~~UNITED NATIONS DEVELOPMENT PROGRAMME~~
~~GLOBAL ENVIRONMENT FACILITY~~

# PROJECT BRIEF

**1. Identifiers**

| | |
|---|---|
| **Project Number:** | CHI/00/G31 |
| **Project Name:** | **Chile: Removal of Barriers for Rural Electrification with Renewable Energies** |
| **Duration:** | 5 years |
| **Implementing Agency:** | UNDP |
| **Executing Agency:** | National Energy Commission |
| **Requesting Country:** | Chile |
| **Eligibility:** | Ratified the FCCC on December 22, 1994 |
| **GEF Focal Area:** | Climate Change |
| **GEF Programming Framework:** | Operational Program 6 |

**2. Summary:**

The objective of the proposed project is to remove the existing barriers to the use of Non-Conventional Renewable Energies (NCRE) for Rural Electrification in Chile, by developing a set of activities that will allow for a decrease in the greenhouse gas emissions produced by conventional energy sources in rural areas. By means of co-financing, or Guarantee Funds, approximately 10,370 households out of a total household market of 74,000 will be supplied with electricity. This project also aims to generate, within rural electrification, the market conditions that will allow for the reduction of emissions produced by diesel-fueled electricity systems. The desired effect is to establish the market conditions for the NCRE to develop in rural and urban areas.

**3. Costs and Financing (US$MILLION)**

**GEF:**

- Project: 5.984~~5,900~~
- PDF B: 0.082~~,400~~
- **Subtotal GEF: 6.067~~,300~~**

**CO-FINANCING:**

- Private: 7.628~~,000~~
- Regional Governments

: 16,.489 ,000 (cash)

0.

: 755 ,000 (in-kind)

- Rural Users-

: 1,.458,000 (cash)

**Subtotal Co-financing 26.330**

**Total Project Costs :**

**32.39731.,642,300 (cash)**

: **+ 0.755,000 (in-kind)**

**4. ASSOCIATED FINANCING (US$): : 32,.397,300**

**5. Operational Focal Point:**

Name: MrsMs. Adriana Hoffmann J.. Vivianne Blanlot Title:

Title: Executive Director Executive Secretary to the CNE

Organization: Comisión Nacional de Medio AmbienteEnergía (CNE) (CONAMA)

Date: 25 AprilMarch 11, 2000

**6. Implementing Agency Contact:**

Dr. Nickholas Remple, UNDP, New York; tel: 212-906-5426; fax 906-6688; email nick.remple@undp.org

## LIST OF ACRONYMS/ABBREVIATIONS

| | |
|---|---|
| BIP | Banco Integrado de Proyectos, (Integrated Project Database) |
| CNE | Comisión Nacional de Energía (National Energy Commission) |
| CONAMA | Comisión Nacional del Medio Ambiente (National Environment Commission) |
| CORFO | Corporación de Fomento de la Producción (Production Development Corporation) |
| ERNC | Energías Renovables no Convencionales, NCRE (Non-Conventional Renewable Energies) |
| FNDR | Fondo Nacional de Desarrollo Regional (National Fund for Regional Development) |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| INE | Instituto Nacional de Estadísticas (National Statistics Institute) |
| INN | Instituto Nacional de Normalización (National Normalization Institute) |
| IPCC | Intergovernmental Panel on Climate Change |
| MIDEPLAN | Ministerio de Planificación (Ministry of Planning) |
| NCRE | Non-conventional Renewable Energy |
| NPV | Valor Presente Neto (Net Present Value) |
| PDF | Project Development Facility |
| PER | Programa de Electrificación Rural, REP (Rural Electrification Program) |
| PIB | Producto Interno Bruto, Gross Domestic Produce (GDP) |
| SEC | Superintendencia de Electricidad y Combustibles (Superintendent of Electricity and Fuel) |
| SENCE | Servicio Nacional de Capacitatión y Empleo (National Training and Employment Service) |
| UNDP | United Nations Development Program |
| UNFCCC | United Nations Framework Convention on Climate Change |

## CHAPTER 1. BACKGROUND AND CONTEXT

### 1.1 Country Background

1. Chile covers 756,096 square kilometers and is divided into twelve regions from north to south, in addition to a thirteenth region corresponding to the Metropolitan area. According to the 1999 data registered by the National Statistics Institute (INE), Chile's population is over 15 million with 2.2 million (15% of the population) living in rural areas. Approximately 6 million, or 40% of the population is concentrated in the city of Santiago. Other important cities are the neighboring cities of Viña del Mar and Valparaíso, with a combined population of 638,632, and Concepción with 953,787 inhabitants.

2. The Chilean economy has experienced accelerated growth over the last decades. Between 1989 and 2000, Gross Domestic Produce (GDP) grew at a 6.8% yearly rate. The country's annual consumption has also grown at rate similar to, or higher than, the GDP in areas such as the energy sector.

3. Chile's per capita energy consumption is still low, at 0.062 TJ per inhabitant, as compared to other industrialized countries. The energy intensity index shows a declining tendency similar to that experienced by advanced countries. The opposite, however, is true in relation to $CO_2$ emissions associated with the energy sector of the country and its future projections.

4. The country's primary energy sources are based on crude oil (43.6%) and coal (17%), with the remaining energy derived from firewood, hydroelectricity, and a small proportion of natural gas. This energy matrix composition has not been constant over the years, and recently there has been a continual decrease in the use of hydroelectricity relative to~~in favor of~~ fossil fuel energy resources.

5. The susceptibility of hydroelectric generation to periods of drought has strongly impacted the country over the last years. In addition, the availability of natural gas from Argentina, resulting from economic co-operation agreements between both nations, has led to a dramatic change in energy use. The generation of electricity in Chile, based on hydro resources, is currently nearly 58% for the Central Interconnected System. It is estimated that, over a 15-year time frame, electricity will be generated equally by hydro and fossil fuels (mainly natural gas and coal).

6. The demand for electricity will continue to have an increasing importance in supporting economic growth of the country. For example, the copper mining industry, which represents one of the highest energy consumption sectors of the country, will continue to expand in the years to come. Therefore, given no policy changes, it is expected that greenhouse gas (GHG) emissions per capita will continue to grow.

7. This situation has motivated government authorities to develop corrective strategies that will allow ~~to~~ the nation's economy to grow while not leading to increases in GHG emissions. It is clear that promoting policies for more efficient energy use may have strong short-term effects. From a long-term perspective, these policies could lead to important changes in the

composition of Chile's energy mix.

8. After considering both national and international experiences in the field, it is the goal of the Chilean government to promote the removal of ~~the~~ existing barriers to the installation of competitive energy markets for NCRE in Chile.

9. National authorities have already begun to address rural electrification through programs established over the last five years. There are two main reasons for continuing rural electrification programs. First, these are programs that have successfully addressed the needs of the population and, with certain adjustments to meet some additional objectives, will continue to build on previous experience. Second, based on this previous experience with conventional energy sources, the challenges presented by implementing NCRE are now better understood.

10. The current situation is appropriate for installing NCRE in Chile, as the conditions for a reliable market are sufficient to allow for continued growth in the near future. Therefore, the strategic objective of influencing the composition of the national energy mix may be achieved.

11. Chile's geographic and climatic diversity presents ~~an~~ excellent potential for the use of renewable energies throughout the country. Solar energy is abundant in the north, hydro and biomass/agricultural energy are in the south, and there is potential for wind energy in coastal and the southern-most areas.

12. Approximately 99% of the urban population, or 12,600,000 inhabitants, have access to electricity. While 76% of rural households have access to electricity, 24% of rural households (136,669 households) lack electricity. Of these households, approximately 88,420 are expected to receive electricity for domestic use from conventional sources. The remaining 48,250 households represent the target market for this project.

13. The rural electrification process in Chile has been systematically implemented through grid extension. However, there is an important segment of rural households that are not viable grid extension projects. These households are in the less populated, and most economically challenged, regions of Chile. The existing energy alternatives for these communities are currently financed by means of subsidies for diesel and gasoline electricity generators.

### 1.2 Legal Framework

~~14.~~ In accordance with the economic policy applied in the country, activities related to the generation, transmission and distribution of electricity in Chile are primarily carried out by the private sector. State intervention is restricted to regulatory, compliance and subsidiary functions.

14.

15. Electricity companies are free to manage their investments, commercialization services and operations of their installations. Nevertheless, these companies must comply with certain obligations, regulations and technical norms, established by law, that constitute the regulatory framework of the electrical sector. For example, distribution companies are obligated to provide service within their corresponding concession area, and must respect maximum tariffs set by the authority for the sale of electricity to low-consumption clients. For electrical systems demanding 1500 KW or less, which includes rural electrification projects installing diesel generators and NCRE, the law dictates that maximum pricing to be agreed between the Municipal AuthoritiesMayor of the respective City Hall and the corresponding Distribution Company. The law determines a tariff system regulating supply pricing, service quality, functioning service hours and all the pertinent conditions. State organizations participating in the regulation of the electricity sector in Chile are: National Energy Commission (CNE); Ministry of Economy, Development and Reconstruction; Superintendent of Electricity and Fuel (SEC); and the National Environment Commission (CONAMA), among others.

### 1.3 Rural Electrification and Non-Conventional Renewable Energies in Chile

16. By the end of 1994, and in response to the initiative of President Eduardo Frei to incorporate all the segments of Chile's population into economic development, an agreement was developed by the National Energy Commission (CNE) to initiate the Rural Electrification Program (REP). The purpose of the REP was to provide solutions for the lack of electricity in rural areas, by incorporating the concepts of equity, reduction of migration, productive development, and decentralization of decisions. The goal of the REP was to provide electrification, as a first stage, to 75% of rural households in the country during the 1994-2000 period. At the time, rural electrification coverage reached only 59%. To accomplish the objective, the State implemented a co-financing system that involved private electricity distribution companies, the beneficiaries, and a state subsidy. The REP was developed by decentralized regional management, where each region elaborates, evaluates and finances its projects according to regional needs, while addressing national goals and objectives.

