideration. *SURE* works on the assumption that it is necessary to acknowledge the population's expectations, the overall conditions of the community, and to ensure a lasting operational order of a power configuration for a specific community. The final goal of the computer programme is to generate practical output that can offer effective, affordable and suitable energy solutions to rural communities.

SURE optimises off-grid and grid-connected options for developing sustainable energy infrastructure and reducing poverty in remote rural community.

The system structure

The user provides the model with inputs which describe technical and non-technical information. Different from other systems, *SURE* calculates the assets of a community, it evaluates technology, costs and resource availability of power combinations within a full-energy-menu, and significantly, its algorithms measure the trade-off that particular energy configurations may cause on the physical, financial, natural, social and human community's assets. *SURE* is a methodological package. It is composed of an analytical programme to model power systems decisions; and it provides the methodological tools to obtain participatory information from key informants and other sources.

The fundamental components upon which the *SURE* soft-ware is based are the conceptual notions that guide the RESURL project, as seen in Chapter 2 section 2.1; and on inputs, i.e., information, and values to undertake systematic multi-criteria analysis. The system draws on two kind of input information, primary and secondary. The model illustrates the output of the multi-criteria analysis on a *sustainable livelihood pentagon*. The *SURE* software processes the information with the **Compromise Programming Multi-Criteria Method**. The method employs weightings.

The outputs

The outputs of the multi-criteria analysis emerge in two-stages. The first stage produces energy technology recommendations that could be viable and could fulfil the community energy demands, as well as creating a community's baseline. This is a 'pre-selection' phase that uses the technology options, costs and resource availability information provided to the system. In its second stage, the programme establishes a prioritisation of options. In phase 2 the evaluation of each energy technology alternative against the five capitals indicators is made.

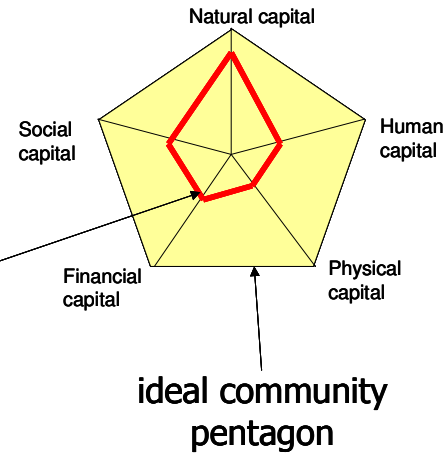
3.3 *SURE* Approach and Computer Programme

While designing the computer model *SURE* (Sustainable Rural Energy Multi-Criteria Decision-Support System), the team worked in both, Spanish and English. Currently, we have translated most of the windows to English. In Spanish the model is called *SEER* (Sistemas Soporte para Energización Rural). We have the advantage that in the future, the programme will be improved and completed for Spanish and English speakers.

The community's assets within a Sustainable Livelihoods Approach

- Natural capital
- Social capital
- Human capital
- Financial capital
- Physical capital

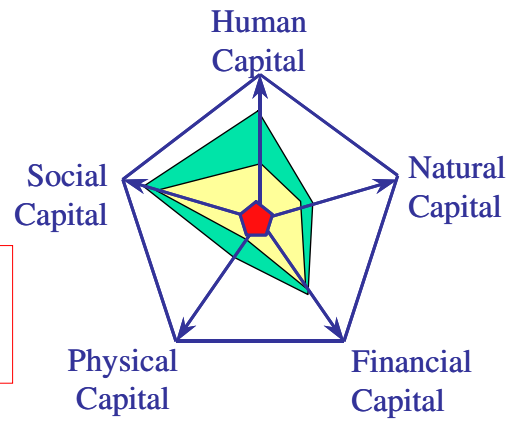
e.g. initial community pentagon



Aims of the RESURL model

To define the community's own pentagon.

To improve the initial community's pentagon by supplying energy.



Sustainable Rural Energy Multi-criteria Decision-Support System *SURE* (SSER)

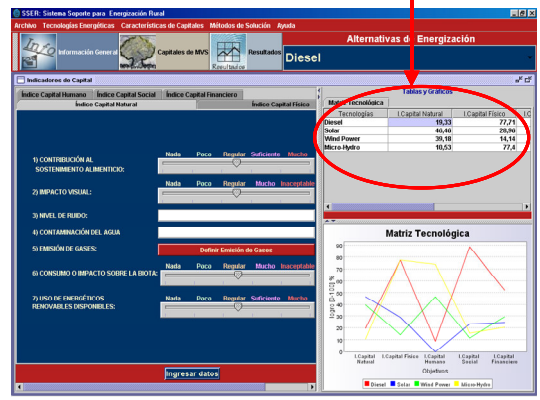
Structure of the Evaluation Computer Programme

- Phase 1: Information input and characterization of the Community
- Phase 2: Definition and Selection of Energy Technologies

Phase 2B in *SURE*

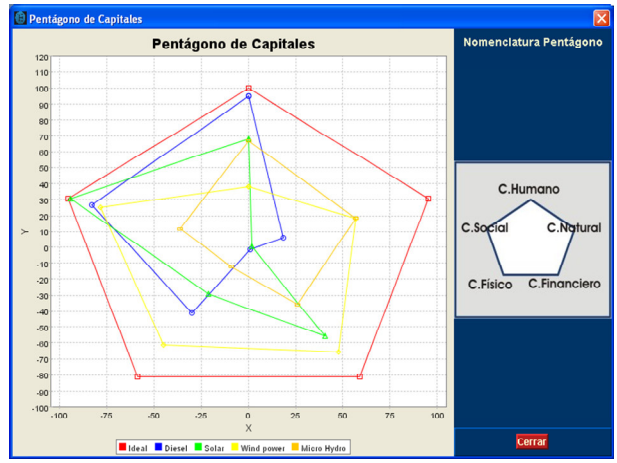
Indicators Matrix

The system helps constructing the indicators matrix (evaluating alternatives) prompting questions of how energy technology affects the community's capitals.



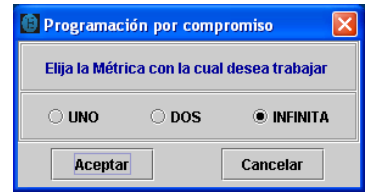
Phase 2B:
The Community's Pentagon in *SURE*

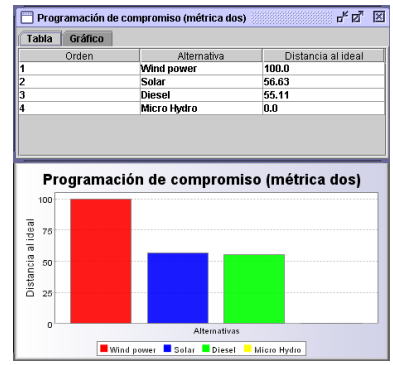
It is possible to appreciate the impact of the energy alternatives on the community's pentagon.



Phase 2C:
The Multi-criteria Methodology

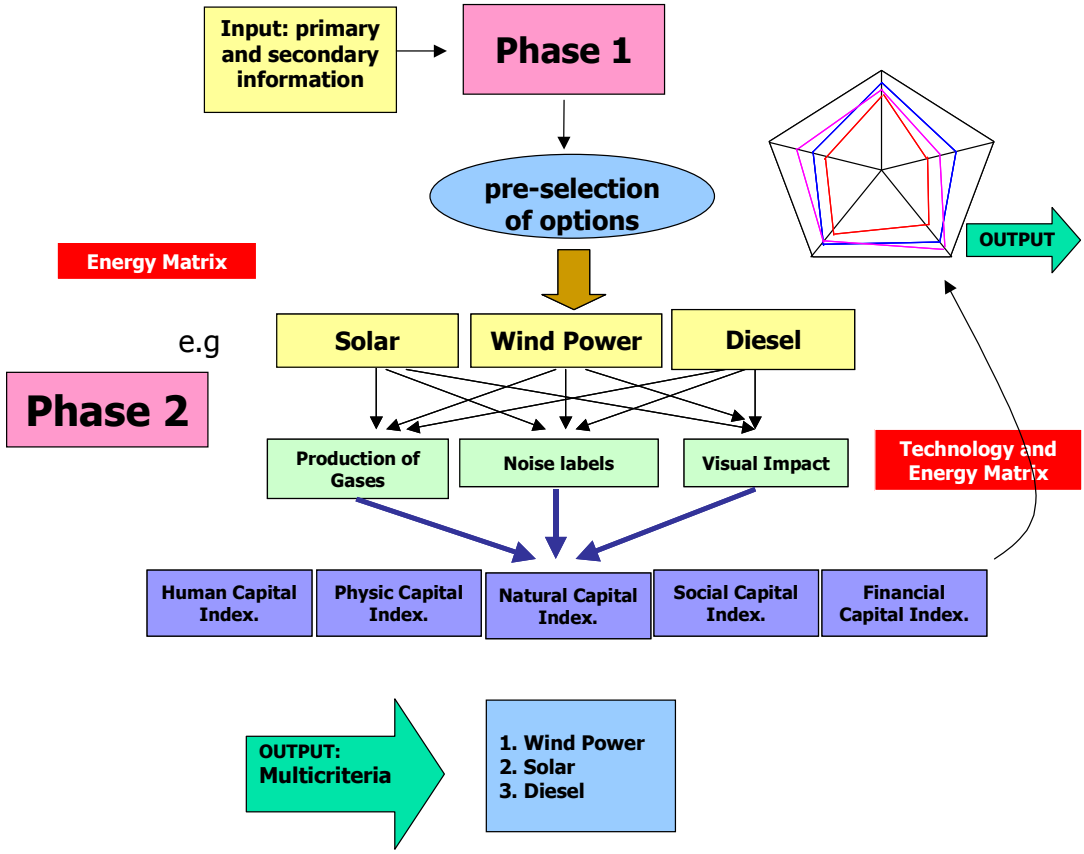
- Using the Indicators Matrix, the Multicriteria analysis is undertaken
- The output is the prioritised technology options





The RESURL *SURE* approach

1. Establishing decision-makers
2. Surveys and secondary information
3. Characterisation of community (Phase 1)
4. Technical pre-selection of options
5. Evaluation of the alternatives (Phase 2)
6. Application of the Multi-criteria analysis
7. Technology selection
8. The sensitivity analysis


Input: primary and secondary information
Phase 1
pre-selection of options
OUTPUT
Energy Matrix
e.g
Solar
Wind Power
Diesel
Phase 2
Production of Gases
Noise labels
Visual Impact
Technology and Energy Matrix
Human Capital Index.
Physic Capital Index.
Natural Capital Index.
Social Capital Index.
Financial Capital Index.
OUTPUT: Multicriteria
1. Wind Power
2. Solar
3. Diesel

ANNEX I
PUBLICATIONS, CONFERENCES AND THESES - THE WAY FORWARD

Publications

Published

Haselip, J., Dyner, I., and Cherni, J A * (2004), 'Electricity market reform in Argentina: assessing the impact for the poor in Buenos Aires'. *Utilities Policy* (In print)

Felipe Henao, Ricardo Smith, Jaime Aristizabal, Claudia Alvarez, Isaac Dyner, Judith Cherni, Patricia Jaramillo y Gabriel Awad (2004) Models for Analysing Energy Policies and Decision Making in Rural Energy Plans'; (Spanish). *Boletín del Observatorio Colombiano de Energía*. Vol 12. 2004. Universidad Nacional de Colombia, Bogotá, Colombia

Cherni, Judith A (2003) 'Renewable energy technology and sustainable livelihoods', *DFID Energy Knowledge and Research Newsletter*, 17, November, 6

Cherni, Judith (2003) A.'Multicriteria analysis to evaluate renewable energy technology performance in rural areas' (Spanish), *Energética*, 30, 7-17

Alvarez, C., Awad, G., Dyner, I. and Cherni, J. A. (2003) 'Energy and poverty in isolated areas in Colombia' (Spanish), *Energética*, 30, 19-32

Olalde, RF, Quintana, P C, Martinez, YI, and Cherni, Judith AJ. (2003) 'Renewable energy sources in function of sustainable rural development: Escambray Sierra, Cuba' (Spanish), *Energética*, 30, 33-42

Sánchez, T, Escobar, R and Cherni, JA (2003) 'Evaluation of electrification with renewable energy technology in rural isoalted communities in the Peruvian Andes and Jungle' (Spanish), *Energética*, 30, 43-50

Smith, R, Jaramillo, P, Angel, W., Henao, F and Cherni, JA (2003) 'Decision-making model for the energisation of non-connected isolated areas' (Spanish), *Energética*, 30, 43-60

Cherni, J A. (2003) 'Conceptual and practical perspectives of ecological modernisation and globalisation' (Spanish) Perspectiva conceptual y práctica de la modernización ecológica y la globalización *Theomai, 7, volume, 2nd semester*

Cherni, Judith A (2002) 'Technologies and sustainability in the context of neo-liberal globalisation' (Spanish) *Energetica*, 28, 47-56

Cherni, Judith A. (2002) 'Evaluating energy options for poverty reduction in remote rural areas', *DfID Energy*, Issue 14, May, pp 4-5

Cherni, Judith A (2002) 'Renewable energy for rural areas: solutions and barriers' (Spanish), *Boletín del Observatorio Colombiano de Energía*, Junio, 2002. No. 6, pp 3-5

Conference Papers

- **2004**

XXI Congreso Latinoamericano de Hidráulica. 'Metodología de selección de pequeñas centrales hidoeléctricas dentro de las propuestas de energización de zonas aisladas basados en medios de vida sostenibles'

Olalde Font, Raúl; González Morera, Taymi; Mantilla, Isaac Pedroso, Quintana Pérez, Candido, Dyner Rezonzew, Isaac, Sanchez, Teodoro, Cherni, Judith A.,

I Iinternacional Symposium Tecnotransfer 2004, Havana Cuba. 'Impacto de las transferencias tecnológicas de sistemas energéticos en el desarrollo económico sustentable de comunidades rurales comunitario El caso de Cuba'

Henao, Juan Felipe, Jaramillo, P., Smith R., Cherni, J., and Isaac Dyner. "A Multicriteria Decision Support Model with Multiple Decision Maker Manage for Rural Energy Planning"; (Spanish). III Congreso Colombiano y I Conferencia Internacional Andina de Investigación de Operaciones CCIO-2004. Cartagena de Indias, 2004.

Henao, Juan Felipe, Jaramillo, P., Smith , R., and Cherni, J. "Methodology Aid Approach for Assign Weights of Relative Importance in Multicriteria Discrete Problems"; (Spanish). III Congreso Colombiano y I Conferencia Internacional Andina de Investigación de Operaciones CCIO-2004. Cartagena de Indias, 2004

Henao, Felipe, Smith, R., Jaramillo, P., Dyner, Isaac and Cherni, Judith. II Simposio Internacional de Manejo del Agua y el Medio Ambiente, Barquisimeto, Venezuela, Septiembre 9 al 11 de 2004, 'SELECCIÓN DE PCH PARA LA ENERGIZACIÓN DE ZONAS AISLADAS USANDO MEDIOS DE VIDA SOSTENIBLES' -

- **2003**

Judith A. and Sheate, William. *International Association of Impact Assessment IAIA,* Cherni, 'Environmental assessment of energy options in remote rural areas: Case study of Peru', Marakesh, Morocco, March

Smith, Ricardo; Cherni, Judith A., Sheate, William, Jaramillo, P., Dyner, I., Angel, William and Henao, Juan F. EURO/INFORMS Joint International Conference. 'Decision-making for Rural Energy using multicriteria analysis', Istanbul 6-10 July, 2003.

Cherni, Judith A. *V Latin American Congress on Electricity Generation and Transmission CLAGTEE* 'Sustainable renewable energy technology for isolated rural areas. An Approach. The cases of Colombia, Cuba and Peru', Caxambu, Brasil, 16th-20th November.

Alvarez, Claudia, Awad, G., Dyner, I. and Cherni, Judith. *9th International Latin American Conference of Rural Electrification CLER.* 'Advances in the evaluation of renewable energy in isolated areas. Poverty and energy. The case of Colombia' ('Avances en la evaluación de energización sostenible de zonas aisladas en Colombia – pobreza y energía'), La Habana, Cuba, 5-10 Mayo.

Cherni, Judith A. *9th Conferencia Latinoamericana de Electrificación Rural CLER* , 'Renewable energy for isolated rural areas. The need for methods to evaluate technological options' (Energías renovables para zonas rurales alejadas. Necesidad de métodos para evaluar las opciones tecnológicas), La Habana 5-10 Mayo, 2003.

- **2002**

Cherni, Judith A., 'Technological and Scientific changes for a modern ecological modernisation. Towards a different development?', *II International Conference Environment Century XXIst*, Universidad Central Las Villas, Santa Clara, Cuba –November.

Smith, Ricardo, Patricia Jaramillo y William Ángel, Henao, Felipe. "A Decision Support Model for Supplying Enegy to Rural Isolated Areas". (Spanish) 3ra Conferencia Internacional de Energía Renovable, *Ahorro de Energía y Educación Energética, CIER* 2003. 27 de octubre al 1 de noviembre de 2003 - La Habana, Cuba.

Henao, Felipe, Smith, R., Jaramillo, P., and Ángel, W. "A Decision Support Model for Supplying Energy to Rural Isolated Areas"; (Spanish). *VI Seminario Internacional sobre Análisis y Mercados Energéticos*. Medellín; Colombia. 1 al 3 de Octubre de 2003.

Henao, Felipe, Smith, R., Aristizabal, J., Alvarez, C., Dyner, I., Cherni, Judith, Patricia Jaramillo y Gabriel Awad. 2003. "Models for Analysing Energy Policies and Decision Making in Rural Energy Plans"; (Spanish). *Seminario: Las Reformas Pendientes en el Sector Energético en Colombia.* El Observatorio Colombiano de Energía de la Universidad Nacional de Colombia. Bogotá, 2003.

Master Theses Related to RESURL

Completed and Published in the Library

2004

Imperial College London

'Renewable Energy for the Poor and the Electrification Law in Peru', Felix Preston

'Effectiveness of Renewable Energy Promotion Law in China, within the Contexts of Electricity Reform', Jo Kentish

2003

Imperial College London

'Costs-benefits analysis of the use of renewable energy technologies to a developing economy: the case of Argentina', Chinedu E. Okeke

'Power sector reform – Electrification and the Poor. A case for Tanzania', Rashdeep Kalsi

'The evolution of energy policy in South Africa: prospects for renewable energy', Lisa Petrovic

'Milking the desert: Water security potential for rural livelihoods through solar energy. The case of La Paz, Baja California Sur, Mexico', Dalia B. Cohen

'An investigation into the impacts of electricity sector liberalisation upon low-income consumers in Buenos Aires, Argentina', James Haselip

2002

Imperial College London

'A sustainable livelihoods framework to explore the impacts of renewable energy technology on remote rural communities. The case of Cuba', Yohan Hill

'Advantages and disadvantages of technology transfer of renewable energy to rural areas in the Caribbean. The Case of Cuba', Chloe Meacher

2001
'Assessing social and environmental impacts of renewable energy technologies on islands – The case of Rodrigues Island', Benjamin Gill

In Process
National University of Colombia, Medellín
'Contribution of renewable energy services to rural poverty reduction. A Systems Dynamics approach' (Spanish), Claudia Patricia Alvarez Barrera

National University of Colombia, Medellín
'Decision-making support system for rural energisation' (Spanish), Juan Felipe Henao Piza

University Central of Las Villas, Cuba
'A Technology Matrix for Improving Energy Solutions in Remote Communities. The Case of Mountainous Villages, Cuba', Taymi Rodriguez

1st NESLI Workshop
Imperial College London, May 10th , 2002

Attendees:

Organisation	Name	Email
IIED	Salleemul Huq	Saleemul.Huq@iied.org
BP Solar	Roebyem Heintz	heintzr@bp.com
AEA Technology	Richard Boud	richard.boud@aeat.co.uk
ERM	Joanne Neale	joanna.neale@erm.com
	Robin Vanner	robin.vanner@erm.com
IT Power	Judith Lipp	judith.lipp@itpower.co.uk
ESD	Ottavia Mazzoni	ottavia@esd.co.uk
ITDG	Smail Khennas	smailk@itdg.org.uk
Commonwealth Science	Viraal Balsari	vbalsari@yahoo.co.uk
University of Reading	David Fulford	D.J.Fulford@Reading.ac.uk
University of Surrey	Yacob Mulugett	Y.Mulugetta@surrey.ac.uk
Imperial College	Peter Pearson	p.j.pearson@ic.ac.uk
	Brad Carmady	brad.carmady@ic.ac.uk
	Judith Cherni	j.cherni@ic.ac.uk
	Raquel Garcia	raquel.garcia@ic.ac.uk
	Matt Leach	m.leach@ic.ac.uk

Presentations

Roebym Heintz, BP Solar
Solar solutions for sustainable development and livelihoods: lessons learned in the Philippines.

Joanna Neale, Environmental Resources Management
Private supply of rural energy services - lessons learned from Gabon's electricity and water concession.

Richard Boud, Future Energy Solutions, AEA Technology
Development of the 'Enpower' energy appraisal tool for poor communities: lessons learned from field trials in South Africa.

Ottavia Mazzoni, Energy for Sustainable Development
Sustainable energy for a market driven approach to rural development

Small Khennas, Intermediate Technology Group
Small wind energy systems in developing countries: strategies and challenges.

Dr Peter Pearson, Imperial College
Prospects for energy development and concluding remarks.

The concluding discussion is summarised below:

- presentations provided very good examples from mostly renewable energy projects in a diverse range of countries. Further workshops could target presentations on other energy forms and the sustainable livelihoods concept. Many felt that this concept remains difficult to get a handle of, and further work is suggested.
- the workshop acts as a useful peer review of work underway, although one presenter felt that more critical feedback would be useful. It was also suggested that the workshop should be used to influence policy in a meaningful way. The objectives of the network need to clearly stated.
- the involvement of the private sector is valued given the projects they are now involved in and the contribution they are able to make to the topic.
- presentations are available in electronic format upon request

From feedback received it seems that it was a useful exercise and attendees agreed that a further workshop in 9-12 months would be welcome. The issue of how to enable dialogue between participants was raised. It was generally felt that networks such as HEDON were appropriate venues for such dialogue and replication of networks not desirable.

Organisations that have shown interest in attending further workshops:

Shell Foundation
Sussex Research Associates
DfID
E7
Ecosecurities
Sussex Institute of Development Studies
Liverpool University
University College London
Manchester University

The following organisations that have been suggested to invite to further workshops:

Oxfam
Centre for Alternative Technology
BioDesign
HEDON coordinator
University of East Anglia

2nd NESLI Workshop
Imperial College London, February 21st, 2003

"*Sustainable livelihoods, technology sustainability and networking*"

Participants and Summary of Discussion

Attendees:

Organisation	**Name**
DfID	Peter Davies
BP Solar	Graham Baxter
Shell Foundation	Karen Westley
HEDON	Grant Ballard-Tremeer
Sussex Research Associates	Andrew Barnett
UCL	Sheila Meikle
University of Surrey	Yacob Mulugett
Las Villas University	Cándido Quíntana Pérez
Imperial College London	Bill Sheate
	Brad Carmady
	Dennis Anderson
	Juan Rodriguez
	Judith Cherni
	Peter Pearson

Presentations

The Sustainable Livelihoods framework – Application in RESURL
Judith Cherni, Imperial College London
DfID Energy for Development Research, **Peter Davies, DfID**
"Energy, poverty and gender: A review of the evidence and case studies in rural China" An IDS report for the World Bank, **Andrew Barnett, Sussex Research Associates**
Lessons learnt from a review of the national China Stoves Programme,
Karen Westley, Shell Foundation
Cuban experience of sustainable rural development: Electrification of isolated areas, **Candido Quintana, University of Las Villas, Cuba**
"Privatisation of the Electricity Industry in Developing Countries--is it benefiting the extension of service to low income households?"
Dennis Anderson, Imperial College London
Application of sustainable livelihoods to a scoping study in Indonesia and Ghana, **Sheila Meikle, University College London**
International energy networks: Four observations, three suggestions, and one distraction!, **Grant Ballard-Tremeer, ECO**

Summary of Discussions at 2nd NESLI Workshop

Various questions and discussion are summarised below:

- Sustainable Livelihoods was explained as a framework. It implies an idea - where principles of social, environmental, economic and policy sustainability prevail - and a methodology that looks into people's five types of assets and is participative. The framework utility and its limitations were discussed during the presentations.
- Important issues have been known for some time and either forgotten or regularly reinvented. For example, it is sometimes forgotten that people are energy poor because they are poor. Also, energy services that do not generate cash won't reduce poverty. Therefore the infrastructure that will use the energy needs to be assessed – not just household needs. Possibly using the enterprise as the unit of measure would be preferable to the common adoption of the household (as available data is mostly in that format).
- The direct positive effects of using PV systems in education facilities was shown with a very interesting video for a remote rural community in Cuba.
- Financial viability of decentralised systems has changed. Local private capital is also important for financial sustainability.
- Idea of complementary inputs. Works both ways, as no electricity often comes with no road access. Low load factors of some projects clearly not viable – indicative of systems used for lighting only.
- 3 approaches to reduce rural poverty through energy – (1) maximise poverty reduction – grid extension often biggest bang for buck (2) maximise market penetration; and (3) adopt different answers for particular groups.

Graham Baxter of BP Solar also reported on recent activities in the Philippines and described how BP Solar has been able to develop projects and the importance of external funding. Once again it seems that it was a useful exercise and attendees agreed that a further workshop in approximately 6-9months would be welcome. It was also agreed that a short summary of the NESLI workshop would be made available on the HEDON web site.

RESURL2 - Consolidation and Applications

We enclose below the full document that we provided DfID in which we state the follow-up actions necessary to promote the findings of the project. It contains details of further stages to scale-up the project.

November 2004-March 2006
Judith A. Cherni and Dennis Anderson

1. What is the Existing Project?

The project promotes clean and modern/sustainable energy technology for poverty reduction and environmental protection in remote rural areas of developing countries. The aims of the RESURL project are to enhance the understanding of the relationship between access to energy and poverty reduction and environmental sustainability, to *ex-post* evaluate energy technology, to recommend appropriate clean energy technology options in future poverty reduction energy development policy, and to raise the benefits users may accrue from the installed energy systems in remote rural areas.

The project's remit of poverty eradicadication is in line with the Millenium Development Goals (MDG) and corresponds with the key commitments of the 2002 Earth Summit at Johannesburg to promote renewable energy and improve access to affordable and environmentally sound energy services. RESURL's purpose reflects the findings of the lattest UNCTAD Report on the need for better use of technology to improve the conditions of the world poorest.

RESURL is built upon a partnership with the Cuban Ministry of Science, Technology and Environment; the Central University of Las Villas, Cuba; the National University of Colombia, in Medellín; the international NGO Intermediate Technology Development Group (ITDG), in Lima and Cajamarca, Peru; and specialist consultant from ITDG UK/Regional programme Sahel (PREDAS-CILSS), and under the leadership of the Centre for Energy Policy and Technology at Imperial College London.