17. Each project undergoes a rigid evaluation to determine private investments as well as the corresponding amount of subsidy, which is only provided to those projects that present a social positive social evaluation and a private negative private sector evaluation[1]. Public funding is provided by the National Fund for Regional Development (FNDR), which is a financing source to help regions develop social investment sector projects. Since the REPs competes with other social projects to acquire financing from this fund, a special reserve provision (FNDR-ER) was created in 1995 to exclusively finance rural electrification projects. The support from the Fund to different regions is realized according to a methodology that promotes regional efforts in this area. Public expenditure in rural electrification, since the initiation of the REP to the end of 1994, has been close to US$ 115,000,000, and has provided electrical power to 90,145 households (national coverage of 76%).

18. The creation, promotion and co-ordination of the REP is the responsibility of the CNE.

[1] Methodology of the Preparation and Evaluation of Rural Electrification Projects. MIDEPLAN-CNE. 1996

Between 1995 and 1999, it promoted regional efforts, delivered technical assistance to optimize investment decisions, and monitored the results of the program. The main actions are:

a) Regional co-operation agreements;
b) Adaptation of the methodological-institutional framework;
c) Annual control and monitoring of the Program;
d) Widespread dissemination of the Program;
e) Technical assistance for self-generation systems;
f) Elaboration of preliminary regulations for the use of PV systems;
g) Grid extension pre-investment studies; and,
h) Ex post evaluation.

~~18.~~19. The CNE has been working on the implementation of projects financed by international agencies to promote the use of renewable energies and the linkage with institutions concerned with the promotion of experience exchange ~~interchange~~. As a result, the following actions have been developed:

a) Energy Initiatives of the Americas, where the CNE, on behalf of the Government of Chile, presides over the Workgroup on Rural Electrification;
b) Wide Co-operation Agreement in Renewable Energies, with the US Department of Energy (DOE);
c) Greenhouse Gas Emissions Reduction Project in Chile, developed in conjunction with CONAMA and the assistance and financing of the UNDP/GEF; "Generation of Electric Energy by Gasification of Forest Biomass"; and,
d) Rural Electrification Project of an indigenous community, by means of hydroelectric small power-houses, developed in conjunction with the UNDP and financed by APEC.

~~18.~~20. As an outcome of these initiatives, a number of rural electrification projects with NCRE were developed and evaluated[2,3,4,5] with the objective of analyzing the difficulties resulting from their operations. The analysis concluded that wind, photo-voltaic (PV), biomass/agricultural residues, or hydro technologies differ in their conception, quality, service provided, and mainly in the relationship between the user and the electricity solution.

~~18.~~21. It is accurate to say that the objective for the program in the 1995-2000 period has been successfully reached. Estimations, however, indicate that 136,600 households still have no access to electricity. These households correspond to a rural population of approximately 600,000 inhabitants. Some regions have 70% coverage, however, others have an 85% coverage, which indicates differences in regional development. Therefore, the Government in-office has made the following commitments, to be carried out within its term: a national rural

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[2] Analysis of the Incorporation of the Small Hydroelectric Powerhouses in the Rural Electrification Program. MIDEPLAN, 1997

[3] Expost Evaluation of some wind projects implemented in the country; Puaucho and Villa Las Araucarias cases. MIDEPLAN, 1997.

[4] Expost Evaluation of PV projects implemented in the country; I, IV and VII regions, MIDEPLAN, 1997.

[5] Management and Results of the Project: "Generation of Electric Energy by Gasification of Forest Biomass"; Methane Case. UNDP, 1999.

electrification coverage of over 90%, with ~~regional~~ levels of 90% coverage for each region. That is, a total State investment of 180 million dollars and electricity for 98,000 households.

~~18.~~By the time the REP ends in 2005, approximately 64,735 households will still depend on candles, kerosene and batteries to satisfy their energy needs. State policy regarding these households indicates that, given the high geographical dispersion and the amount of investment needed to provide them with electricity, these households are not to be included in any electrification program. The State's effort to increase rural electrification will come to an end once 90% coverage is reached. Expected goals and results for the REP by the year 2005, in terms of rural electrification coverage, are reflected in Table 1.1.

22.

**Table 1.1 Results of the REP**

| | Rural Households | | | |
|---|---|---|---|---|
| **End of year** | **Total** | **With Energy** | **Without Energy** | **Coverage** |
| 1999 | 570,557 | 433,888 | 136,669 | 76 % |
| 2005 | 622,458 | 557,723 | 64,735 | 90 % |

~~18.~~State programming establishes that 90% of the 98,244 households will be electrified through grid extension in the 2000-2005 period, with the remaining 10% to have access to electricity through diesel generators. However, an important percentage of these households may use NCRE if the barriers that prevent the entrance of these technologies into rural areas are removed.

23.

~~18.~~In relation to NCRE, it is worth noting that Chile was one of the first countries in the world to use solar energy for industrial purposes. In 1972, the first solar industrial plant was installed in the city of Antofagasta, located in the northern part of the country. Systematic solar energy measurements began in 1961. The national heliometric inventory records measurements in more than 120 stations along the country. In 1987, the Solar Energy Laboratory of the Federico Santa María University (Universidad Federico Santa María) published the National Inventory of Heliometric Evaluations. It contains monthly and annual rates of daily global radiation over a horizontal area from 129 heliometric stations. Examination of this registry indicates that northern Chile has extraordinary conditions for the use of solar energy. Between the I and IV regions, the solar energy potential can be classified among the highest in the world, as it is shown in Table 1.2, which illustrates annual radiation rates by region.

**Table 1.2 Solar Radiation Annual Rate**

| Region | Solar Radiation (Kcal/(m$^2$/per |
|---|---|
| I | 4.554 |
| II | 4.828 |
| III | 4.346 |
| IV | 4.258 |
| V | 3.520 |
| VI | 3.676 |
| VII | 3.672 |
| VIII | 3.475 |
| IX | 3.076 |
| X | 2.626 |
| XI | 2.603 |
| XII | 2.107 |
| RM | 3.570 |
| Antarctica | 1.563 |

~~25.~~24. In relation to wind energy, the first organized attempt to evaluate the resource as to its application corresponds to a series of experiments carried out in the Atacama Desert between 1962 and 1963 by Dr. Dannies, an expert from UNESCO. The study concluded that northern Chile presents favorable conditions for the installation of 25 and 300 kW unit plants. In 1992, the University of Chile elaborated a study entitled "Wind Energy in Chile: Evaluation of its Potential". This study presented wind~~s~~ directions and velocities in 60 meteorological stations, although it is still necessary to carry out investigations taking into account wind energy demand. Studies must consider ~~a~~ wider coverage, station density, wider registration periods, greater number of daily registers, and the height necessary to obtain reasonable measurements. Such investigations have not yet been carried out since they have not been considered ~~a~~ needed for national energy development.

~~26.~~25. In relation to low scale hydroelectric resources, initial studies indicate that in Regions VIII to XI there are abundant hydraulic resources to be utilized in small hydro. Still, efforts need to be made to measure the volume of flow, and estimate values and measurements of net heights available for hydroelectric generation, in rural communities having households in need of a project of such characteristics.

~~18.~~26. Since 1994, isolated efforts have been made to incorporate NCRE in the REP. Pilot projects using different technologies, including PV, wind, small hydro and gasification of forest biomass, have been implemented. The operational results of the pilot projects are diverse, but in general terms, the Government and private companies supply electricity to isolated households by using diesel electricity generators, given the operational reliability of the equipment in both technological and economic terms.

~~18.~~27. The use of renewable energy in Chile has been published in the study: "Inventory for the Elaboration of the Installations of Non-Conventional Renewable Energies in Chile". It demonstrates that, in 1998, the NCRE contributed approximately 105.08 TJ to the National

Energy Balance. That is, 0.0132% of the final energy consumption[6]. The types of NCRE energy contributions include:

- 43.46% solar-thermal energy
- 24.06% solar PV energy
- 31.14% small hydro
- _0.44% wind energy
- _0.90% others[7]

~~29.~~28. Under the frame of the PDF B[8], a study identified households that will never have access to electricity through grid extensions due to their extreme isolation and dispersion conditions. Approximately 29,355 households were identified, which are part of the 64,735 households that do not fall under the State's assistance through REP. Considering the total number of households (and the 9,824 households that will be electrified by the program through diesel-fueled systems within the next 5 years) the estimated potential market for NCRE in new rural electrification projects is 74,559 households.

~~30.~~29. After analyzing and integrating the results of the former study with the potential market analysis, the distribution of resources by household has been developed (Table 1.3).

**Table 1.3 Potential by Resource**

| Resource | Household Potential |
|---|---|
| Solar (S) | 20,667 |
| Hydro (H) | 19,094 |
| Biomass (B) | 55,604 |
| Wind (W) | 17,324 |

~~31.~~30. Table 1.4 shows the number of households to receive electricity by various resources, assuming that an area can sustain more than one type of renewable resource. The distribution of the different combinations of renewable resources, by household, is shown in Table 1.4. The estimation of the regional distribution of non-electrified households that have the potential for using renewable energy is provided in Table 1.5.

[6] Development implemented with large hydroelectric power-houses and the commercial profitability of biogas have not been considered in this analysis of the NCRE
[7] Includes wind pumps, solar pumps, solar cooking stoves, firewood gasification and geothermal installations.
[8] Study "Estimation of the Application Potential of Renewable Energies in Rural Electrification".