2. Achievements of RESURL

RESURL has produced information and analyses on some of the poorest groups that constitute the 2 billion people without electricity and those inappropriately supplied world-wide, and has made significant paths into an area that has huge potential to contribute to poverty reduction. The project has established links with government, academics and implementing organisations in Latin America and the Caribbean that work in the interest of the poor and the environment. The British Academy has earlier on supported a short academic visit during the current project for Prof I. Dyner from the National University of Colombia. Over three years, RESURL has achieved a range of outputs: on the relationship between the provision of modern energy technology and rural livelihoods, a methodological package – tested in Colombia, Cuba and Peru (CCP) - to assess the performance and effectiveness of stand-alone modern energy technology that has been installed in remote rural areas (MAP-RESURL), a multi-criteria system – piloted in CCP - that consists of original criteria for information and analysis and new software to assist rural energy decision-making (*SURE)*, and a practical tool to increase the technical and knowledge capacity of current, or prospective, users of modern energy technology. The underlying criteria are based on the five forms of capital required for sustainable livelihoods: human

resources (health and education), financial, natural or environmental, physical infrastructure, and social networks.

3. What is needed now

Technologies are now available to improve access to energy by the rural poor in remote areas. However, unless appropriate information is made available to users and to decision-makers, new developments will, no doubt, end up with the same flaws as previous schemes and will not succeed in reducing poverty in the longer-term. RESURL 2 is ready and willing to begin this process: to consolidate the outputs achieved, enhance direct benefit to users, effectively tighten up and promote the designed and tested evaluation methods in the government, academic and private sectors, to write-up and disseminate acquired knowledge, and to start exploring poverty reduction and sustainable energy in a wider frame of utilities liberalisation process.

4. Building on the Outputs

This process starts with scaling up the outputs already achieved. It is compelling to provide expertise and answers to initiatives and calls that RESURL has awakened, and many activities have commenced or begun to develop already. The active role of the participating countries will be crucial in this second stage of the project, and the expertise each member has demonstrated over the three –year project will be drawn upon at each stage. Developments planned and initiated include;

- Disseminating the insights and analyses produced on poverty reduction, energy technology and sustainability within the English-speaking world through journal submissions, conferences, PhD work, MSc Theses and academic visits.
    - The insights and analyses we had produced on poverty reduction, energy technology and sustainability will be disseminated to better serve the MDG by promoting well-informed sustainable energy development in rural poor communities of developing countries. We will improve the quantitative and qualitative analysis of the collected original information.
- Expansion and refinement of survey and analysis techniques of both the post evaluation tool-kit MAP-RESURL and the *SURE* for future energy development, including regional and national use of the tool and software. This will further work on the specialist Technology and Energy Matrixes and add value to the Technical Capacity-Building tool for local users.
    - There is co-funding approved for MSc projects from both the University Las Villas, Cuba, and the University of Colombia to follow up our work on the Technology Matrix, *SURE,* and System Dynamics.
- Facilitating the appropriation of the post-evaluation and *SURE* practical approach and methods by government and agencies in Colombia, Cuba, Ecuador and Peru to increase the chances of poverty alleviation. The Mininstry of Planning and the Economy (MEC), and the Ministry of Science, Technology and the Environment (CITMA) in Cuba have both expressed an interest in adopting the methods and RESURL also has plans to work with the Vice-Presidency and the National Electrification Board of Ecuador.
- Exploring the issue of electricity reform in developing countries in greater depth, especially the 'hard task' of extending energy services to the poor and the potential of renewable technologies. Key questions to be answered include;
    - Is market liberalisation facilitating the access of the poor to modern energy services or is it by-passing the poor? Is it another barrier?

- Is market liberalisation facilitating or hindering the introduction and use of new and environmentally sound energy technologies?

A literature review on the subject of liberalisation and access to electricity by the poor in developing countries is proposed. This will form the basis of the research proposal *RESURL 3: Market liberalisation, poverty and the environment*.

ANNEX II

POST-EVALUATION TOOLS AND MANUAL FOR LOCAL USERS

Manual for Users of Renewable Energy Technology in Rural Areas (Spanish)

Mantenimiento de los Sistemas Energéticos. Consejos Técnicos e Información Medioambiental

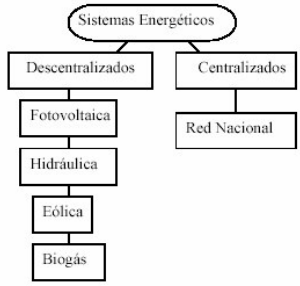
RESURL

Universidad Central de Las Villas. CETA.Cuba.
Imperial College of London. DfID. UK.
Colaboradores: CITMA. Cuba.

Esta guía lo ayudará a

1. Identificar cada uno de sus sistemas.
2. Conocer los principales problemas que pueden presentarse en cada sistema.
3. Conocer las soluciones de estos problemas.

En las comunidades los sistemas energéticos pueden ser vistos de la siguiente forma:



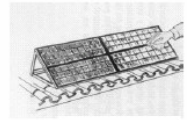
Sistemas, Principales problemas y posibles soluciones

➢ **Sistema Fotovoltaico**

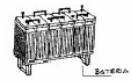
1. Disminución de la eficiencia por acumulación de polvo en la superficie del panel.
2. Deterioro de las baterías por mala operación.
3. Pérdida de la eficiencia de la batería por envejecimiento técnico.
4. Incorrecta orientación de los paneles.

➢ **Soluciones**

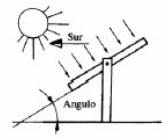
1. Limpieza según las características del lugar. En ocasiones se hace necesaria, al menos diaria.



2. Es necesario tener los recambios disponibles antes de que se produzcan afectaciones serias al sistema.



3. Nunca instalar un panel sin consultar un especialista. En caso de verse en la necesidad el panel debe ser instalado de cara al SUR.



➢ **Sistema Hidráulico**

Existen diferentes tipos de turbinas hidráulicas. En dependencia de estos tipos los problemas que se presenten pueden ser:

Turbina Pelton Y Michel Banki.

Cojinete guía de la turbina

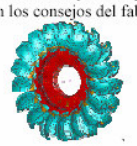
El primer cambio de aceite debe hacerse después de 3 - 6 meses de funcionamiento. Los cambios de aceite posteriores serán hechos según sean requeridos evaluando muestras de aceite.

Si se encuentran partículas de metal en las muestras de aceite, el cojinete debe desmantelarse inmediatamente para la inspección.

Rodete debe inspeccionarse regularmente para verificar posibles daños de los objetos extraños en el agua. El intervalo de tiempo entre cada inspección es dependiente del volumen de arena en el agua.

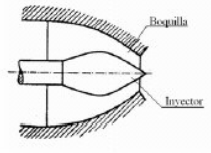
La inspección del rodete se hace visualmente. Debe prestarse atención particular al área entre las cucharas.

Si se han formado grietas o defectos menores, éstos deben ser quitados puliendo la superficie según los consejos del fabricante.



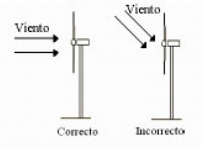
➢ **Inyector principal**

Deben inspeccionarse la punta de la aguja y la boquilla con respecto a los daños de los objetos extraños. Si el agua contiene lodo o arena, las puntas de la aguja pueden perder su forma original.



➢ **Sistema Eólico**

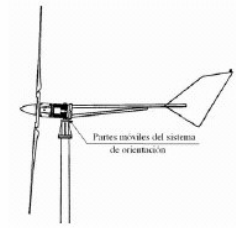
1. Orientación incorrecta de la máquina en relación con la dirección al viento.



2. Deterioro de las baterías por mala operación.
3. Pérdida de la eficiencia de la batería por envejecimiento técnico

➢ **Soluciones**

1. Lubricar las partes móviles del sistema de orientación, incluyendo el cojinete que permite la orientación de todo el conjunto.



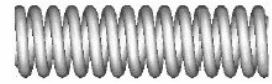
2. Mantener una vigilancia permanente sobre el nivel de agua de la batería. **NO PERMITIR QUE NUNCA LA BATERIA QUEDE SECA.**
3. Es necesario tener los recambios disponibles antes de que se produzcan afectaciones serias al sistema.

➢ **Sistema biogás**

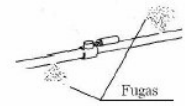
a. Aumento de la acidez del gas.
b. Fugas.

➢ **Soluciones**

1. Garantizar que el sistema siempre tenga los filtros necesarios para disminuir la acidez del gas, estos pueden ser de desechos metálicos de un taller mecánico (virutas de hierro).



2. Chequear el sistema para detectar las fugas y reparar las tuberías.



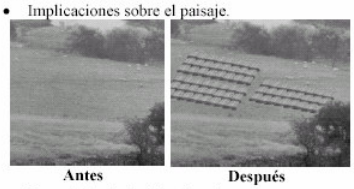
La tecnología y nuestro medio ambiente. Impactos Ambientales

RESURL

Universidad Central de Las Villas. CETA. Cuba.
Imperial College of London. DfID. UK.
Colaboradores CITMA. Cuba.

1. Sistemas fotovoltaicos

- Implicaciones sobre el paisaje.

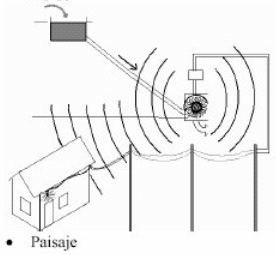


Antes **Después**

- Deposición final de las baterías.

2. Sistemas Hidráulicos

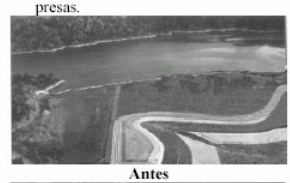
- Ruido



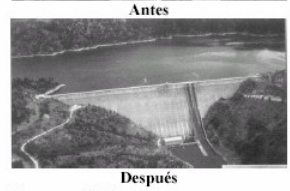
- Paisaje

Antes **Después**

- Cambio de uso del suelo en el caso de las presas.



Antes



Después

3. Sistemas Eólicos

- Ruido

- Paisaje

Antes

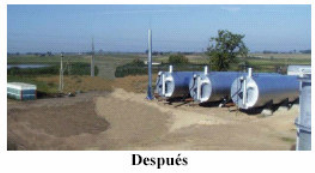
Después

- Fauna. Posible impacto con aves migratorias.

4. Sistemas de Biogás

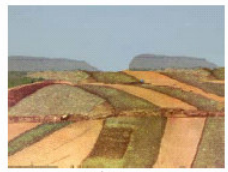
- Paisaje

Antes

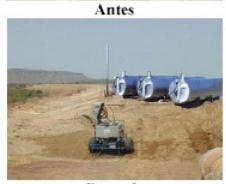


Después

- Cambio de uso del suelo



Antes



Después

Ventajas de poseer sistemas energéticos renovables

1. Utilización de un recurso natural no agotable.
2. Eliminación de las emanaciones de gases contaminantes y otros que causan deterioro del medio ambiente.
3. Posibilidad de utilizar recursos locales.
4. Descentralización de los sistemas energéticos.
5. Incremento de la capacitación local.
6. Creación de una conciencia energética y ambiental.
7. Fomento de la solidaridad entre los miembros de la comunidad
8. Son energías económicas para los consumidores.
9. Brindan, de manera ventajosa, servicios deseados por la comunidad.

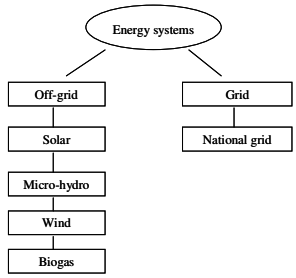
Maintenance of the Energy System. Technical recommendations and Environmental information

RESURL
Universidad Central de las Villas. CETA. Cuba
Imperial College of London, DFID, UK
With the collaboration of: CITMA, Cuba

This guide will help you to:

1. Identify each one of the systems
2. Recognize main problems in each system
3. Acknowledge the actions solve these problems.

Within the communities the energy system are classified as follows



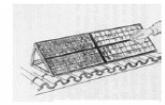
Systems, main problems and possible solutions

Solar system

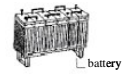
1. Low efficiency due to accumulated dust in the panel's surface
2. Damaged batteries resulted from wrong operation
3. Low battery efficiency due to ageing equipment
4. Incorrect orientation of the panels

Solutions

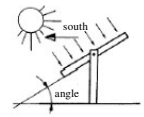
1. Cleaning according to site characteristics. If necessary, daily.



2. Ready to use spare equipment to avoid damage to the system



3. Never install a panel without specialised technical supervision. If extremely necessary install it facing south.



Micro-hydro system

There are different types of hydro-turbines. According to these types the main problems are:
Bearings and heads

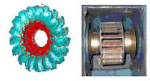
Pelton and Michel Banki turbines

The first change of oil should be done after 3 - 6 months of operation.

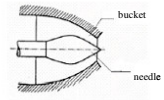
Following oil changes should be done according to need checking oil samples.
If metal particles are found in the oil the turbine must be dismantled for inspection.
The disk must be regularly checked to look for damaged caused by objects in the water.

The time-lapse between inspections depends on the volume of sand in the water. The inspection of the disk is visual. Special attention must be paid to the area between the blades.

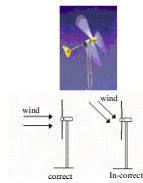
When cracks or any minor defects are found they must be polished up according to manufacturer's instructions.



Main jet
The needle and the bucket must be checked to look for damage caused by objects in the water.
If water contains mud or sand the tips of the needle might lose their original form.

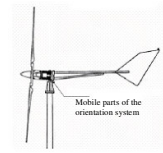


Wind system
1. Incorrect orientation of the equipment respect to wind direction.



1. Low efficiency of battery due to wrong operation
2. Low efficiency of battery due to ageing of equipment

Solutions
1. Lubricate all mobile parts of the orientation system including the shaft and the head.

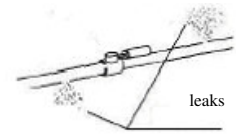


2. Keep a routinary check of the water level in the battery. NEVER ALLOW THE BATTERY TO GET DRY.
3. Have ready available spare parts to avoid damages to the system.

Biogas
a. Increase acidity in the water
b. Leakages

Solutions
1. Verify the system always have the adequate filters to decrease acid levels of the gas. The filters might be from metal scraps.

2. Check the system for leaks and repair the pipes.



Technology and our environment
Environmental Impacts

RESURL

Universidad Central de las Villas. CETA. Cuba
Imperial College of London, DFID, UK
With the collaboration of:
CITMA, Cuba

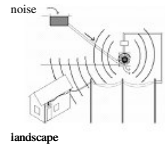
1. Solar (photovoltaic)

- **Impacts on the landscape**

before after

- **Battery disposal**

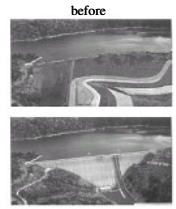
2. Micro-hydro system



- Change in landuse

before after

- **Change in land use due to the construction of the reservoir.**



3. Wind system

Advantages of a renewable energy system

1. Use of a renewable natural resource
2. No generation of air pollutants
3. Possibility of using local resources
4. Alternative use to national grid
5. Increase of local technical training
6. Promotion of local cohesion
7. Low cost energy production
8. Offer services welcomed by the community

- **Impact on wildlife. (migrant birds)**

4. Biogas

- **Landscape**

SURVEY METHODOLOGY (MAP-RESURL)

RESURL is an international project which goal is to produce a research tool to help decision-makers with the selection of technology for renewable energy in remote rural areas. The overall aim of the field-work is to evaluate and measure the factors that contribute to effective, viable and appropriate energy developments in rural areas using a multidisciplinary and participatory perspective. A questionnaire and a semi-structured interviews were undertook.

i. Questionnaire

Two types of criteria, primary and secondary, were used to decide upon the selection of the case studies in Cuba, Colombia and Perú.

I. Primary criteria

The case studies were selected within the overall rural population of each country. As a further condition was considered that the case study area is under poverty conditions and that it was located far from main roads and urban centres. The criteria considered were:

- **Rural Poor**

  A characterisation of the assets of the community in terms of social, financial, human, physical and natural capitals – as indicated in the sustainable livelihoods approach.

- **Geographically isolated**
  The case study is not easily accessible by regular means of transport and responds to the above circumstances of physical location.
- **Energy condition**
  Each case study was classified according to one of the following descriptions of their access to energy:
  1. with very little modern energy – primarily relies on use of traditional biomass (wood wastes)
  2. well served by modern energy - for example central grid connection, or through mini-grid supplied by diesel generators or renewables
  3. limited applications off-the-grid, i.e., renewables and mixed categories.

The multi-dimensional and multi-country methodology enables the incorporation of the three energy situations, and aims at assessing all the technological options. It was acknowledged that the reality of the countries may restrict the full variety in the actual sample.

II. Country specific secondary criteria

- The secondary criteria consisted of a set of categories that would normally correspond to geographical divides in a country. The divides are very likely to be the result of the country's macro social and physical conditions.
- The main categories proposed are social, political, economic, ethnic, institutional, and physical.
- Given the characteristics of the RESURL project (with a focus on method as well as detailed fieldwork), communities were selected on the basis of nation specific categories.
- Country specific

Selection of case studies following geographical distinctions that represent one or more of the criteria below and their potential categories:

1. physical (e.g., coast/jungle/ mountains)
2. political (e.g., represented /not represented in government)
3. economic (priority and non- priority development areas; centralised and private market areas)
4. social (e.g., poorer/ wealthier areas, developed/less developed)
5. demographic (e.g., ethnicity)
6. institutional (e.g., ownership of energy schemes, Private entrepreneur, Community/cooperative, Public/government)
7. other

The subject-areas of study

The field work collected information on technical and non-technical factors that affect people's sustainable livelihood and the state of energy development for a set of case studies (each of which represents a rural, poor, isolated community, with certain access to energy, and that reflect particular characteristics within the national policy and geography). Four subject-areas were investigated for each case study:

- Technology
- Socio-economy
- Environment and physical
- Policy and power

The population sample

The population sample was considered to be representative and surveyed in groups
i. families or domestic units (men and women),
Three hundred (300) households were selected in each, Colombia, Cuba and Peru. The three primary criteria above were used in order to select the sample in each country (i.e., poverty, location and energy condition). Two different regions were surveyed in each country. The size of the population in each community varied. The survey was applied to at least 50% of the population.

The reason behind the sample size is to compare in the future the results by country. The sample size is not representative of the population size of the participant countries.

ii. Semi-structured interviews

These were carried out to representative of local institutions, community leaders and regional policy-makers. The questions surrounded electricity installations, relation to central government, and particular conditions in the specific community. This was a qualitative investigation.

Questionnaires

Domestic questionnaires were applied to the head of the family, or the person present at the time of the survey. In few instances, the interviewer waited until the head of the family came back from work in order to interview him or her. The survey aimed that female and male heads were represented equally. The application of the questionnaire took between 25 and 35 minutes. Most questions in the questionnaire are closed-ended. Only a few questions are open-ended and request a more detailed response by the interviewee.

METHODOLOGY FOR FIELD WORK AND INSTRUCTIONS FOR INTERVIEWERS

The following instructions were provided to interviewers to use in both Surveys. Questionnaire for survey 1 is in page 59 and questionnaire for survey 2 is in Annex III.

Field-Work Methodology, RESURL

Useful Guidelines for the interviewer
Prepared by Rafael Escobar, ITDG, Peru

1. The interviewer and the interviewee

- It is necessary to briefly introduce the goal of the survey and to explain the interviewee how it may benefit the community and the family which will provide the information.
- Simplicity and clarity of presentation are important. These will encourage the interviewee's confidence and avoid defensiveness.
- The interviewee must know that the questionnaire is being applied to other families and that we have been approved by the respective authorities or organisation in the community to carry out the survey.
- The interviewer must inform about the duration of the interview to avoid uncomfortable feelings if it extends longer than expected.
- The interviewer must establish an open dialogue providing some recommendations without patronising. The communication must be fluent and thoughtful. It is understood that we search for information but we also must provide some.
- The name of the head of the family must be written at the end of the interview and not at the beginning. The reason for this is the fear for land property taxation and legal accusations (particularly in Peru). This will allow the interviewee to gain confidence and trust the interviewer.
- In many cases the family does not have the education level to allow fluency in providing the required information. If necessary, provide an example for clarification.
- A good sense of humour by the interviewer is important to lower tensions and raise confidence. If necessary, address different aspects, such as children, education, health, etc. in the conversation, which may be less controversial than income..

2. Application of the questionnaire

- An important issue to consider is the relation of the family within the rural context. This is essential to avoid false information.
- The gender of the interviewee should be considered when interviewing. If it is female, in many cases she may not know about participation in the system. If it is male, he tends to emphasize the information of the process where he participated.
- It is necessary to try to interview both heads of family to be able to compare information with the two visions. This ensures participation. For this purpose it is necessary to previously know the activities and when they may have spare time to dedicate to you..
- The previous point implies that the application of the questionnaire should consider the family habits. This means that if it is not possible to interview the head of the family then it has to be done through the other members of the family.
- In communities where there is a modern energy system, a random sample must be applied. This must include the area of meeting for the families (central part of town, generally more illuminated) and the periphery zone (marginal) where small businesses and shops are commonly found.
- Within the energy system consider: power, type of system and type of settlement (*anexo, caserío, centro poblado, villa, distrito, provincial*).
- In the case of businesses, consider a sample amongst those more representative such as small warehouses, normally managed by families, and those with a consumer service activity, such as restaurants.
- In all cases consider time and duration of the interview. If necessary, go to the next

question and return later to unanswered or incomplete ones.

3. Relationship with leaders and local authorities

- The introduction of the project's team must be simple and short.
- It is important that local leaders know the goal of the survey. Never raise false expectations.
- Heterogeneity between the leaders is important as well as the opinion of those without power. In communities with access to modern energy service, consider the power system in respect to the service.
- In some places there is a community leader who is more knowledgeable. The interviewer must handle the situation to avoid emphasis on this aspect of leadership.
- Give free space for women leaders. In many cases the male leader considers he knows more and imposes his presence.
- In communities where independent management of electric service exists, the interviews should be directed to both female and male representatives within the organisation.
- Contrasting the information should not allow tensions.
- Concentrate on the criteria of the project and avoid other topics not relevant such as agriculture.
- Leaders and authorities must know that the results of the survey will be available for the community.

4. Relationship with regional authorities.

- If possible, have a contact to inform about the project and our interest in helping to identify problems and the future possibilities with this project.
- The meeting must begin defining the project: goals, objectives and products.
- In all cases, put emphasis in the usefulness of final products for supporting their policies.
- The criteria to follow in a conversation, or semi-structured interview, are:

a) What natural and financial resources are used for rural electrification; b) The achievements or level of electrification reached; c) What obstacles were present; d) If there are environmental problems and how they face them; e) What strategies are implemented to promote energy provision; f) If they have human resources to implement the strategies; g) What topics are important for local training; h) What are the regional resources that may be used to improve energisation levels; i) Make final considerations in respect to energy provision and look for real possibilities of work in the future.

- Leave information about the project to the directors or ministry representatives to keep communication and improve the relationship.

5. Relationship within the community

- Make clear what the project could bring. Consider the objectives of the project and future achievements.
- The communication must be simple and non-hierarchical.
- Do not make promises. offer a project or future actions.
- Ask about families' knowledge on local authorities and themselves respect to the management of the energy system.
- Try to *re-construct* the facts with the information of present and past energy system.
- Identify the role played by each stakeholder in the community (population, authorities, and leaders) to see if there was coordination and participation in the decision/management of the system.
- Consider gender and be democratic in the opinions as rural areas tend to minimise women' roles.
- If there is experience of local meetings, agree to attend to them as this shows respect to the community.
- Messages should be clear and thoughtful. This is to identify weaknesses and potentials within their possibilities.
- Offering opinions should not develop into providing judgement. Residents should be oriented on the analysis and contrasts of planning, management and construction of an

energy system.

INSTRUCTIONS FOR INTERVIEWERS

1. What is RESURL and what are the survey's goals?

RESURL is an international project that aims to develop methodological tools to help decision-makers to develop appropriate and sustainable energy supply in remote rural areas in order to improve community's livelihoods.

This survey is a key tool as it gathers household information on a number of issues: socio-economic aspects of the community, main sources of energy and its impacts on the environment; the relationship between community and authorities in energy supply matters; and the environment. Therefore, this survey allows generating a diagnosis of the site which will be the basis for the development of a energy project. The quality of the data obtained is very important to us.

Preliminary information
This section of the survey gathers basic information about the household, and on the type of energy supply. It draws on two criteria, geographic and environmental, and the second depends on the main goal.

Socio-economic information
It aims to collect information on household conditions and their inhabitants, their socioeconomic level, income and access to different services.

Technological information
This section aims to gather information about the different types of energy and their use in the household. From question 40 onwards it looks to establish the conditions of the service in case the household has an energy system. Otherwise, these questions should be replied as NA (not applicable).

Environmental information
It aims to obtain information on possible impacts caused by energy equipment. It also looks for impacts in the surroundings caused by the use of different sources of energy used by the household.

Management, Planning and Policy
The section looks to obtain information on community's involvement and its relationship with the local and regional authorities regarding installation and maintenance of energy equipment.

2. Mark only one option
In all the questions only ONE option should be selected. The cases where there is a multiple option are marked with a [*] at the end of the question.

3. Answer all the questions
All questions from the survey must be answered, except questions 35, 36 and 37 where it clearly states that they must be answered only in case that fuel-wood or biomass is used.

4. Answering with a statement
Some questions and some options must be filled with a statement. For example, question 35 *Why do you use fuel-wood or biomass?* Or the common option of *Others, Which?* _____ should be answered in the space provided. In case the space is insufficient, the final part of the questionnaire *Comments* should be used making reference to the adequate question (i.e. Q35 for the *reasons of use fuel-wood or biomass*, or Q45 for the *type of energy used in tourism as a productive activity*).

5. Comments or additional/other information

Any information that cannot be registered under the existing questions but that you think is relevant for the RESURL's study, must be recorded in the section *Comments*, preferable noting the question that it refers to.

6. Clarifying specific questions
   a) Question 5
      The energy system based in "renewables" refers to the existence of any type of system even if it is not in use.
   b) Question 10
      The physical environment refers to the surveyed community/household surroundings.
   c) Questions 17 - 19
      It must indicate the **main** material in floors, walls and ceiling (roof).
   d) Questions 21 - 26
      This refers to information on the interviewee, in first place, and then, on other representative of head of the household.
   e) Question 27
      "Children" refers to under-age 16.
   f) Questions 35 - 37
      The term "biomass" refers to "other organic material with" used in the same way as fuel-wood. These questions must be answered only if the household uses fuel-wood or biomass.

Survey 1 Household Questionnaire: post-evaluation of renewable energy systems.