## Table 1.4 Household Percentage by Type of Resource

| Resource | Number of Potential Households | Percentage |
|---|---|---|
| S | 10,291 | 13.80% |
| H | 127 | 0.17% |
| B | 26,333 | 35.32% |
| W | 76 | 0.10% |
| S-H | 4,153 | 5.57% |
| S-B | 1,773 | 2.38% |
| S-W | 2,791 | 3.74% |
| H-B | 12,506 | 16.77% |
| H-W | 447 | 0.60% |
| B-W | 13,469 | 18.06% |
| S-H-B | 1,321 | 1.77% |
| S-H-W | 338 | 0.45% |
| H-B-W | 203 | 0.27% |
| S-H-B-W | - | 0.00% |
| S/R | 731 | 0.98% |
| **Total** | **74,559** | **100.00%** |

Solar (S), Hydro (H), Biomass (B), Wind (W)

## Table 1.5 Regional Distribution

| Region | Number of Non-electrified Households | Potential Number of Households |
|---|---|---|
| I | 689 | 602 |
| II | 14 | 14 |
| III | 610 | 479 |
| IV | 9,369 | 6,776 |
| V | 4,019 | 3,370 |
| VI | 9,860 | 3,495 |
| VII | 17,836 | 8,278 |
| VIII | 24,027 | 10,708 |
| IX | 25,903 | 9,912 |
| X | 36,417 | 25,204 |
| XI | 1,944 | 1,800 |
| XII | 560 | 500 |

| | | |
|---|---|---|
| RM | 5,422 | 3,421 |
| **Total** | **136,669** | **74,559** |

### 1.4 Legal Framework for NCRE in Chile

~~32.~~31. Government policy in the area of the NCRE is consistent with ~~the~~ established global energy policies, in that NCRE competes on equal terms with traditional energies. Given ~~the~~ actual technological development, and in conjunction with ~~the~~ established energy policies, it is possible to use NCRE to provide conventional electricity to rural isolated communities. In the case of conventional electrical supply, wind energy generation installations and geothermal plants may be~~seem~~ economically viable~~fit~~ given local conditions and pricing of conventional electricity generation.

## CHAPTER 2. PROJECT OBJECTIVES AND DESCRIPTION

### 2.1 Project Objectives

~~33.~~32. The overall objective of the proposed project is to assist the Government of Chile to reduce GHG emissions by avoiding the use of~~not using~~ fossil fuels to satisfy the energy needs of the rural population. The project will: (i) promote the removal of ~~the~~ barriers that prevent the successful use of renewable energies in the Chilean rural electrification program, generating within the existing institutional framework the conditions for the development of a NCRE market in Chile, and (ii) promote public and private investments towards the development of rural electrification with non-conventional energies.

### 2.2 Rationale for GEF Financing

~~34.~~33. The Government of Chile has financed pilot projects with renewable energies. These experiences have allowed for the demonstration of the benefits of ~~the~~ incorporating such systems in isolated areas and the need, in some cases, to organize community users to ensure the long-term sustainability of projects. Given the existence of barriers and ~~the~~ market conditions, rural electrification tends to be accomplished by projects using diesel generators, and through grid extension.

~~35.~~This project identifies the barriers to the use of NCRE in rural electrification. The successful implementation of the project will eliminate the barriers and disseminate these NCRE technologies with the participation of private investments. The aim of the project is the creation of NCRE national development in rural electrification, resulting in the generation of a positive global impact, even after its termination. This project is consistent with the Climate Change Operational Program #6 - “Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs”.

## 2.3 Barriers to the Utilization of NCRE in Rural Electrification

~~36.~~34. The barriers to the introduction and adoption of the NCRE in rural electrification identified in the elaboration of the project are: (a) lack of rural electrification projects with NCRE; (b) lack of regulations for renewable energy equipment; (c) lack of certification procedures for renewable energy systems and their installation; (d) lack of general knowledge with respect to NCRE; (e) lack of formal training programs; (f) existence of high cost investments in projects with NCRE; (g) perception of associated risks with renewable energy technologies; (h) lack of technical expertise, equipment, and analysis to make wind resource measurements; and (i) lack of NCRE commercial projects having economies of scale. These barriers are described below.

(a) Lack of Rural Electrification Projects with NCRE

~~37.~~35. The model utilized by authorities for rural electrification projects with NCRE is the same that applies to the extension of conventional electricity. Private companies are in charge of preparing and petitioning their projects to regional governments for the awarding of the subsidies for rural electrification, where the operation and maintenance of the systems is provided for a monthly fee. It is worth noting that this model has been successful for the NCRE projects that have used it.

~~38.~~In most cases, engineering studies for grid extension projects are conducted by the energy companies through extensions of their own installations. The preparation of a NCRE project, however, demands resource evaluation and much more detailed engineering studies than that of a grid extension or diesel generation project, and therefore has higher costs and requires more preparation for the companies. Therefore, the NCRE projects are not abundant and, when analyzing subsidies awarded by regional governments, the NCRE alternative is not predominant, notwithstanding that it may be the economic and technologically preferable options. As a consequence, most of the isolated communities of the country have access to electricity by means of diesel or gasoline fueled electricity generators, and that has set a tendency in rural electrification.

36.

(b) Lack of Regulations for Renewable Energy Equipment

~~39.~~Chile has a national system of regulations established by the National Normalization Institute (INN). This Institute is charged with elaborating a body~~collection~~ of regulations for NCRE to be utilized in the REP. International experience in the subject is advanced, as ASTM and European norms are available for procedures and standards that allow for the certification of PV panels. U.S. and European norms include procedures to approve the construction of small hydroelectric powerhouses.

37.

~~40.~~ A barrier to the involvement of the private sector in the NCRE market is the lack of a

legalized technical market tied to the electrical regulations of Chile. There is a lack of understanding regarding the technical requirements of each project, the minimum equipment required, quality standards, work designs, safety of the installations and assembling of the equipment. There is no basis of understanding developed from previous experiences with NCRE, yet it is the responsibility of the companies to operate and maintain the equipment to maximize the equipment's useful life.

38.

(c) Lack of Certification Procedures for Renewable Energy Systems and their Installation

~~41.~~39. Another barrier that NCRE projects faced is the lack of certification procedures for renewable energy systems and their installation to ensure compliance with~~to~~ technical and safety regulations.

~~42.~~40. The lack of certification for renewable energy systems and their installations may result in the implementation of projects that comply with neither technical nor with minimum quality service specifications. There are small hydropower stations that do not comply with the stipulated generation potential, while other stations have been deserted. In addition, there are wind systems that operate only two hours average a day and PV systems that have been abandoned due to spare parts and equipment failure.

(d) Lack of General Knowledge with Respect to NCRE

~~43.~~41. To date, there is a lack of knowledge in Chile with respect to renewable energies including: characteristics, applications, benefits, operations, and environmental and sustainability advantages with respect to other self-generation alternatives (e.g., diesel-fueled electricity generators). This lack of knowledge manifests at all levels, from the potential users of the technologies to energy distribution companies, government, and NGO~~'~~s.

~~44.~~42. This lack of knowledge has also prevented the development and dissemination of the NCRE in all their applications. It has limited the development of a market that could become attractive for the development and implementation of new projects with NCRE. Even when certain NCRE projects have been awarded to the REP, they have not been welcomed by traditional distribution companies, who instead offer grid extensions or diesel electricity generators as the preferred solution.

(e) Lack of Formal Training Programs

~~45.~~The PDF B ~~project~~report "Training Program Plan for the Introduction of the Use of Renewable Energies in Rural Electrification in Chile" verified the lack of formal training programs in the field of renewable energies in all of the country. In particular, there are no polytechnic training programs or university level training. Of Chile's 50 universities, only three

(6%) provide instruction on subjects related to renewable energies in mechanical, electrical and hydraulics engineering.

43.

~~46.~~44. The lack of formal training programs results in a lack of trained technicians able to develop NCRE projects, operate the systems, and provide adequate technical service. Therefore, the development of rural electrification projects with NCRE is limited not only by the adequate definition and execution of the project, but also by the lack of technical capacity to operate and adequately maintain the systems.

(f) Existence of High Cost Investments in Projects with NCRE

~~47.~~45. Overall, NCRE projects are characterized by their high cost investment in relation to projects using diesel or gasoline generators. On a 20-year horizon, however, the optimal decision would generally be the implementation of projects utilizing NCRE. Nevertheless, the number of barriers as described in this document generates a high level of uncertainty regarding the economic flow of the project. Therefore, private companies that operate in this sector tend to not be in a position to use their investment resources for NCRE projects as the projects have higher risks.

~~48.~~46. This risk avoidance has prevented the materialization of many rural electrification projects with NCRE. Companies tend to favor the installation of electrical generators, which require a lower up-front investment and have a higher perceived profitability, even if operation expenses are higher for traditional technologies.

(g) Perception of Associated Risks with Renewable Energy Technologies

~~49.~~47. A barrier to the introduction of NCRE is the perception of risk associated with the economic results of the projects. The lack of knowledge of the technology, the lack of national training capacity, and the scarcity of commercial-scale projects all contribute to the uncertainty of potential NCRE project investments. An analysis of pilot projects using different types of technologies has shown that there is an increase in risk perception associated with NCRE technologies.

~~50.~~48. Despite the identified need to implement electricity solutions in isolated areas coupled with the Government's co-financing of projects with NCRE, traditional distribution companies would rather promote and implement diesel solutions. When regional authorities have awarded NCRE projects, companies have not been willing to implement them. For example, in Santa María Island (Isla Santa María), a hybrid wind diesel project ended up being executed using only diesel. Another example is the electrification of the Alto Bío-Bío by means of small hydro, where Saesa Frontel (the distribution company) presented a grid extension offer at a

higher investment.

~~51.~~49. This barrier also affects a number of diesel systems operating and servicing communities with populations of over 500 inhabitants. Many of these systems could be hybridized by means of NCRE, thereby reducing operation costs, fossil fuel consumption, and emissions produced. The perceived risk of lower revenue and future costs of hybrid alternatives has led the local government to invest in the technology transformation of the systems.

(h) Lack of Technical Expertise, Equipment and Analysis to Make Wind Resource Measurements

~~52.~~50. Chile has an enormous potential for exploiting wind resources. The only systematic evaluation effort of this resource has been the inventory of meteorological information, which does not allow for the development of electrical generation projects. The lack of systematic efforts to evaluate this resource for electrical development purposes has led to a lack of suitable professionals, technicians, equipment and practical experience to gather adequate information to define projects. This barrier has resulted in a lack of projects using wind energy.

~~53.~~51. Although there may be economic and technical reasons for carrying out electrical generation projects with wind energy, it is difficult to implement them at this time due to the lack of adequate long-term measurements over long periods of time (e.g., with an adequate number of daily registrations). This type of information would permit the characterization of the resource according to its magnitude, intensity and internal capacity.

(i) Lack of NCRE Commercial Projects Having Economies of Scale

~~54.~~52. The lack of large-scale NCRE demonstration projects is a barrier that prevents the different actors in the national energy market from understanding the possibilities of developing NCRE projects. Such large-scale projects benefit from economies of scale derived from providing electricity to a larger number of households, thereby transforming it into a commercially attractive project. These economies of scale may be obtained through amounts invested, as well as in the operation, maintenance, and administration of the projects.

~~55.~~53. The lack of commercial demonstration projects with NCRE tends to heighten the levels of uncertainty and risk as perceived by potential investors when evaluating investments in rural electrification.

## CHAPTER 3. PROJECT ACTIVITIES/COMPONENTS AND EXPECTED RESULTS

~~56.~~54.This project has been designed to remove the barriers that prevent the adoption of NCRE for rural electrification in Chile. The elimination of the following barriers (as discussed in Section 2.3) would help generate a market for the NCRE in Chile:

A. Lack of r~~R~~ural ~~E~~electrification ~~P~~programs with NCRE;
B. Lack of ~~N~~norms for ~~R~~renewable ~~E~~energy e~~E~~quipment;
C. Lack of ~~C~~certification p~~P~~rocedures for ~~R~~renewable ~~E~~energy ~~S~~systems and their ~~I~~installations;
D. Lack of ~~G~~general k~~K~~nowledge with ~~R~~respect to NCRE;
E. Lack of f~~F~~ormal t~~T~~raining p~~P~~rograms;
F. Existence of ~~H~~high ~~C~~cost ~~I~~investments in ~~P~~projects with NCRE;
G. Perception of ~~A~~associated ~~R~~risk with ~~R~~renewable ~~E~~energy t~~T~~echnologies;
H. Lack of ~~T~~technical ~~E~~expertise, ~~E~~equipment and ~~A~~analysis to ~~M~~ake ~~W~~wind ~~R~~resource ~~M~~measurements; and,
I. Lack of NCRE ~~C~~commercial ~~P~~projects ~~H~~having ~~E~~economies ~~o~~of ~~S~~scale.

~~57.~~55.To help remove the barriers to adoption of NCRE in rural Chile, several activities have been designed including:

1. Generation of a ~~P~~portfolio of ~~R~~rural ~~E~~electrification ~~P~~projects using NCRE;
2. Elaboration of ~~T~~technical ~~N~~norms for ~~E~~electrification ~~S~~systems with NCRE;
3. Elaboration of ~~E~~electrification ~~S~~systems' ~~C~~certification ~~P~~procedures with NCRE;
4. Implementation of a ~~D~~dissemination and ~~P~~promotion ~~C~~campaign of the NCRE;
5. Development of a ~~T~~training ~~P~~program;
6. Design and ~~E~~execution of a ~~L~~large-~~S~~scale PV ~~D~~demonstration ~~P~~project;
7. Development of a ~~F~~financial ~~M~~mechanism of ~~R~~risk ~~M~~mitigation ~~I~~investment in ~~P~~projects with NCRE;
8. Definition of the $CO_2$ ~~E~~emissions ~~R~~reduction ~~P~~project by means of ~~H~~hybridizing the ~~E~~existing ~~P~~projects; and,
9. Creation of ~~T~~training ~~C~~capacity to ~~E~~evaluate ~~W~~wind ~~R~~resources in Chile.

~~58.~~56.The relationship between the barriers and the activities designed to address them is illustrated in Table 3.1. Further information on the proposed activities is given in the following section.

**Table 3.1 Matrix of Barriers and their Associated Activities**

| Barriers → | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| **Activities ↓** | | | | | | | | | |
| **1** | X | | | | | | | | |
| **2** | | X | | X | | | X | | |
| **3** | | | X | | | | X | | |
| **4** | | | | X | | | X | X | |
| **5** | | | | X | X | | X | X | |
| **6** | | | | | | X | X | | X |
| **7** | | | | | | X | X | | X |
| **8** | | | | | | X | X | | X |
| **9** | | | | X | | | X | X | |

**Activity 1. Generation of a Portfolio of Rural Electrification Projects using NCRE**

~~59.~~57. The development of rural electrification projects using NCRE will be incorporated into the State's awarding of subsidies, allowing for competition with traditional projects. This initial group of projects considers approximately 12,500 households where basic and detailed engineering projects will be implemented.

~~60.~~58. These pre-investment projects for NCRE are to be located in areas with high electrification potential for NCRE and with lower rural electrification coverage. The regions should coordinate these projects, since they are in charge of prioritizing and assigning financing to the projects.

~~61.~~59. The elaboration of the initial portfolio of projects with NCRE will help gather the following pertinent information by region, community or province:

a) The generation of databases for pre-evaluated projects, estimating investment amounts and funding requirements, understanding possible economies of scale, determining the need for infrastructure, identifying households, and evaluating renewable resources.
b) The decreasing number of households generating electrical power using diesel-based solutions, by presenting a group of competitive renewable energies projects.

~~62.~~60. The existence of this initial group of projects will demonstrate NCRE projects for the State and private investors, thereby allowing them to replicate these projects. Developing new pre-investment studies will increase the number of NCRE projects in Chile thereby increasing the capacity, at both the State and private level, to develop projects using NCRE.

**Activity 2. Elaboration of Technical Norms for Electrical systems with NCRE**

~~63.~~61. The CNE generated the Terms of Reference for both the elaboration of technical norms and the certification procedures for electrical systems using NCRE. The following activities and actions will help support the development of these norms and procedures:

a) development of a national and international level analysis of technical norms for these technologies;
b) identification of the technical aspects that require standardization, to ensure a sustainable and successful operation of each of the NCRE technologies; and,
c) analysis of standing procedures and systems for the incorporation and approval of norms by the INN, and the further development of such procedures.

~~64.~~62. The resulting norms and procedures for electrical systems with NCRE will be used to develop a Technical Framework validated as an Official Chilean Electrical Norm by the Superintendent of Electricity and Fuel (SEC). This Framework will involve a collection of norms for PV systems, mini- or small-hydro, wind and hybrids, and biomass gasification systems. The Framework will help ensure standard equipment quality, work designs, safety of the installations and equipment assembly, the responsibilities of the installation companies and their operations, and would facilitate the entrance of the private sector into the renewable

energy market. The process of developing the Framework will require feedback from technology promoters and implementers, the opening of new technological markets, and the impulse and dependability of the technology for electrification projects using NCRE.

**Activity 3. Elaboration of Certification Procedures for Electrical Systems with NCRE**

~~65.~~63. To develop a system of certification procedures for NCRE, it is necessary to evaluate the existing and required conditions for compliance with technical norms. Equipment quality, inspection of installations, and the regulation and supervision of installers will all be examined. To develop the certification procedures, the following activities will be conducted:

a) investigate the available capacity and experience in relation to certification in Chile;
b) analyze the legal, administrative and technical frameworks for the implementation of a certification system in the country;
c) analyze the procedures and certification systems for electrical systems using renewable energies in other countries;
d) define, according to the norms elaborated in Activity 2, the pertinent aspects of certification for equipment and installations with NCRE;
e) establish certification procedures ensuring compliance with Chilean technical norms; and,
f) identify needs for equipment and infrastructure in the institutions that may carry out the certification of systems with NCRE in Chile.

~~66.~~64. Co-operation will be sought with institutions possessing installations and capacities that may allow them to take on certification duties. For example, the universities possessing laboratory equipment and some experience in implementation will be contacted for co-operation.

~~67.~~65. Similar to Chile's experience with environmental certification systems, the implementation of this activity will allow for the development of a NCRE electrical system certification market within Chile. The development of this market will sustain certification capacity in Chile beyond the duration of this project. The certification procedures will help to ensure quality and safety aspects of the NCRE project. In addition, the sustainability of NCRE projects will be reinforced through the development of a spare parts and components market. Decreased maintenance fees, improved response time to system failures, and increased profitability of the projects will all contribute to the sustainability of the NCRE market.

**Activity 4. Implementation of a Promotional Campaign for NCRE**

~~68.~~The objective of the promotional campaign for NCRE in Chile is to demonstrate the economic, technical, and environmental advantages of these technologies and their application to rural electrification.

66.

~~69.~~67. This promotion campaign involves the following activities:

a) identify the objectives and applications of the promotion campaign. That is, design a campaign in terms of objectives, coverage, focus, target audience, resources, and market. The campaign will include the promotion of training programs for users;
b) execute the campaign according to its design; and,
c) perform annual measurements and evaluations of the campaign's impact to determine if the intended results were achieved. This evaluation is to be carried out using indicators including: the number of NCRE projects introduced, the entrance of new suppliers to the market, the interest of companies in executing these types of projects, the response capacity to market demands, the drive by potential users to implement electrification solutions using NCRE, among others.