RESURL
DFID funded project
2001 - 2005 SURVEY 1

POST-EVALUATION QUESTIONNAIRE OF RURAL RENEWABLE ENERGY SYSTEMS

Review 05 14/08/2003

PRELIMINAR INFORMATION

P1. CODE: |____|____|____|____|____|
P2. DATE M/____/D/____/Y/_____/
P3. INTERVIEWER: _____
P4. GENDER OF INTERVIEWEE: 1. ___ Female 2. ___ Male
P5. RENEWABLE ENERGY SYSTEM:
1. ___ Solar 3. ___ Microhidroelectric 5. ___ None
2. ___ Biogas 4. ___ Wind
P6. IS THE SYSTEM IN USE AT PRESENT?
1. ___ Yes 2. ___ No 3. ___ NA

P7. COUNTRY: _____
P8. MUNICIPALITY: _____
P9. VILLAGE/COMMUNITY/SETTLEMENT: _____
P10. PHYSICAL ENVIRONMENT:
1. ___ High Mountain 5. ___ Coast
2. ___ Low mountain 6. ___ Sabanna
3. ___ Valley 7. ___ Other. Which? _____
4. ___ Rainforest
P11. OTHER CRITERIA: _____

A. SOCIO-ECONOMIC CHARACTERISTICS

P12. How long have you lived in this locality?
1. ___ Less than one year
2. ___ Between 1 and 3 years
3. ___ Between 3 and 6 years
4. ___ More than 6 years
5. ___ NK/NR

P13. Are you originally from this Municipality?
1. ___ Yes
2. ___ No
Where are you from? _____

P14. Your home is:
1. ___ Own
2. ___ Rented
3. ___ Other
Which?: _____

P15. Type of housing
1. ___ Cottage
2. ___ House
3. ___ Flat
4. ___ Other. Which?: _____

P16. How many rooms are there in this home?
1. ___ 4. ___
2. ___ 5. ___
3. ___ 6. ___ 6 or more

P17. The FLOOR is made of:
1. ___ Soil 3. ___ Finished
2. ___ Cement 4. ___ Others
Which?_____

P18. The WALLS are made of:
1. ___ No walls 4. ___ Brick/concrete
2. ___ Soil/clay 5. ___ Zinc plates
3. ___ Wood 6. ___ Other
Which? _____

P19. The ROOF is made of:
1. ___ Straw 5. ___ Zinc plates
2. ___ Slate 6. ___ Wood
3. ___ Clay Tile 7. ___ Other
4. ___ Eternit Which? _____

P20. How many adults live in this home?
1. ___ Betwen 1 and 3 adults
2. ___ Between 4 and 6 adults
3. ___ More than 7 adults

P21. Are you…	P22. Age	P23. Education level	P24. Employment/ profession	P25. Sector	P26. TOTAL Monthly income
1. Head of family	1. 13-18 years	1. None	1. Housewife	1. Rural	1. $50.000 or less
2. Spouse	2. 19-35 years	2. Elementary	2. Student	2. Industry	2. $50.001 - $100.000
3. Other	3. 36-54 years	3. Secondary	3. Self-employed	3. Commerce	3. $100.001 - $200.000
	4. Over 54	4. Higher	4. Employee	4. Government	4. $200.001 - $300.000
	5. NK/NR	5. NK/NR	5. Retired	5. Tourism	5. $300.001 - $400.000
			6. Unemployed	6. Other	6. More than $400.000
			7. NK/NR	7. NK/NR	7. NK/NR
1 2 3	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
1 2 3	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

P27. How many children are there in this home?
1.___ 0 3. ___ 4-6 children
2.___ 1-3 children 4.___ 7 or more children

P28. Do you have access to the following services?

1 Drinking water	1. ___ Yes	2. ___ No
2 Sewage system	1. ___ Yes	2. ___ No
3 Latrine / toilet	1. ___ Yes	2. ___ No
4 Medical service - Surgery	1. ___ Yes	2. ___ No
5 Education - 1ary, 2ary	1. ___ Yes	2. ___ No
6 Radio / TV / Press	1. ___ Yes	2. ___ No
7 Telephone	1. ___ Yes	2. ___ No
8 Waste collection	1. ___ Yes	2. ___ No

P29. Would you consider there are more job opportunities in other communities?
1. ___ Yes
2. ___ No (Go to P31)

P30. Why are there more job opportunities in other communities? [*]
1. ___ Better access
2. ___ Better land and irrigation conditions
3. ___ Better energy supply
4. ___ Better education level
5. ___ Other Which? _____

B. TECHNOLOGICAL CHARACTERISTICS

P31 - P34. Considering the boxes below indicate one or more options in the columns below

Type of energy	Box 1		Number of hours of use per day	Box 2	Reasons of use	Box 3	
1. Solar	6. Gas	11. Diesel	1. 0	5. 9 to 12 hours	1. Availability	4. Safety and cleanliness	
2. Biogas	7. Kerosene	12. National grid	2. Up to 3 hours	6. More than 12 hours	2. Habit or tradition	5. Saving time	
3. Microhidroelectric	8. Coal	13. None	3. 3 to 6 hours	7. Not applicable	3. Costs	6. Other	
4. Wind	9. Wood	14. Other	4. 6 to 9 hours			Which? _____	
5. Candles	10. Batteries	Which? _____					

You use energy for: activitiy/equipment	P31. Type of energy you use in each activity/equipment Box 1	P32. Number of hours of use per day Box 1 & 2	P33. Why do you use this type of energy? Box 1 & 3
1 Cooking	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
2 Lighting	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
3 Fridge	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
4 Heating	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
5 Radio	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
6 Television	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
7 Iron	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
8 Water pump	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
9 Traditional Mill	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
10 Battery recharger	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
11 Vehicle/bike	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
12 Ventilators/fans	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
13 Washing machine	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6
14 Other equipment	1 2 3 4 5 6 7 8 9 10 11 12 13 14	1 2 3 4 5 6 7	1 2 3 4 5 6

P34. Do you use wood/natural fuel?

1. ___ Yes 2. ___ No

Why? _____

P35. Who is in charge of collecting the wood?

1. ____ Mother
2. ____ Father
3. ____ Daughters
4. ____ Sons
5. ____ Other
6. ____ DN/NR
7. ____ NA

P36. How much time per week do you spend collecting it?

1. ___ <4 hours
2. ___ 5 a 10 hours
3. ___ >10 hours
4. ___ NK/NR
5. ___ NA

P37. How much money do you spend per month in energy?

1. Less than 500
2. 500 - 999
3. 1000 - 2999
4. 3000 - 4999
5. More than 5000
6. NS/NR
7. NA

1. Solar	1 2 3 4 5 6 7
2. Biogas	1 2 3 4 5 6 7
3. Microhidroelectr	1 2 3 4 5 6 7
4. Wind	1 2 3 4 5 6 7
5. Candles	1 2 3 4 5 6 7
6. Gas	1 2 3 4 5 6 7
7. Kerosene	1 2 3 4 5 6 7
8. Coal	1 2 3 4 5 6 7
9. Wood	1 2 3 4 5 6 7
10. Batteries	1 2 3 4 5 6 7
11. Diesel	1 2 3 4 5 6 7
12. National grid	1 2 3 4 5 6 7
13. Other	1 2 3 4 5 6 7

P38 - P39. For which activity do you use energy and which type of energy?

P38. Activity 1. Yes 2. No		P39. Type of energy used (Use the categories shown in Box 1)
1 Rural	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
2 Industry	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
3 Commerce	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
4 Government	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
5 Tourism	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
6 Agriculture	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
7 Handicraft	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
8 Other	1 2	1 2 3 4 5 6 7 8 9 10 11 12 13 14
9. None	1 2	13

P40. How long have you been connected to the grid/energy equipment?

1. ___ < 6 months
2. ___ 6 months - 1 year
3. ___ 1 - 3 years
4. ___ > 3 years
5. ___ NK/NR
6. ___ NA

P41. How satisifed are you with the energy equipment?

1. ___ Very satisfied
2. ___ Satisfied
3. ___ Unsatisfied
4. ___ Very unsatisfied
5. ___ NK/NR
6. ___ NA

P42. Who helped you to buy the equipment?

1. ___ Community
2. ___ Local authority
3. ___ Government
4. ___ NGO
5. ___ NK/NR
6. ___ NA

P43. Did you receive any technical training?

1. Yes, and was enough
2. Yes but was not enough
3. No, any kind
4. NK/NR
5. NA

1. Community	1 2 3 4 5	4. NGO	1 2 3 4 5
2. Local authority	1 2 3 4 5	5. Other	1 2 3 4 5
3. Government	1 2 3 4 5	Which? _____	

P44. Which technical problems do you have with the energy equipment?

1. ____ Battery
2. ____ Turbines
3. ____ Shutdowns
4. ____ Few hours
5. ____ Operators
6. ____ Technical cost
7. ____ Lack of knowledge
8. ____ Lack of local technicians
9. ____ Outside technicians don't come
10. ____ Management
11. ____ Other. Which? _____
12. ____ NA

P45. The existing equipment need:

1. __ Specialized technical assistance
2. __ Investment
3. __ To improve the operation
4. __ Change
5. __ NK/NR
6. __ NA

P46. How frequent are power cuts in the area? 1'

1. ___ Daily
2. ___ Weekly
3. ___ Monthly
4. ___ Rare
5. ___ Doesn't work
6. ___ NK/NR
7. ___ NA

P47. Are the electrical problems affecting the family activities?

1. ____ A lot
2. ____ Some
3. ____ No
4. ____ NK/NR
5. ____ NA

P48. You consider that the tariff in your area is...

1. ___ Very good
2. ___ Good
3. ___ Regular
4. ___ Acceptable
5. ___ Bad
6. ___ Very bad
7. ___ NK/NR
8. ___ NA

P49. How much per month would you agree to pay in order to improve the service?

1. ____ < 10%
2. ____ 10% - 20%
3. ____ > 20%
4. ____ Nothing
5. ____ NK/NR
6. ____ NA

P50.Do you experience financial difficulties to pay for the service?

1. Many
2. Few
3. None
4. NK/NR
5. NA

1. Adquiring equipment	1 2 3 4 5
2. Maintenance	1 2 3 4 5
3. Consumption fee	1 2 3 4 5
4. Fuel	1 2 3 4 5
5. Property fee	1 2 3 4 5
6. Loan payment	1 2 3 4 5

Who helps to the maintenance of the equipment?

1 ____ Local, regional or national authority/government
2 ____ Supplier agency
3 ____ Financial agency
4 ____ The owners
5 ____ Nobody
6 ____ Other. Who? _____
7 ____ NK/NR
8 _____ N/A

P52. What is necessary for an energy project to be succesful?

1 ____ Low cost
2 ____ Easy to install
3 ____ Easy maintenance
4 ____ Users survey
5 ____ Participation of users in management
6 ____ Technical support
7 ____ Other. Which? _____
8 ____ NK/NR
9 ____ N/A

P53. How succesful is your energy system?

1 ____ Very succesful
2 ____ Moderate
3 ____ Not very succesful
4 ____ Complete failure
5 ____ NK/NR
6 ____ N/A

Why? _____

P54. Does the system you installed respond to your needs?

1. ____ Yes
2. ____ No
3. ____ NK/NR

Why _____

C. ENVIRONMENTAL CHARACTERISTICS

P55. Is there or has been damage to the environment when the equipment...

1. Considerable damage
2. Slight damage
3. No damage
4. NK/NR
5. NA

1. …was delivered	1 2 3 4 5	3. …operates	1 2 3 4 5	5. … was uninstalled	1 2 3 4 5
2. …was installed	1 2 3 4 5	4. …receives maintenance	1 2 3 4 5	6. N/A	1

P56. Which impacts have affected the environment due to the energy system used?

1. Positive
2. No changes
3. Negative
4. N/A
5. NK/NR

Systems	Environmental Impact							
	01 Air	02 Water	03 Soil	04 Animals	05 Vegetation	06 Health	07 Landscape	08 Other
1. Solar	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
2. Biogas	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
3. Microhidroelectric	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
4. Wind	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
5. Candles	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
6. Gas	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
7. Kerosene	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
8. Coal	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
9. Wood	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
10. Batteries	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
11. Diesel	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
12. National grid	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
14. Other	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

P57. Have the impacts on the environment affected you?

1. ___ A lot
2. ___ Few
3. ___ Nothing
4. ___ NK/NR
5. ___ NA

P58. How was the surrounding environment before, and how is it now?

_____

_____

D. PLANNING AND POLICY MANAGEMENT

P59. Have you asked your local authorities to change or improve the energy system?

1. ____ Yes
2. ____ No (Go to P61)
3. ____ NK/NR

P60. Did you receive a reply?

1. ____ Yes
2. ____ No
3. ____ NK/NR

P61. Did you participate in energy decision processes in your community?

1. ____ Yes
2. ____ No (Go to P62)
3. ____ NK/NR

P62. What was your role in the participation process?

1 ____ As authority
2 ____ As representative of an organisation
3 ____ As a consumer
4 ____ Other
Which? _____
5 ____ NK/NR

P63. Do women participate in the decision process regarding energy systems?

1. ____ Yes
2. ____ No
3. ____ NK/NR

P64. Do you think is important the women participation when chosing an energy system?

1. ____ Yes
2. ____ No

Why? _____

P65. Why was decided to have electricity in your community?

_____

_____

P66. Do you think the following factors would improve the energy service?

1____ Government participation
2 ____ More financial aid
3 ____ More participation of local groups
4 ____ More training and education
5 ____ New laws
6 ____ Other
Which? _____
7 ____ NK/NR

THANK YOU VERY MUCH FOR YOUR HELP AND PATIENCE!!!
TO BE FILLED BY THE INTERVIEWER
COMMENTS:
INTERVIEWEE ATTITUDE:

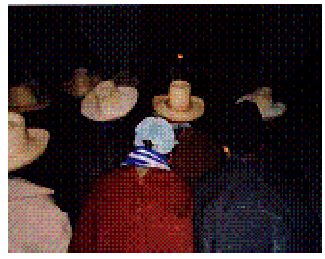
Photographic documentation

1

2

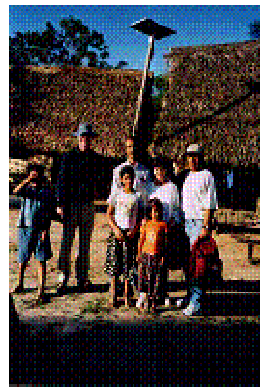
3

4



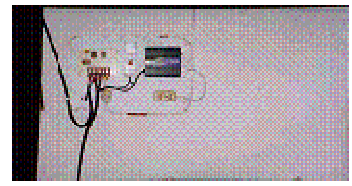
5

6



7

8



9

1. Handicraft making in San Francisco, Peru; 2.Electricity distribution of a microhydro plant in Marantiales, Cuba; 3. Hut without electricity in the rain forest in Ucayai, Peru; 4. Solar panels in individual households in San Francisco, Peru; 5. Public meeting with use of kerosene lamps in Ahijadero, Peruvian Andes; 6. Site of a previous diesel plant. Newa microhydro plant in Marantiales, Cuba; 7. Solar panel and team in San Francisco, Peru; 8. Solar panel on a school's roof in Marantiales, Cuba; 9. Solar panel installation in a hut in Roca Fuerte, Peru.