Overall, the following activities will be carried out: design of the national promotion campaign; developing advertisement production for TV, radio and the news media; developing advertisement campaign during the project execution; promotion through workshops and specialized events; promotion through specialized media; design and support of the project webpage; promotion of specific outcomes of the project, such as standards, certification procedures, Guarantee Fund, among others; and evaluation and monitoring of the promotional campaign.

~~70.~~68. The above actions will facilitate the promotion and generation of rural electrification projects with NCRE by promoting training programs for users, and increasing the awareness of the population concerning these technologies. Overall, the promotion campaign will increase the probable operational success of the projects. Therefore, the information campaign on NCRE will reinforce the formation of a NCRE market while reducing the high-risk perception attributed to these technologies.

**Activity 5. Training Program Development**

~~71.~~69. Training needs for NCRE were determined in the PDF B project "Training Program Plan for the Introduction of the Use of Renewable Energies in Rural Electrification". These training needs will involve diverse participants involved throughout the life cycle of the NCRE projects: conception/design, generation and evaluation, execution and operations, and maintenance. The training needs for the various NCRE technologies are detailed in Table 3.2.

**Table 3.2 Training Needs**

| PROBLEM AREAS REQUIRING TRAINING | CAUSE | CONSEQUENCE | TRAINING ACTIVITY PROPOSED |
|---|---|---|---|
| **PV** | | | |
| (i) Users tamper with system leading to sub-optimal operational results | • Lack of knowledge regarding equipment functioning | • High percentage of failure in regulators and batteries<br>• Abandoned systems | • Train users in basic functioning of the system.<br>• Orient training to improve electrical technicians' knowledge of maintaining and installing PV systems.<br>• Train in management, administration, maintenance, operation, and equipment replacement (for Servicing Companies). |
| **Wind** | | | |
| (i) Users make faulty connections | • Lack of knowledge regarding use of the technology. | • Failures in the system<br>• Long energy blackout periods. | • Train users to work with this type of technology.<br>• Train professionals and technicians in this type of technology. |
| (ii) Failure in the evaluation of the wind resource | • Lack of wind required for the correct operation of the system. | • Short periods of service<br>• Systems not working properly | • Train the creators of the projects in the adequate evaluation of the generation resources. |
| **Hydro** | | | |
| (i) Failure in the execution of the work | • Failure in the engineering design | • Abandoned small power-houses | • Train professionals in the design and size/extent/capacity of hydro projects. |
| (ii) Incorrect evaluation of the resource | • Lack of water for the optimal functioning of the system<br>• Failure in the engineering design | • Low quality service<br>• High failure rate<br>• Abandoned small power-houses | • Train the project designers to correctly evaluation the hydro resource, and to design of hydro-based solutions.<br>• Train technicians to operate and maintain the installations. |
| **Biomass/ Agricultural Residues** | | | |
| (i) Lack of knowledge of the technology | • Insufficient information, as only one project is currently being evaluated | • Insufficient information, as only one project is currently being evaluated | • Train those responsible for the administration, operation and maintenance of the plant regarding equipment functioning.<br>• Train users regarding the proper use of the technology. |

~~72.~~70. Among the training activities that must be implemented, the following different target groups have been identified:

a) decision-making professionals within the frame of rural electrification with NCRE, including those in government and in private companies;
b) users of renewable energy electrification solutions, mainly users of PV systems;
c) supervising inspectors who, according to norms and regulations, certify the quality and safety of the installations executed by private companies; and,
d) installation technicians and maintenance workers who deal with electrification systems using NCRE.

~~73.~~71. A tracking and development program will be used to evaluate, through feedback solicited from participants, the ability of the training program to attain results. Based on these evaluations, the training program will be revised and updated as necessary.

~~71.~~72. The final result of the program, aside from the specific human resource training activities, is the generation of a training model that may be replicated by formal educational institutions to satisfy Chile's demand for trained human resources. This demand will stem from the removal of barriers that prevent the development of the NCRE. Therefore, appropriate training will help to solve this demand problem while leading to the formation of a market in this area.

**Activity 6. Design and Execution of a Large-Scale PV Demonstration Project**

~~71.~~73. The results of the study "Preparation of a Financing Mechanism for PV Systems", conducted within the PDF B, indicated the need for additional financial contributions to the execution of a large-scale demonstration project using PV systems. Such a demonstration project would allow investors to see the profitability of these projects given the amount of households to be electrified. Companies assuming the risk to administrate and operate these systems require a financing level provided by subsidies. However, the State through the FNDR is not willing to provide such subsidies given the high level of uncertainty. By not executing this demonstration activity, households eligible for electricity, in particular geographically dispersed and isolated households, may not benefit from the States' financing and, therefore, not be included in the frame of the REP.

~~73.~~74. This activity considers the execution of a large-scale demonstration project utilizing PV systems. The project will directly install 6,000 individual PV systems in isolated areas of the "IV" Region of Chile through a service concession to be awarded to a private enterprise based on an open bidding, thereby promoting the removal of technological and market barriers. The removal of barriers will allow the entrance of technology and the development of other PV projects. The State, technology users, private companies, and GEF will provide financing.

~~74.~~75. This demonstration project will show the State that large-scale PV system project investments are socially profitable, while showing the private sector that these investments are financially profitable. Therefore, creating conditions to allow for the replicability of this type of project will facilitate the expansion to over 20,000 households, as previously shown in Table 1.3. To help ensure this replicability, this activity will involve both short and long-term follow up on the PV systems' performance.

**Activity 7. Development of a Financial Mechanism for Investment Risk Mitigation of NCRE Projects**

~~78.~~76.Through the PDF B study "Preparation of a Risk Mitigation Mechanism for Renewable Energies", a series of risks associated with electrification using NCRE was identified. These risks can be classified into two groups: Economic and Financial Risks; and Technological and Operational Risks. The following section outlines a mitigation mechanism for economic and financial risk, whereas technical and operational risks are mitigated by the project design (see Chapter 4 on Risks and Sustainability).

~~79.~~77.According to the PDF B study, the first group of risks is mainly associated with the level of investment needed by systems using NCRE, as opposed to diesel-fueled systems. The financial risk is expressed through the uncertainty associated with the operational costs that projects using NCRE would have, as compared with the diesel solution. ~~The i~~Investors are not willing to assume this risk~~,~~ and prefer to invest a smaller amount of resources and obtain~~have~~ more certain cash flows~~;~~, rather than potentially achieving~~having~~ greater profits but at~~yet supporting~~ a greater risk.

~~80.~~78.The creation of a risk mitigation or Guarantee Fund is needed in order to eliminate or mitigate the economic and financial risks associated with the investment differential in projects using NCRE, opposite to electrification using diesel generators. This Fund has two components as discussed below.

~~81.~~79.The first component of the Fund ($1,200,000) will be to cover~~guarantee~~ ~~cover~~ the difference in investment amounts between the two project alternatives: the diesel solution and NCRE solution. ~~This Fund equalizes costs between alternatives.~~ The objective here is to equalize costs between alternatives, and ~~in a such way that~~ the Guarantee Fund to provide a guarantee for the investments by the ventur~~eal~~ capitalists (e.g., Chilean bank(s)). ~~will cover the difference in the investment amounts between the two project alternatives. The operation of the Fund will guarantee the investment differential according to financial evaluations of project alternatives. By equalizing costs, the Fund will facilitate the application for credits from the private sector to finance higher investment costs in rural electrification projects using NCRE in Chile.~~

~~82.~~80.The second component of the Fund ($800,000) will be to guarantee the investments in hybrid energy projects (e.g., rural electrification diesel engine systems to a mix of NCRE/diesel) that will allow for the transformation of approximately 650 households out of potential market of 3,000 households.

~~83.~~The specific administration and operation mechanism of this Guarantee Fund will be developed during the project finalization. The project will support Chile's national financial banks with the application for credits from the private sector. ~~The GEF would lend necessary commitment authority through a legally binding guarantee agreement such as an "legally binding "instrument of commitment" to be drafted prior to the start of the project. Such an instrument would be issued by the GEF trustee, and would requires a definition define of performance monitoring criteria and procedures. In the event that a project fails according to~~

the established criteria, the Guarantee Fund would be accessed by the bank(s). The cCriteria wouldwill be established prior to the start of the project, and may involve the venture capital providers submitting a summary of defaults to the GEF. Overall, the guaranteereserve arrangement may will not require actual disbursements of GEF resources until default is demonstrated. The specific administration and operation mechanism of this Guarantee Fund will be developed during the project execution. The project will support Chile's national financial banking with the application for credits from the private sector, with the intent of only covering the differences between investment costs for the NCRE projects. For each project that is executed under this mechanism, the project will grant an equivalent monetary guarantee for the investment differential to the private banking that will finance this differential.

81.

A Fund Administration Committee, composed of UNDP, CNE, and the Bank(s), will, will be established to determine the projects to be funded and guaranteed by the Guarantee Fund. Prior to the start of the project, success criteria will be established that will be used by the Fund Administration Committee. The main responsibilities of this Committee will be:

82.

a) Evaluate the requests made by the investors for an application that will be guaranteed by the Guarantee Fund. If an application is approved, the Bank will give a credit to the investor;

b) Evaluate, after 2 years of electrification project operations, the financial outcomes of the electrification project with reference to the performance monitoring criteria. The purpose is to decide whether there is a need to release guarantee funds to the Bank(s).

Evaluate the requests made by the investors for an application that will guaranteed by the Guarantee Fund. If an application is approved, the Bank will give a credit to the investor;

Evaluate, after 2 years of electrification project operations, the financial outcomes of the electrification project with reference to the performance monitoring criteria. The purpose is to decide whether there is a need to release guarantee funds to the Bank(s).

When an investor determines cost inequality between alternatives, the Guaranty Fund will be released thereby guaranteeing new projects under this mechanism. During the GEF project execution, the use of this mechanism will allow for the reduction in the uncertainties associated with cash flows and will facilitate the removal of financial barriers in this market. The objective of the Guarantee Fund is to provide backing to the national financing system for awarding credits for project financing of NCRE and the transformation of diesel systems to NCRE. By the end of the project, financial institutions will award credits to projects using NCRE, without having to provide additional guarantees for the assignment of such credits.