Examples of transcripts of interviews in Peru.

LOCAL GOVERNMENT OF PUCALLPA, PERU.
Interviewee: Dr. Samuel Cancaya, Director of the General Directorate of Mines, Ministry of Mines and Energy.
Date: 17th of June 2002

- The main problems we have here are related to energy, communications and technology.
- Roads are difficult to construct due to soil humidity and because it would not be possible to use them for at least 8 to 9 months a year.
- With respect to energy, we have especial geographical characteristics besides the isolation of the department of Ucayali
- Our population feels abandoned due to all these problems
- We have forests but wood gets no competitive prices in Pucallpa. This is the reason why we are planning to get a finished product to give it an added value and make it profitable.
- When we talk about development we refer to the main areas where we have problems. We need energy to fuel engines and this will not be possible with solar panels.
- We are having meetings with frontier development committees.
- We received a donation from the government of Canada of $150 million Can dollars which will be used for electrification.

Electrification management

- Due to the difficult conditions of the towns we have considered the use of alternative technologies such as solar energy through solar panels, but this is not efficient because of the constant cloudy conditions. Although it is the only available alternative and only energy resource to have electricity in the houses.
- The electricity operation groups in the area are condemned to disappear because of the distance to our towns makes the use of fuels more expensive, and the humidity damages the machinery.
- It is not possible to use wind energy because there is no wind force in the area.
- We are waiting for the installation of a satellite dish to develop the project *Guascaran Peak* so we can ourselves plan the use of solar panels.
- Some panels have already been installed. They are 474 each one of 50 KW power. This has been enough for house lighting through the use of batteries. It also allows the use of a small radiotelephone and some pump systems.
- We are thinking of handing the supervision of these systems to local governments.
- The main cause of malfunction of these solar panels is the inappropriate use and maintenance of the batteries. Therefore, it is a human problem and not a technology problem.

Ecological issues

- The consideration given to using solar panels is not ecological. It is because of the high cost of oil due to he isolation and remote location of the communities. As they cause no modifications to the ecosystems, they are the most viable option.
- The cutting of trees in the forest for fuel wood has reduced considerably. Now we collect wood that has been carried in the river or gets stuck in the banks.
- The trees are cut just for the wood industry and only with the adequate permits.
- For the oil extraction, the company carried out important work in social awareness as well as in actions to prevent environmental impacts.
- There is an agreement between REPSOL and the government to promote tourism in the area.

We have no power to supervise the actions of these companies. This is done by OSINER.

INTERVIEW IN SAN FRANCISCO COMMUNITY, Amazon Rainforest, PERU.
Don Jorge, Energy Committee Leader
Date: 18th of June 2002

- The panels system was installed in 1992.
- We received a visit from MEM and CTAR of Ucayali and they told us there were 32 panels for San Francisco. Each person had to pay 100 soles. Those who were interested (us) met to make 5 mts poles and committed to pay and to install the poles. We set up an electrification committee.
- We signed an agreement with CTAR and MEM. It establishes that when the grid gets to San Martin, the panels will be sent to another place. In addition to the 32 panels we had to pay 12 thousand soles. We complied with everything and paid 320 soles per month for over a year.
- We opened a bank account and made monthly deposits of 10 soles for each user.
- As it worked properly, more people wanted to join and then we asked for a wider service which was approved with 32 extra panels with the condition that the committee should be changed into a firm. We also needed to buy 20 panels with self-funding. We made all the arrangements and now we are a firm. We began asking for the 100 soles of each user and we needed extra funds to make a one-off payment as required. Thus, we asked the *Sudamerican* Bank for credit and withdrew the money from the other bank (continental). Mr. Enrique the provider of the service and also our warrantee. Then the panels were installed but they began to fail.
- 90 % of the panels were not working and their control system burnt out. People from the MEM said the panels were bad; those from SOLAREX said it was a problem with the installation. So we have been under these conditions for over two years now. We had arranged for another credit and we had to stop it but we did buy the other 20 panels in cash. These 20 panels were also installed but defective were as well.
- Those who were paying punctually wanted their money back.
- We changed wires and connections but after a while the batteries also failed.
- The first 32 panels worked well. We don't know the brand. But when these users (who used to pay on time) saw the others were not paying then they also refused to pay. Since 1999 there has been any payment. The batteries are pretty damaged after 5 years.
- As we were a firm we had an accountant and as everything had to be cancelled in 2000, the firm only lasted for two years.
- The firm revenue was of 300 - 320 soles per month.

Economic activities

- Handicraft is the main means of livelihood. It is mainly for tourists and is a well known international unit.
- We have a contract for a month of 1000 soles per person. There are ten of us and the handicraft is made for a firm called PARA. The crafts are destined for the United States.
- We also organise craft fairs and as there are many tourists we sell there.
- Agriculture is normally for self-consumption with surplus sold at the market.
- We also have fishing activities and fish are sold for good prices, depending on the type of fish. Part of it is also for self-consumption.
- Commercial activity is also important in our community

Education

- We have bilingual education at primary school.
- Our school and teachers are also bilingual.
- We have a technical college in primary productive activities. Some teachers there are bilingual.
- In San Francisco the beginning of the term is normal as there is no flooding, but when there is flooding, then classes begin in May or June.
- We have 225 to 300 "comuneros" (communal landowners) of whom only 150, aged between 18 - 50, are able to work.
- We have 300 children of whom 200 are students.

Women's participation

- Women do not participate in communal tasks. They are organised in the mother's club, and at the women's club. They have sewing workshops, handicraft and in that way they are organised to work.

Services

- We have a drinking water system but we don't have the pump system.
- There is a German firm which has a botanical garden. They have funded the community with 7000 USD. We wanted to use this money to buy a bigger motor for the water pump but then we will have a bigger problem buying the oil for it. That is the reason we were thinking of solar panels. We need an initial investment of 400 USD and we want to use rest of the money to expand the net. We now have 34 "piletas" but we want to expand them.

ANNEX III
The methodological Package for energy Infrastructure Development in Rural Areas

Survey 2: Household Questionnaire

RESURL
DFID funded project
2001 - 2005

SURVEY- RURAL ENERGY DECISION-MAKING

Review 05 14/08/2003

PRELIMINARY INFORMATION

P1. CODE: |____|____|____|____|____|
P2. DATE M/____/D/____/Y/_____/
P3. INTERVIEWER: _____
P4. INTERVIEWEE GENDER: 1. ___ Female 2. ___ Male
P5. AVAILABLE SERVICES (i.e. drinking water, sewage, etc.):
P6. LOCALITY:

P7. COUNTRY: _____
P8. PROVINCE: _____
P9. COMMUNITY: _____
P10. PHYSICAL ENVIRONMENT:
1. ___ High mountain 5. ___ Coast
2. ___ Low mountain 6. ___ Savanna
3. ___ Valley 7. ___ Other. Which? _____
4. ___ Rainforest
P11. OTHER CRITERIA: _____

A. TECHNOLOGY

P12.Why do you need energy?

1. Education 5. Radio/TV/Video 9. Handicraft
2. Lighting 6. Cooking 10. Industrial activities
3. Health 7. Heating system 11. Farming and livestock
4. Radio/Comunication 8. Agriculture 98. NK/NR
99. NK

P13. What type of energy do you use in the following activities? (select some sources)

Activity	Energy sources: 1, Firewood 2, Animal 3, Kerosene 4, Candles 5, Petrol 6, Batteries 7, Gas 8, Diesel 9, Other 98. NK/NR 99. NA
Cooking	1 2 3 4 5 6 7 8 9 98 99
Drinking water pump	1 2 3 4 5 6 7 8 9 98 99
Lighting	1 2 3 4 5 6 7 8 9 98 99
Heating	1 2 3 4 5 6 7 8 9 98 99
Transport	1 2 3 4 5 6 7 8 9 98 99
Agriculture	1 2 3 4 5 6 7 8 9 98 99
Handicrafts	1 2 3 4 5 6 7 8 9 98 99
Industriales Activities	1 2 3 4 5 6 7 8 9 98 99
Farming and livestock	1 2 3 4 5 6 7 8 9 98 99
Telephone/ Communication	1 2 3 4 5 6 7 8 9 98 99
Radio/TeleviYeson	1 2 3 4 5 6 7 8 9 98 99
Other activities	1 2 3 4 5 6 7 8 9 98 99

P14. Do you know any renewable energy?

1. Yes ( ) 98. NK/NR
2. No ( ) 99. NA
Which type ? _ _ _ _ _ _ _
_ _

P15. Do you use firewood?

1. Yes ( )
2. No ( )
98. NK/NR
99. NA

P16. Who collects the wood?

1.Mother 2. Children
3. Father 4. Daughters
5. Other
98. NK/NR
99. NA

P17. How many days per week do you go out to collect wood?
_ _ _ _ _ _ _ _ _ _ _ _

P18. How many hours?

1. Less 1 hour
2. From 1 to 3 hours
3. More than 3 hours
98. NK/NR 99. NA

P19. How much do you spend weekly for energy use? (In local currency)

Source	Expenditure	Notes/comments
1. Firewood		
2. Candleselas		
3. Gas		
4. Animal		
5. Petrol		
6. Diesel		
7. Kerosene		
8. Bateries		
9. Other		
98. NK/NR		
99. NA		
88. Total		

P20, How satisfied are you with the energy sources you use?

1. Very satisfied 4. Very unsatisfied
2. Satisfied 5. Not satisfied/ not fully satisfied
3. Unsatisfied 6. Other 98. NK/NR 99. NA

P21. Which one of the following activities that require energy are more important for you? Select in importance order with 1 as the most important. Not all option need to be assigned a number. Level of importance might repeat for several activities. 98. NK/NR 99. NA

Activity	
Cooking	1 2 3 4 5 6 7 8 9 98 99
Drinking water pump	1 2 3 4 5 6 7 8 9 98 99
Lighting	1 2 3 4 5 6 7 8 9 98 99
Heating	1 2 3 4 5 6 7 8 9 98 99
Transport	1 2 3 4 5 6 7 8 9 98 99
Agriculture	1 2 3 4 5 6 7 8 9 98 99
Handicrafts	1 2 3 4 5 6 7 8 9 98 99
Industriales Activities	1 2 3 4 5 6 7 8 9 98 99
Farming and livestock	1 2 3 4 5 6 7 8 9 98 99
Telephone/ Communication	1 2 3 4 5 6 7 8 9 98 99
Radio/TeleviYeson	1 2 3 4 5 6 7 8 9 98 99
Other activities	1 2 3 4 5 6 7 8 9 98 99

P22. Which one of the following services is more important in your community? Select in importance order with 1 as the mort important. Not all option need to be assigned a number.

1. Drinking water 2. Sewage system 3. Health service
4. Energy (electricity) 5. Education centres 98. NK/NR 99. NA

P23. How satisfy are you and your family with the present water supply?

1. Very satisfied 2. Satisfied 3. Unsatisfied
4. Very unsatisfied 98. NK/NR 99. NA

P24. How satisfied are you with your income to cover for food for your family?

1. Very satisfied 2. Satisfied 3. Unsatisfied
4. Vey unsatisfied 98. NK/NR 99. NA

P25. How satisfied are you and your family with the health system?

1. Very satisfied 2. Satisfied 3. Unsatisfied
4. Vey unsatisfied 98. NK/NR 99. NA

P26. How satisfied are you and your family with the energy service?

1. Very satisfied 2. Satisfied 3. Unsatisfied
4. Vey unsatisfied 98. NK/NR 99. NA

P27. Have you ver considered to leave the community?

1. Yes (go to P31) 2. No (go to P32) 98. NK/NR 99. NA

P28. Would you remain in the community if you had energy service?

1. Yes 2. No 98. NK/NR 99. NA

B. LOCAL ENVIRONMENT

P29. What is your opinion about using of the following resources to produce energy? (refer to natural resources in the area)

1. The river :
2. The forest :
3. The lake :
4. The waterfall :
5. The soil :
6. The mountains :
7. Other special element :

98. NK/NR
99. NA

P30. Would you still use firewood if you had kerosene or gas?

1. Yes 2. No 98. NK/NR 99. NA

P31. What would you use the wood for?

1. Heating 2. Open air burner (fire, oven, ceramics)
3. Other 98. NK/NR 99. NA

P32. What, if any, changes to nature do you observe in your area? (i.e., more rain, more tress, less soil fertility, etc.)

P33. Has the health of any member of your family been affected by the use of fuels?

1. Yes Type of illness
2. No
98. NK/NR 99. NA

C. SOCIO - ECONOMIC CHARACTERISTICS

P34. How long have you lived in this place?

P35. Which is your position in the family?

1. Head of family 3. Father/Mother 5. Other 99. NA
2. Husband/wife 4. Son/daughter 98. NK/NR

P36. How old are you?

P37. How many people live in this household?

P38. Have you gone to any of the following schools?

1. None 3. Secundary 5. Other 99. NA
2. Primary 4. Graduate 98. NK/NR

P39. Who owns your house?

1. Private 3. Family 98. NK/NR
2. Leased 4. Other 99. NA

P40. How many rooms are there in the household?

P41. The floor is made of (observe and note down, avoid the question)

1. Soil 2. Cement 3. Finished 4. Other
98. NK/NR 99. NA

P42. The walls are made of … (observe and note down, avoid the question)

1. Soil 2. Wood 3. Brick/concrete
4. Zinc plates 5. Other 98. NK/NR 99. NA

P43. The roof is made of … (observe and write down, avoid to make the question)

1. Straw 4. Eternit 7. Prefabricated 99. NA
2. Slate 5. Zinc plates/calamine 8. Other
3. Clay tile 6. Wood 98. NK/NR

P44,. What activities better contribute to the family income?

1. Agriculture 4. Commercial 7. Mining 98. NK/NR
2. Livestock 5. Government 8. Fishing 99. NA
3. Industrial 6. Toursim 9. Other

P45,. Is private or leased the land used for rural activities?

1. Private 2. Leased 98. NK/NR 99. NA

P46. What do you do with your rural products?

1. Sold in local community 3. Self consumption 98. NK/NR
2. Sold out of community 4. Other 99. NA

P47. What is the size of your agricultural plot? (Local unit)

1) 1-3 2) 4-6 3) 6-9 98. NK/NR 99. NA

P48. Do you have animals?

1. Yes 2. No 98. NK/NR 99. NA

P49. How many do you have of the following?

1, Cattle 4. Sheep 7. Other
2. Pigs 5. Birds 98. NK/NR
3. Horses 6. Bees (honeycombs) 99. NA

P50. Do you use the animals for commercial purpose?

1. Cattle 1. Yes 2. No 6. Bee 1, Yes 2, No
2. Pigs 1. Yes 2. No 7. Others 1, Yes 2, No
3. Horses 1. Yes 2. No 98. NK/NR
4. Sheep 1. Yes 2. No 99. NA
5. Birds 1. Yes 2. No

P51. What is the total monthly income of the household? (national currency) (It can be weekly, specify)

	Ammount
Agriculture income	
Cattle income	
Labour force income	
Other economical activities income	
Other (specify):	
Total	

1. Less than S/. 100 4. S/, 400 to S/, 799 99. NA
2. S/, 100 to S/, 199 5. More than S/, 800
3. S/, 200 to S/, 399 98. NK/NR

P52. To which of the following financial resources do you have access?

1. Loans 4. Banks 7. Natillera 98. NK/NR
2. Savings 5. Family 8. Other 99. NA
3. Cooperatives 6. Pawnshop 9. None

P53. Do you have access to loans for energy supply?

1. Yes 2. No 98. NK/NR 99. NA

P54. What is the maximum price you can afford to have energy supply?

P55. What is the maximum price you can afford to cover the monthly tariff of energy supply?

P56. Have you received any loan in the last 12 months? What for?

1. Yes 99. NA
2. No
98. NK/NR

D. COMMUNITY ORGANISATION

P57. Does your community have any of the following natural resources?

Source	Availability 1. Abundant 2. Sufficient 3. Rare 4. None 5. Other 98. NK/NR 99. NA
Wood	
Water	
Hours of sun exposure	
Wind	
Agricultural waste	
Other crops (specify)	
Waterfalls	
Other	

P58. Do you have access to the following services?

1. Drinking water
2. Aqueduct
3. Sewage system
4. Health system
5. Education
6. Air transport
7. Water transport
8. Land transport
98. NK/NR
99. NA

P59. Are there trainned people to repair equipment in the community?

1. Yes 2. No 98. NK/NR 99. NA

P60. Are there communal activities?

1. Yes 2. No 98. NK/NR 99. NA

P61. Which of the following activities are performed jointly in the community?

1. Collection of water
2. Cultivate land
3. Cropping
4,. Equipment installation
5. Construction of households/ or roads
6. Other
98. NK/NR
99. NA

P62. Are there people in the community with managerial skills to manage energy services?

1. Yes 2. No 98. NK/NR 99. NA

P63. Do you or any leader in the community participate in meetings about energy?

1. Yes 2. No 98. NK/NR 99. NA

P64. Has the community organised for planning and perform any communal project? (i.e. construction of a road, construction of a hospital, telecommunications). ,

1. Yes 2. No 98. NK/NR 99. NA

P65. Which communal projects have been organised and what have been the results? (success / failure)

_____
_____
_____
_____
_____

P66. Have you ever asked the authorities to supply energy systems?

1. Yes 2. No 98. NK/NR 99. NA

P67. Did your get a reply?

1. Yes 2. No 98. NK/NR 99. NA

P68. What are the factors that obstruct the instalation of an energy system in your community?

1. Lack of fund/financial resources
2. Lack of training
3. Lack of natural resources to generate energy
4. Lack of support from local authorities
5. Other
98. NK/NR
99. NA

P69. Do women participate in community decisions?

1. Yes 2. No 98. NK/NR 99. NA

P70. Do you think that women participation in communitary decisions is important?

1. Yes 2. No 98. NK/NR 99. NA

P71. What is your opinion about the safety conditions in this community?

1. Good
2. Acceptable
3. Bad
98. NK/NR
99. NA

SURVEY METHODOLOGY of *SURE*

The aim of the survey was to gather first-hand information from the population that might be direct beneficiaries as well as from other local stakeholders. As in the previous study, we undertook structured in all three countries, and also semi-structured interviews in Cuba and Peru. This was a smaller scale study than MAP-RESURL. It aimed to know local conditions of specific communities. The information was gathered in order to test the designed decision-making computer model.

Two types of criteria, primary and secondary, were
used to decide upon the selection of the case studies in Cuba, Colombia and Perú.

i. Household Survey

Structured Questionnaire

I. Primary criteria

The case studies were selected within the overall rural population of each country. As a primary condition it was considered that the case study area is under **poverty** conditions, it was located **far from** main roads and urban centres, with difficult access, and had **no source of modern or renewable energy** technology, or these were defective, insufficient, too expensive, and the population relied heavily on traditional biomass.

II. Country specific secondary criteria

- As in MAP-RESURL, secondary criteria consisted of a set of categories that would normally correspond to geographical divides in a country. The divides are very likely to be the result of the country's macro social and physical conditions. It must be stressed that the application of secondary criteria for selecting communities in each country was made with the purpose to gather information for testing the programme.
- The secondary criteria applied by all the national teams was **geographic**. Each national team defined at least two different parts of the country with different physical characteristics to survey.
-

<u>The subject-areas of study</u>

- The household questionnaire, and also the questions addressed to stakeholders, draws on dimensions of the 'sustainable livelihoods approach' (SLA). It describes a rural population as having five types of assets, or capitals. The questionnaire thus gathers information on each of these five aspects of the community (i.e., financial, physical, social, natural and human). In addition, it looks at a community's energy priorities.
-

The population sample

The population sample was considered to be representative of the community visited.

One hundred (100) households were selected in each Cuba and Peru; 240 households were surveyed in Colombia. The size of surveyed population in each community varied. The survey was applied to at least 50% of the population.

ii. Semi-structured interviews

These were carried out to representative of local institutions, community leaders and regional policy-makers. The questions surrounded electricity installations, relation to central government, and particular conditions in the specific community. This was a qualitative investigation

Energy provision to enhance a community's sustainability – A draft application of *SURE* – The case of San José de Cravo North, Colombia

This section briefly explains the application of the *SURE* model and methodological package and summarises some of the findings relating to one remote community of San José de Cravo North. Colombia. According to DANE (2002), there are 7050 inhabitants in San José de Cravo North. In November 2003, a Colombian team of specialists applied the Survey to 101 households (RESURL, 2004) and their local leaders with the objective to obtain primary information to provide participatory inputs to the model. It identified the main characteristics of the population, current energy demands and how they would use additional power.

The aim of the application was to define, evaluate and select a group of different energy technology alternatives to be implemented in this rural community. The model operates in two main phases. It produced the community's characterization, using analysed data from the participatory household survey; and then the model related to the selection of a set of energy technology alternatives to be implemented in the community.

SURE is an interactive system. Figure 3.1 shows the design of the computer window (see Annex III).

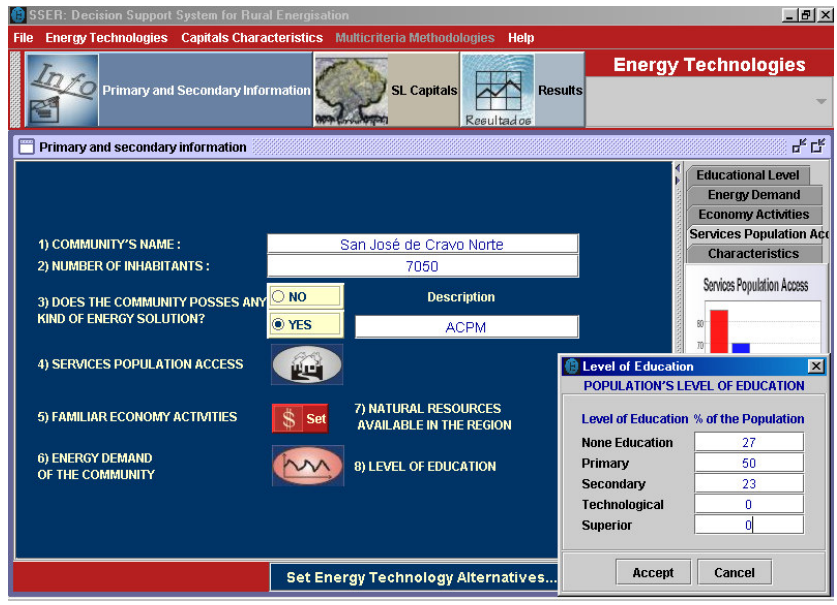


Figure 3.1. Entering community's information in *SURE*, RESURL, 2004

The findings on San José de Cravo North

Once all the information was entered, the system crosses it and, following heuristic rules, it identified the following aspects of the community.

- The population of San José de Cravo North required an energy technology solution that would supply energy-time 24 hours a day due to the current health clinic (refrigeration of vaccination) and communication centre electricity requirements.
- Also, the energy system design should enable the community to increase the current daily access to electricity for pumping water to at least 16 hours, as well as incrementing the number of inhabitants that require that service (al least 80% of the population that require pumping water service).
- Due to the weather conditions in the region, refrigeration and ventilation in people's homes is an important health issue. In addition, energy for lighting the houses, a TV and a radio, (at the same time) emerges as another requirement. Given that the needs are very similar in every surveyed household, it would make sense to provide a common energy solution.
- Agriculture and livestock are the two main economy activities in the region. Any energy design should contribute to enhance the conditions of production in those sectors, for example, through the drying of grains, or through the improvement to the current cooling chain in the livestock production sector.
- There are abundant water and solar resources in the region. Natural resources available in the region together with the population's daily habits lead to conclude that wood would still be used in José de Cravo North – in particular for cooking food outdoors. This would be recommended by the model but only if it was under supervision in order not to over-extract this resource.
- Finally, energy technology solutions such as Diesel, ACPM, Gas and interconnection to the national grid, are not considered for sole implementation in San José de Cravo North due to the condition of its roads and long distance between the village and the nearest main cities, including the capital of Arauca. However, since the community already has a ACPM (Diesel) generator that supplies 8 per cent of the population, it might be sensible to combine it with a non-conventional technology. A complement solution would most certainly be based on a renewable natural resource rather than increasing dependence on fossil fuel and transportation across the community's road system. This would work to expand the existent Diesel generator.

It must be stressed that the criteria proposed by UPME Colombia (2000) says that any energy solution provided to rural communities that have more than 500 inhabitants (i.e., San José de Cravo North) must supply electricity that is of the same quality as that obtained from the national grid and must equal to that provided to the country's main cities. This means that a supply of 24 hours of stable service and with a coverage percentage of the population near to 100 % would be expected from any energy system that the model would simulate and finally offer as a best option.

Evaluation of Sustainable Livelihoods Indicators

A most innovative aspect of *SURE* application was to evaluate each energy technology alternative against new indicators designed for the five community's capitals, i.e., natural, physical, human, social and financial (UPME, 1999; 2000; RESURL Energy/Technology Matrix). The model then produced an Indicator Matrix that indicated the extent of change to the community's capitals when exposed to the energy system alternatives.

Figure 3.2 shows the distortion produced to each of the overall baseline (a pentagon) following the application of the values obtained in the Indicator Matrix. That is,

$IC = IC_0 \pm \delta E$

where,

IC is the capital indicator

- IC_0*: Initial value of Capital indicator*
- δE*: effect of solution on capital*

The external pentagon represents an ideal community pentagon where all the assets are fully and equally developed. The internal pentagons are however more real and simulates the impact of energy alternatives on each one of the capitals in the case of San José de Cravo North baseline pentagon.

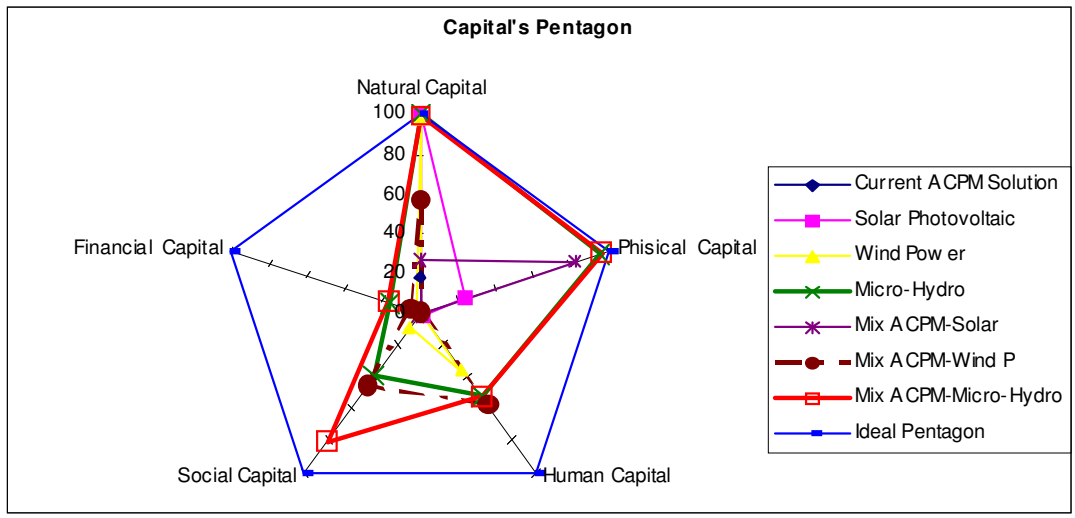


Figure 3.2. A simulation of the effect of suggested energy solutions on San José de Cravo North's overall assets, RESURL, 2004

Figure 3.3 shows how different energy solutions may enhance each of the five capitals in relation to the effects of the current diesel generator (100%), which is represented by in San José de Cravo North. Two alternatives emerged as the most suitable for improving the overall energy problem San José de Cravo North: a hybrid combination of diesel generator and a micro-hydro plant, or a micro-hydro plant alone. Should the combination option be adopted, natural, physical and social capitals would benefit the most.