85.Establishing and operating this Guaranty Fund will improve the effectiveness of the Government's resources (i.e., resources for investment in new projects US$ 9,185,000 and resources for investment in hybridization US$ 1,200,000) and private sector resources (i.e., resources for investment in new projects US$ 3,936.000 and resources for investment in hybridization US$ 1,200,000) that will be spent on rural electrification projects. Further details on the budget are given in Table 6.1 (Chapter 6).

86.83.The use of this Guarantee Fund will help initiate a new group of rural electrification projects with NCRE. These projects will service approximately 3,720 households, and the transformation of diesel systems to NCRE systems will impact approximately 650 households.

**Activity 8. Definition of the $CO_2$ Emissions Reduction Project by Means of Hybridizing the Existing Projects**

87.84.A hybrid system is an electricity generating system capable of efficiently using different energy sources, including NCRE or traditional fuels, to provide electricity for an isolated community. The hybrid systems offer a good technical solution when faced with the problem of variability in solar resources, as it allows for consistent electricity service. In this sense, the hybrid systems are based on a mix of resources, including solar and diesel, that have been used broadly around the world. The hybridization of existing diesel systems in Chile with NCRE will allow for decreases in $CO_2$ emissions to the environment and, therefore, contribute to reducing the greenhouse effect.

88.85.Specifically in this project, it is proposed that the existing systems based on diesel-fueled engines be converted to hybrid systems by incorporating the use of NCRE as appropriate to the resources available in each area. The benefits of transforming these diesel engine systems to a mix of NCRE-diesel (hybrid systems) include environmental (because they reduce diesel consumption by approximately 80%); economic; and quality of services since with the modifications consistent electricity supply will be available in most cases. To this end, the implementation of the following activities is needed:

a) an inventory of the communities having diesel installations in Chile, including their characteristics;
b) development of engineering studies to determine technological and economical feasibility to develop these projects case by case; and,
c) implementation of adequate measurements of the resource in these projects.

89.86.The outcome of this activity will generate hybrid projects to be executed through State and private sector financing, and the investment of the Guarantee Fund described in Activity 7.

**Activity 9. Creation of Training Capacity to Evaluate Wind Resource in Chile**

90.87.Measurements and evaluations of wind resources will be made to estimate the potential use

of the wind energy in Chile and to allow for future design of wind energy projects. It is suggested that a series of activities be designed to develop complete measurements and evaluations in some areas of the country where wind potential is most favorable for the development of projects.

~~91.~~88. The activities needed to implement this process are the following:

a) definition of the internal capacities and the preparation of the participants for the learning process;
b) definition of the areas where the accurate measurements are to take place;
c) accumulation of existing data and information related to the resource;
d) processing and analysis of the data to evaluate and characterize the resource;
e) purchase, installation and training regarding the measuring stations;
f) operation and maintenance of the measuring stations;
g) collection and endorsement of the information obtained from the measuring stations;
h) training and final analysis of the data; and,
i) dissemination of the procedures and results.

~~92.~~89. The final results of this activity will be accurate measurements in certain areas of the country, and the internal capacity within Chile, to further develop accurate measurements and evaluations of the wind resources for future wind-related projects for rural electrification.

## CHAPTER 4. RISKS AND SUSTAINABILITY

~~93.~~90. The main risks associated with the proposed project relate to the external conditions that may alter the national energy market and/or the investment in rural electrification, thereby affecting the development of a NCRE market in Chile.

~~94.~~91. As an outcome of barrier removal, it is expected that projects using NCRE be technologically but also economically competitive with grid extensions and diesel/gasoline generators. Therefore, lower prices of some fuels may pose a risk to the project, as this scenario would make it attractive for investors to execute energy projects with diesel generators. The social benefits of the project are considered in the evaluation of each project. According to the “Methodology of Evaluation Projects for Rural Electrification”, from the Ministry of Planning and Cooperation (MIDEPLAN), all the rural electrification projects must be evaluated in both economic and social terms. The economic evaluation allows for the calculation of the state subsidy amount required for each project; and, the social evaluation allow permits the best technological alternative to be chosen for implementation in the rural electrification project (i.e., diesel, grid extension or NCRE).

~~95.~~92. This project is imbedded within the institutional frame of the REP, which considers reaching 90% coverage by the year 2005 with the investment of approximately US$ 180 million dollars. Therefore, deviations of the expected resources to other areas or budget

cutbacks (e.g., economic crisis, a national catastrophe) is another risk to the project.

~~96.~~93. One internal risk, mitigated by the project design, is associated with the use of technology that is relatively new to Chile. While Chile has a national system of regulations established by the National Normalization Institute (INN), to help further address the technology risks this Institute will be charged with developing standards or regulations for NCRE to be used in the REP. International standards will be used as a starting point, and ASTM and European norms are available for procedures and standards that allow for the certification of PV panels. U.S. and European norms include procedures to approve the construction of small hydroelectric powerhouses. Other international standards will be likewise used to facilitate the adoption of NCRE in Chile. Further, the potential low performance of systems or reliability of technical services will be mitigated by rigorous technical performance monitoring & reporting; adequately trained, local operators, maintenance and service staff and entrepreneurs; and research and development services from the Universities and other agencies

~~97.~~94. A second internal risk of the project, also mitigated by the project design, involves the participation of the private sector. To ensure that the private sector sees these opportunities as potentially rewarding, specifically over the longer-term, the recovery of costs of good quality energy services will be addressed through a tariff structure that will be used to structure payments. Since several organizations will be required to implement the program (e.g., electric distribution companies, supplying/servicing companies), the operation and maintenance will be provided for a monthly fee. The investments in rural electrification in Chile have been traditionally executed by the private companies of electric distribution that have carried out development mainly through the extension of the grid or mini, diesel-fueled engine systems. This project, therefore, considers the level of involvement of these companies as key to success.

~~98.~~95. In addition, the proposed project involves the participation and coordination of local committees and individual households as decision-makers. Therefore, a project of this nature may face risks including the non-participation of local communities or households. The non-participation of the local communities is address through awareness campaigns, and the use of committees such as the Pro-light Committees in rural communities. Also, the provision of these good quality energy services will provide a "win-win" situation for all. The provision of good quality energy services is expected to lead to an improved quality of life.

# CHAPTER 5. PARTICIPATION, SUSTAINABILITY AND IMPLEMENTATION ARRANGEMENTS

## 5.1. Government Commitment and Institutional Provisions

~~99.~~96. The highest level of Environmental and Energy authorities from the country supports this project. The approval for the preparatory study (PDF B) was given by the Executive Secretary of the CNE and approved by the Executive Director of the CONAMA. The government of Chile has supported important achievements related to rural electrification coverage over the last 5 years, and has incorporated a second stage of the REP for the period 2000-2005.

~~100.~~97.The National Energy Commission, an institution that has developed similar projects with UNDP/GEF, will execute the project. This institution has been responsible for the management of the REP at a national level, with results that reflect the achievement of specific goals. To obtain such results, it has developed various projects in co-operation with different national and international organizations.

~~101.~~98.The UNDP office in Chile will support the program, providing assistance in the design and conduct of international competitive bids for equipment and service; in the procurement of technical assistance; and, in the arrangements for in-country collaboration with other national and international organizations.

### 5.2. Local community participation and sustainability

~~102.~~99.The participation of the local communities in the REP is guaranteed by the experience developed with traditional rural electrification. Participation has been granted by the creation of Pro-light Committees in rural communities that have no access to electricity. It is necessary to incorporate the lessons learned by the development of these pilot projects into NCRE projects.

~~103.~~100.The cooperation of the following organizations will be required to implement the program: electric distribution companies, supplying/servicing companies, and user organizations. The operation and maintenance will be provided for a monthly fee.

### 5.3. Executing Agency and Implementation

~~104.~~101.The executing agency of the project will be the CNE. This institution will nominate an official as the National Director of the Project. The National Director has the right to sign contracts and payment orders for the project and he/she is responsible for the efficient execution of the project according to UNDP standard procedures. The project will contract a Project Coordinator to carry out day-to-day management under the direction of the National Director.

~~105.~~102.A Project Co-ordination Committee will be established to support the project execution and guarantee that the project activities are in-line with both the project objectives and the national climate change strategy. The Co-ordination Committee will include a representative from the CNE, a representative from the CONAMA, a representative from the UNDP, and the Project Coordinator.

## CHAPTER 6. INCREMENTAL COSTS AND PROJECT FINANCING

~~106.~~103.The project is estimated to have an incremental cost of approximately US$5,984,900, as presented in the Incremental Cost Annex (Annex A Table A.1). The total value of the project is US$ 32,397,300. The incremental cost by activity is presented in Annex A.

~~107.~~104.GEF is asked to provide US$ 6,067,300 as support for the incremental cost of the project (including the value of the PDF B US$ 82,400). The Government of Chile will provide US$ 16,489,000 in cash, plus US$ 755,000 in-kind. Of the US$ 5,984,300 being provided by

GEF, not considering the PDF B, US$ 2,000,000 will be used as guarantee to finance credits for the implementation of rural electrification projects with NCRE thereby partially mitigating the financial and economic risk perception existing in Chile in relation to these technologies. Therefore, the effective GEF contribution would be US$ 3,984,300. Of this, US$ 794,900 will be used to co-finance the investment of 6,000 PV systems for a solar energy rural electrification demonstration project, which will also be financed by Government contribution (US$ 5,814,000), the private sector (US$ 2,492,000) and the end users (US$ 900,000).

~~108.~~105. Table 6.1 shows the costs of the project activities. It is worth noting that the contribution of the users corresponds solely to the internal installations of their households, and not to the monthly fee that will be paid for service.