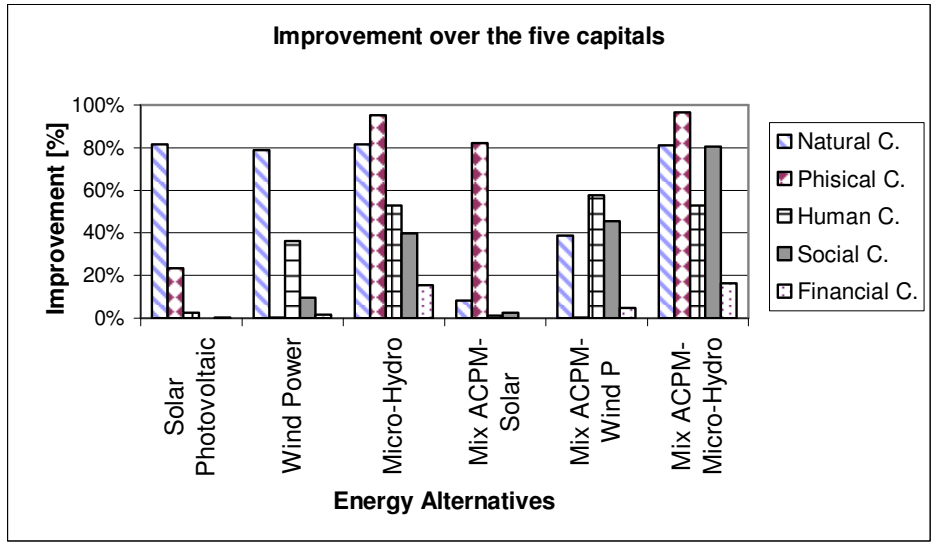


Figure 3.3 Changes to each of San José de Cravo North's assets following different energy system options, RESURL, 2004

Energy Options for San José de Cravo North

Using the multi-criteria Compromise Programming method (with metric two for decision-making and weights), helped us to rank the possible power designs that would enable San José de Cravo North to achieve the required changes and to fulfil its demands, as per the participatory survey above.

The application of the model suggested that the most robust energy alternative for the community is the combination of diesel generation and a local micro-hydro plant. A further finding obtained through the application of the project's *SURE* model was that the current diesel generator as it stands is the less recommended solution in all weighted sets. This finding suggests that the energy system as it is now should be discontinued, although the best solution would be to avoid to get rid of it and instead to complement the electricity supplied by the generator with another type of technology, i.e., from a Micro-Hydro plant in this case.

The results that emerged from the application of *SURE i*n San José de Cravo North are enlightening. The model demonstrated that the best energy alternative for the community is a hybrid that combines the current energy system ***ACPM,*** which is about 440 KW, and a new 500 KW ***Micro-Hydro*** plant. This solution would serve the population for at least 28 years and we calculated that the combined option would supply electricity to around 90 to 100% of the population while it is anticipated that the quality of the service would be similar to that farmers would receives should they were connected to the national grid.

Finally, the model expresses the dynamic character of the pentagon as indicated in Chapter 2 by modelling the effects on the community's capitals of the two best energy alternatives (Hybrid ACPM-Micro-Hydro and Micro-Hydro) within the ideal pentagon. Figures 3.4 and 3.5 show bigger and more symmetrical areas produced by the energy solution than the pentagons shown above. The shapes produced by the model indicate how San José de Cravo North total assets would be affected by the selected energy system. The trade-offs are indicated along the lines that join each capital to the next.

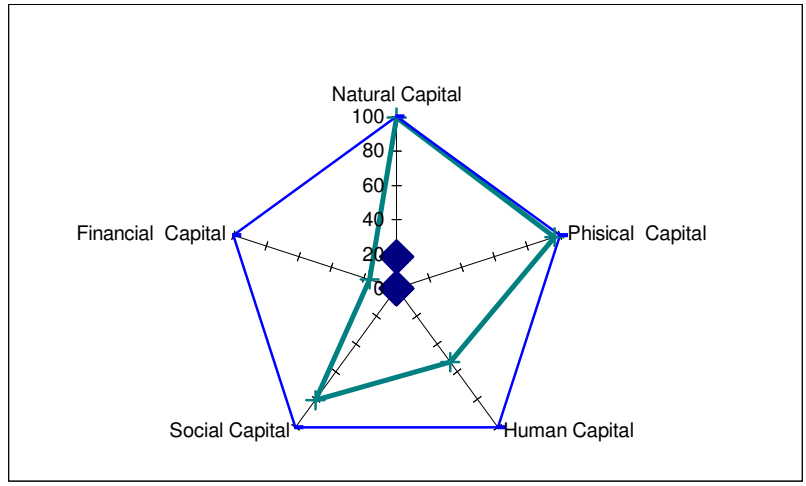


Figure 3.4 New pentagon that a combined option between the current diesel generator and hybrid of diesel generation and a micro-hydro plant would create for San José de Cravo North, RESURL, 2004

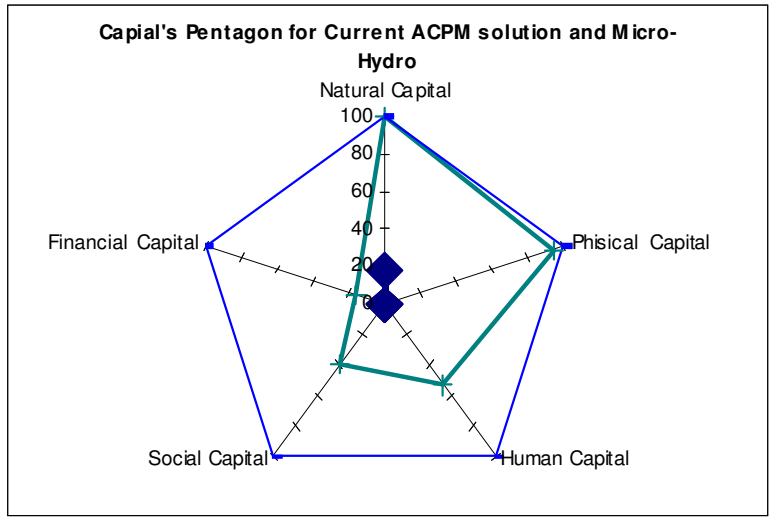


Figure 3.5 New pentagon created by combining current diesel generator and a new micro-hydro plant for San José de Cravo North, RESURL, 2004.

Concluding remarks

The problem that the model approached was to formulate and select an energy design supply system that would best fit San José de Cravo North's energy demands and priorities while guaranteeing high performance in the long term.

In this framework, the model simplified the task of evaluating the different energy options that would best suit the community while maximising its capitals and thereby contributing to poverty reduction in the particular community of San José de Cravo North. The novelty in the model is that in addition to having constructed useful technical indicators to make the energy choices, the project succeeded in incorporating community's information in order to solve the energy problem. The programme can make recommendations through heuristic rules

that promise to be sustainable and well received by the community. The model has the advantage of scientifically evaluating purely technical considerations of designs of both off-grid and grid-connected energy schemes while also incorporating *within the model* the community's assets, demands and priorities.

References

UPME – Ministry of Mines and Energy. Energy Mining Planning Unit (1999). *Línea base geo-referenciada para la formulación del plan de suministro de energía para las zonas no interconectadas de Colombia*. Methodology

UPME - Ministerio de Minas y Energía Unidad de Planeamiento Minero Energético. (2000). Establecimiento de un plan estructural, institucional y financiero, que permita el abastecimiento energético de las zonas no interconectadas, con la participación de las comunidades y el sector privado. Ministerio de Hacienda, DNP, UPME, CREG, PNUD.

RESURL. Energy Matrix. Proyecto RESURL, 2003-2004.

RESURL. "III International RESURL Workshop' – Document presented by the Colombian team, February 2004.

ANNEX IV
International Expressions of Support and Contact Details

International Expressions of Support

1.

-----Original Message-----
From: Charles Mnyanjagha [mailto:cmnyanjagha@yahoo.com]
Sent: 02 January 2004 13:32
To: gill.wilkins@aeat.co.uk
Cc: tom.slesenger@aeat.co.uk; Cherni, Judith A
Subject: COMMENTS ON THE NOVEMBER2004 DFID ENERGY NEWSLETTER

Dear Sir,

Thank you for sending me the November 2004 news letter.

I am working as an assistant engineer (planning) with ESCOM LTD the only electricity utility in Malawi. I am very much interested in energy projects and would like to comment on the following:

(a) Impact of modern energy on micro enterprise

The aim and the purpose of the project are supported. It is true that not all the energy initiatives have had a positive impact. In Malawi for example, there are people in the rural areas who are using solar panels manly for lighting. Many can not afford buying solar equipment which can power refrigeration and heating for commercial purposes. Rural electrification from the grid is not a possibility because of capacity constraints and in fact this can compromise reliability of supply.

There is more to improvement of the micro enterprise with a goal to reduce poverty than modern energy alone.

(b) Renewable energy technology and sustainable livelihoods

The aim of this project to design and pilot methodologies to identify barrier that interfere with the effective performance of decentralised renewable energy technology options is very good.

Renewable technology that we have here for rural areas is Photo voltaics (Solar). This technology is not fully utilised because of the inability of the local people to afford it, though the climate is conducive. In addition maintenance of the equipment is expensive in that an expert has to travel long distances to rectify the fault. This defeats the aim to reduce poverty.

I support that much research should be done to decide what appropriate technology is needed fro a particular place.

I wish you and the entire DFID energy group all success in this new year.

Looking forward to the next edition.

Regards.

Charles Mnyanjagha
ESCOM LTD
Central Planning Unit
Blantyre
Malawi

2

-----Original Message-----
From: Soumen Maity [mailto:soumenmaity2000@yahoo.co.in]
Sent: 01 July 2004 11:52
To: Cherni, Judith A
Subject: Energy project introduction
Dear Dr. Judith,

I would like to introduce myself as Dr. Soumen Maity working at Development Alternatives, New Delhi, India on **Energy Based Sustainable Livelihoods.** At present we are working in a SHELL Foundation sponsored project on "Energy services for village households and livelihood enterprises in Bumdelkhand". We are also working with DFID on a programme for "Strengthening of Poorest Area Civil Society" in India. More information can be had from our website www.devalt.org.

The SHELL Foundation project addresses concerns of women and child health that are linked to inefficient, unreliable and polluting energy use patterns in rural households.
The primary aim of our work is to design a model that services energy needs of rural households and communities. It focussed on the design and delivery of solutions in the areas of

- Cooking fuels
- Cooking devices
- Cooking spaces
- Household lighting.

We aim to create an enterprise support system and strengthen livelihoods so that these energy based services can be available to village families at their doorsteps on a sustainable basis.
Experience of Development Alternatives in India indicates that expenditure on energy is a substantial and increasing part of family budgets. In efficient cook-stoves based on wood and cow dung lead to high smoke levels in cooking areas and adversely impact the health of women. Unreliable grid supply reduces productive time for families and cripples small businesses. Kerosene lit lamps provide poor levels of illumination while causing further indoor air pollution. Village families and communities engaged in dialogue with us have expressed willingness to pay for cost effective, clean, convenient and reliable energy services.
The strategic thrust is on communicating benefits of interventions amongst family decision makers and inducing demand through social mobilization, product and service promotion and credit mechanisms. The main delivery agents of this thrust are the 200 odd women Self Help Groups facilitated by us.
The delivery of energy products and services will eventually take place in an economically sustainable mode through village based individual and group enterprises, several of whom will evolve from existing SHG's. A significant outcome will be enhanced value addition to local resources and improved energy productivity.
We would appreciate to know more about your project with DFID and share between us the learnings of your interventions and approach.
This communication, I hope will help in establishing a collaboration of mutual understanding for promoting energy services to create sustainable livelihoods**.**
Looking forward to hearing from you.
With best wishes,
Dr. Soumen Maity

Details of collaborators in the RESURL project by Country

United Kingdom

Principal Co-Investigator:
Prof Dennis Anderson
Director
Imperial College Centre for Energy Technology and Policy
Environmental Policy and Management Group
Department of Environmental Science and Technology
Imperial College London
South Kensington Campus
London
SW7 2AZ
Telephone: 020 7 594 6776
Fax: 020 7 594 9304
E-mail: dennis.anderson@imperial.ac.uk

Principal Co-Investigator and Co-ordinator:
Dr Judith A. Cherni
Research Lecturer
Environmental Policy and Management Group
Department of Environmental Science and Technology
Imperial College London
South Kensington Campus
London
SW7 2AZ
Telephone: 020 7 594 7316
Fax: 020 7 594 9304
E-mail: j.cherni@imperial.ac.uk

Cuba

Universidad Central de Las Villas.
Centre for Renewable Sugar Energy (CETA)
Dr Raúl Olalde Font - Cuban Team Co-ordinator
Dr Candido Quintana
Eng Idielin Martinez Yon

Ministry of Science, Technology and the Environment (CITMA), Cuba through GEPROP (Gerencia de Proyectos Prioritizados)
Dr Alfredo Curbelo
Dr Oscar Jimenez

Colombia

Universidad Nacional de Colombia , Medellín, Colombia
Professor Isaac Dyner Rezonzew - Colombian Team Co-ordinator
Professor Ricardo Smith
Dr Patricia Jaramillo
Dr Gabriel Awad Aubad
Dr Claudia Álvarez
Juan Felipe Henao

Peru

Intermediate Technology Development Group (ITDG), Perú
Eng Teodoro Sanchez Campos
Lic Rafael Escobar Portal

Other Countries

Dr Smail Khennas - Previous ITDG
Eng. Robert Pinzon - Vice Presidency of Ecuador Complejo de Carondelet CONELEC