~~109.~~106. The project duration is 5 years. All the activities in the project are interrelated and together allow for the removal of the barriers described in Chapter 3 of this document.

~~110.~~107. According to Annex D "Calculations of $CO_2$ reductions", Table D2, the global benefits of the project in terms of $CO_2$ emissions reductions will be 1,754,740 tons of $CO_2$. When the GEF contribution of US$ 5,984,900 is considered, the cost of $CO_2$ reduction is US$ 3.41 per ton of $CO_2$. If the amount of US$ 2,000,000 to be used as a guarantee to finance credits is not included, then this figure decreases to US $2,27 per ton of $CO_2$.

# Table 6.1 Project Financing by Source (US$)

| Activity | GEF Contribution | Government (cash) | Government (in-kind) | Users Contribution | Privates (cash) | Total |
|---|---|---|---|---|---|---|
| Activity 1 Generation of a portfolio of rural electrification projects with NCRE | 300.000 | 200.000 | 36.875 | | | 536.875 |
| Activity 2 Elaboration of Technical Norms for Electrical Systems with NCRE | 365.000 | | 165.000 | | | 530.000 |
| Activity 3 Elaboration of Certification Procedures for Electrical Systems with NCRE | 555.000 | | 36.875 | | | 591.875 |
| Activity 4 Implementation of a Dissemination and promotion Campaign of NCRE | 400.000 | 60.000 | 36.875 | | | 496.875 |
| Activity 5 Training Program Development | 500.000 | | 36.875 | | | 536.875 |
| Activity 6 Design and Execution of a Large-Scale Photovoltaic Demonstrative Project | 794.900 | 5.814.000 | 110.625 | 900.000 | 2.492.000 | 10.111.525 |
| Activity 7 Development of a Financial Mechanism of Risk Mitigation Investment in Projects with NCRE | | | | | | 18.259.625 |
| • Design and development | 70.000 | | | | | |
| • Guaranty Fund for new projects | 1.200.000 | | | | | |
| • Guaranty Fund for hybridization | 800.000 | | | | | |
| • Resources for investment in new projects | | 9.185.000 | 110.625 | 558.000 | 3.936.000 | |
| • Resources for investment in Hybridization | | 1.200.000 | | | 1.200.000 | |
| Activity 8 Definition of the CO2 Emissions Reduction Project by means of Hybridizing the Existent Projects | 200.000 | | 110.625 | | | 310.625 |
| Activity 9 Creation of Training Capacity to Evaluate Wind Resource in Chile | 300.000 | | 110.625 | | | 410.625 |
| Evaluation , Administration, Co-ordination and Monitoring | 500.000 | 30.000 | | | | 530.000 |
| Project Sub Total | 5.984.900 | | | | | |
| PDF B | 82.400 | | | | | 82.400 |
| **Project Total – Including PDF B** | **6.067.300** | **16.489.000** | **755.000** | **1.458.000** | **7.628.000** | **32.397.300** |

## CHAPTER 7. MONITORING, EVALUATION AND DISSEMINATION

~~111.~~108.The project will be monitored by experts from the Co-ordination Committee of the Project, selected by UNDP/GEF or from a consulting firm contracted for this purpose. UNDP's extensive experience in monitoring large projects will be drawn upon to ensure that the project activities are monitored and properly documented. The planning matrix of the project, which includes monitoring indicators, is shown in Annex B.

~~112.~~109.The development of an open information system will guarantee wide dissemination of the lessons learned, as they are substantial. The project will make every effort to identify both successful and unsuccessful experiences so that they can be learned from quickly. This will help investors to make renewable energy investment decisions with the latest available information about success in the Chilean context.

~~113.~~110.The design of this project has drawn upon previous UNDP-GEF sponsored projects and national experience, in particular pilot projects with NCRE that have been developed since 1995. The first lesson has been learned from PV systems implemented in the IV Region and the small hydroelectric power plants in the IX Region. This lesson relates to the importance of equipment standards and installation certification to ensure a high product quality. The second lesson relates to the sustainability of the installations with NCRE over time. It has been verified that the lack of economies of scale makes some projects unattractive for private investors. The failure of some pilot projects implemented with NCRE is due to the lack of basic and detailed engineering studies therefore, from a monitoring point of view, it is of fundamental importance to verifying the quality the engineering aspects of NCRE projects generated under Activity 1.

~~114.~~111.To implement the monitoring and external evaluation, a series of indicators corresponding to each of the activities will be developed. Such indicators will allow, by means of established verification, the implementation of partial evaluations and a final evaluation of the project. In particular, the large-scale PV system project will involve monitoring and evaluation in both the short and long-term. This evaluation process will help to ensure the replicability of this type of project throughout Chile and in other relevant regions.

~~115.~~112.It is worth noting that, among the specified activities of the project, the implementation of a dissemination and promotion campaign has been considered. The objective of the campaign is to publicize, among the participants involved in the REP, the technical, economic and environmental advantages associated in rural electrification with NCRE. The campaign also considers dissemination and promotion to external agents within rural electrification process, so as to promote the advantages represented by the use of NCRE in grid connected systems.

## List of Annexes

## ANNEX A – INCREMENTAL COST

### A.1 Broad Development Goal

The broad development goal of this project is to help Chile incorporate renewable energy technologies into the existing Rural Electrification Program by removing the identified barriers and by demonstrating the social viability and sustainability of these projects, as well as the profitability of their private management.

### *A.2 Baseline*

The actual electricity coverage in rural areas is 76%. The objective of the government is to reach 90% coverage by the year 2005. This coverage will be achieved through privately executed projects. The projects can be subsidized by a decentralized regional development fund, National Fund for Regional Development (Fondo Nacional de Desarrollo Regional, FNDR), if they fulfill the prerequisites (i.e., show positive social-economic return but negative return to the private investor). The subsidies to rural electrification projects totaled almost US$ 115 million between 1994 and 1999.

These projects are mainly grid extension projects, although there exist a few isolated diesel generators and some renewable-based projects. The emphasis on grid extension is due to the existing portfolio of grid extension projects, the feasibility studies that were largely financed by the Government, as well as the reluctance of the principal proponents – distribution companies – to develop other type of projects.

In the absence of the proposed GEF project, this tendency will continue. The electricity coverage will reach 90% by 2005 through the electrification of some 98,000 new households, mostly through interconnection to the grid (90%) and to a lesser extent through stand-alone diesel generators (10%). The private sector will invest some US$ 120 million in these projects and the Government will subsidy them by US$ 180 million. Taking into account the energy mix in the interconnected system and the average fuel consumption in the diesel-powered grids, these new households are estimated to lead to $CO_2$ emissions of some 827,270 tons of $CO_2$ by the year 2020 (i.e., 242,130 tons $CO_2$ for diesel; 585,140 tons $CO_2$ for grid extension. see Annex E, table E.1).

The final 10% of the rural households – about 59,285 in 1999 – are sparsely located in remote areas. They will most likely not be subsidized by the FNDR because the social rate of return for these investments is low due to very high investment needed per household. These households will therefore either continue using candles, kerosene and batteries (charged elsewhere) to satisfy their energy needs (about 90%). Alternatively, if the economic situation permits, up to 10% of households may acquire small gasoline generators for electricity generation. The households use on average US$ 153 for these energy services per year. The NPV for the expenditure using a 10% discount rate amounts to US$ 8.7 million. The use of kerosene and gasoline by these households for illumination purposes generate about 1,426,040 tons of $CO_2$ (baseline) by the year 2020 (see Annex E, table E.1).

On the other hand, some 3,000 rural households that already have electricity rely on diesel-powered small grids. As these households already have access to electricity, they can not participate in the Rural Electrification Program. In the absence of the project, these communities will continue using diesel oil to satisfy their electricity needs. As their economic situation improves, the consumption of fuel is likely to increase in the future (currently many systems only work for a few hours a day). The baseline $CO_2$ emissions resulting from this fuel use are estimated at 95,640 tons of $CO_2$ by the year 2020 (see Annex E, table E1).

Therefore, the total carbon emissions in the baseline case are therefore 2,348,950 tons of $CO_2$ (see Annex E, table E1).

## A.3 Global Environmental Objective

The global environmental objective of the project is to reduce carbon emissions from electricity generationuse in Chile. The project is consistent with the Operational Program #6, "Promoting the adoption of renewable energy by removing barriers and reducing implementation costs". The project seeks to eliminate the identified institutional, financial, as well as capacity- and awareness -related barriers to incorporate renewable energy technologies in the rural electrification program, thus reducing greenhouse gas emissions.

## A.4 GEF Alternative Scenario

In Chile, all social investment projects requiring public finance must be incorporated into the Integrated Project Database (Banco Integral de Projectos) of the National Investment System. The rural electrification projects existing in this database are almost entirely grid extension or diesel generation projects. In the proposed GEF project, a portfolio of renewable energy projects will be generated to compete with the traditional grid extension and diesel generator projects. In order to reduce the high implementation costs of the renewable energy projects, a specific non-grant mechanism will be created. The purpose of this mechanism is to give equal financing conditions to a conventional and a renewable energy project whenever the expected return on these projects is the same – even if the initial investment needed for the renewable project is higher. Furthermore, additional barriers related to information, capacity, technical norms, etc. will be removed by specific activities.

The proposed project aims at demonstrating to the State that renewable energy projects are worth supporting and the social benefits they provide can be sustainable. Similarly, it will demonstrate to the private sector (distribution companies, commercial banks, etc.) that providing energy services using renewable energy can be a profitable business if the projects are carefully designed.

The project will directly install 6,000 PV systems in the IV Region of Chile through a service concession to be awarded to a private enterprise based on an open bidding. Furthermore, it is estimated that some 10% of the households that in the absence of the project would be connected to grid will be electrified using renewable sources and that 80% of fuel will be saved because renewable or hybrid projects will be realized instead of diesel-powered mini grids. Additional fuel savings and hence emission reductions will result from the hybridization of some 650 diesel-

powered systems that are currently operating. The direct reduction of $CO_2$ emissions resulting from these activities is about 90,683 tons of $CO_2$ (see Annex E, table E3) by the year 2020. After the removal of the barriers, the replication potential of these projects makes it economically viable to reduce the $CO_2$ emissions by 1,754,740 tons of $CO_2$ (see Annex E, table E2) before 2020, that means 74,7% of baseline $CO_2$ emissions. A complete review of the methodology used for the emission calculations is presented in Annex E.

### A.5 System Boundary

The system boundary of the project is the rural electrification market in Chile. There are three specific target segments:

1. Households that are within the Rural Electrification Program target of increasing the rural electricity coverage from 76% in 2000 to 90% in 2005;
2. Households that belong to the remaining 10% of the rural population and are not likely to be attended within the REP; and
3. Households that are already electrified and connected to diesel-powered grids which can be converted to hybrid systems.

The total number of these households today is about 143,500. It is estimated that during the project about 10,000 households will be directly intervened and that conditions will be created to use renewable energy in all those households where it is economically viable.

### A.6 Domestic Benefits

The main benefit in both the baseline and the alternative case is the increment in rural electrification from 76% in 2000 to 90% in 2005. In this context, the project does not bring an additional benefit. Nevertheless, there exist some domestic benefits as decreased fuel imports, improved national capacity to deal with renewable energy issues etc. These benefits are not be translated into money in the analysis.

### A.7 Incremental Cost Matrix

Table A.2 summarizes incremental costs activities of the project. Activity 1 will generate a portfolio of projects with renewable energies. Without the projects, only grid extension projects would be taking into account. Activity 2 will develop the standards and regulations for non-conventional technologies, allowing the dissemination of renewable energies. Activity 3 will develop the certification mechanisms necessary to implement the quality of the renewable systems. Activity 4 will allow for the removal of knowledge barrier related to renewable technologies. The training program included in the Activity 5 would be unlikely to take place in the absence of the project and is therefore fully incremental.

Activity 6 proposes the electrification of 6.000 isolated households by means of PV systems within 5 years. The baseline for participating families is the continued use of kerosene, candles

and batteries due to their extreme isolation and dispersal condition. They will not be able to benefit from the Rural Electrification Program promoted by the Government.

Rural families considered in this project spend approximately US$ 15 a month, or US$ 180 a year on candles, kerosene and batteries and other illumination means (excluding equipment cost). Excluding the 18% of the IVA (aggregated value tax), the cost on candles and others is US$ 12.70 a month and US $152.50 a year. Over a 20 year period, the present value (discounted 10%) of these expenditures amounts to US$ 1,451.

At current prices, a 90 W PV system (including a 90 W peak module, charge regulator, battery and 4 fluorescent lamps) cost about US$1,244 (retail) in Chile. Discounting customs duty (10%) to imported goods and the IVA (18%) it comes to US$ 967. To evaluate the full cost of the system over 20 years, replacements must be taken into account. A battery costs US$ 176 (excluding IVA and customs duty) and replacements occur after 4 years. The charge regulator costs US$ 59 (excluding IVA and customs duty) and lasts 10 years, and the fluorescent lamps cost US$ 61 (excluding IVA and customs duty) and must be replaced every 7 years. Therefore, the total present value of a PV system, including replacements comes to approximately US$ 1,667 (excluding IVA and customs duty), over 20 years discounted at 10%.

In summary, the incremental cost estimation for the PV system, including replacements, comes to US$ 1,667 – US$ 1,451 = US$ 216. Though, as the market grows towards its annual target rate of 1,500 systems/year for a period of 4 years, by the end of the project, the price of the PV system is expected to decline on a 13%, that being similar to what rural families pay for the energetic consumption of candles and others. From an initial value of US$ 967 per PV system, it is expected to decline in increasing steps to about US$ 842 at the end of the project. This means that the incremental cost of the PV system will constantly decline from US$ 216 at the beginning until it becomes zero, at the conclusion of the project. The total incremental cost for the installation of 6,000 PV systems is equal to US $794,900, as it is shown on the following table:

**Table A.1 Projected Price and GEF Support for PV Units**

| Year | Installed Systems | Price of the PV System excluding IVA and customs duty (US$) | Incremental Cost per Unit US$ | Total Incremental cost US$ |
|---|---|---|---|---|
| 1 | | | | |
| 2 | 1,500 | 967 | 216 | 323,563 |
| 3 | 1,500 | 934 | 159 | 238,421 |
| 4 | 1,500 | 902 | 104 | 156,179 |
| 5 | 1,500 | 872 | 51 | 76,737 |
| 6 | 0 | 842 | 0 | 0 |
| **Total** | **6,000** | | | **794,900** |

Activity 7 will create a financial mechanism that minimizes risk associated with renewable energy technologies, allowing the displacement of grid extension or diesel power grid projects. Wind resource assessment and capacity development are targeted under Activity 8, permitting the use of wind energy and creating a national capacity for its measurement. Activity 9, generates the

creation of a portfolio of hybridization projects in the country. Investments will grant the implementation of demonstrative projects, reducing $CO_2$ emissions. Co-ordination, Monitoring, Evaluation and Administration are costs associated to the project, and are considered to be totally incremental.

## Table A.2 Incremental Cost Matrix (Costs in US$)

| *Component* | *Benefits/Costs* | *Baseline* | *Alternative* | *Increment* |
|---|---|---|---|---|
| Development of a RE portfolio to be incorporated in the Integrated Project Database | Global Environmental Benefits | Limited amount of renewable energy projects in the portfolio | Renewable energy projects compete fairly with grid-extension and diesel projects in the portfolio | Significant increase in the amount of RE projects in the portfolio (12,500 houses PV, wind an hydro) |
| | Domestic Benefits | Goals of the Rural Electrification Program reached using grid extension and diesel generators | Goals of the Rural Electrification Program reached using grid extension, diesel generators and RET | None |
| | Costs | **200,000** | **500,000** | **300,000** |
| Developing technical norms for RET | Global Environmental Benefits | Lack of technical norms prevent the dissemination of RET | Technical Norms permit RET dissemination | The barrier related to lack of technical norms is removed |
| | Domestic Benefits | Technical norms relate only to conventional energy | Technical norms include both conventional and renewable energy | Increase in technical norms |
| | Costs | **0** | **365,000** | **365,000** |
| Developing certification procedures | Global Benefits | Lack of capacity and mechanisms to certificate RET components and installations | Established RET certification | RET certification makes it possible to enforce the standards and improves the quality of RE systems |
| | Domestic Benefits | None | None | None |
| | Costs | **0** | **555,000** | **555,000** |
| Diffusion and promotion campaign | Global Benefits | Only limited knowledge and information on RET | Extensive diffusion and promotion campaigns remove barriers related to information and awareness | Information and awareness barriers removed |
| | Domestic Benefits | None | None | None |
| | Costs | **60,000** | **460,000** | **400,000** |
| Training Programme | Global Benefits | None | In-country capacity to deal with RET created | Capacity-related barriers removed |
| | Domestic Benefits | No demand for renewable energy training; no supply of renewable energy training. | Supply of renewable energy training satisfies the demand | None |
| | Costs | **0** | **500,000** | **500,000** |

| *Component* | *Benefits/Costs* | *Baseline* | *Alternative* | *Increment* |
|---|---|---|---|---|
| Commercial PV demonstration | Global Benefits | None | Social sustainability of PV electrification and commercial viability of PV services industry demonstrated; 6,000 households using PV systems avoid 25,920[9] tons of $CO_2$ from being emitted in 20 years; potential to reduce 1,426,040[10] tons of $CO_2$ emissions by the year 2020 through PV technology unleashed | Social sustainability of PV electrification and commercial viability of PV services industry demonstrated; 6,000 households using PV system avoid 25,920[1] tons of $CO_2$ from being emitted in 20 years; potential to reduce 1,426,040[2] tons of $CO_2$ emissions by the year 2020 through PV technology unleashed |
| | Domestic Benefits | - 6,000 households have energy services (illumination, radio etc.) through use of kerosene, candles, batteries etc. for which each family spends about US$ 153 per year;<br>- Social benefits generated by investing US$ 5.8 million of public resources for social investments other than PV electrification | - 6,000 households have energy services (illumination, radio etc.) through use of PV systems for which each family spends about US$ 153 per year;<br>- Social benefits generated by investing US$ 5.8 million of public resources for PV electrification | Improvement in the quality of lighting and indoor air; time savings in battery charging |
| | Costs | **14,514,000** | **15,308,900** | **794,900** |

[9] See Annex D, Table D3
[10] See Annex D, Table D2

| *Component* | *Benefits/Costs* | *Baseline* | *Alternative* | *Increment* |
|---|---|---|---|---|
| Risk mitigation mechanism | Global Benefits | None | Mechanisms to direct investments to RET created; perception of risks related to RET reduced; 4,370 households electrified using RET avoiding 64,763[1] tons of $CO_2$ emissions in 20 years; potential to reduce 328,700[2] tons of $CO_2$ emissions by the year 2020 through RET unleashed | Mechanisms to direct investments to RET created; perception of risks related to RET reduced; 4,370 households electrified using RET avoiding 64,763[1] tons of $CO_2$ emissions in 20 years; potential to reduce 328,700[2] tons of $CO_2$ emissions by the year 2020 through RET unleashed |
| | Domestic Benefits | Rural Electricity coverage raised to 90% by investing US$ 180 million of public resources and US$ 120 million of private resources in grid extensions and diesel generators | Rural Electricity coverage raised to 90% by investing US$ 170.8 million of public and US$ 116 million of private resources in grid extensions and diesel generators and US$ 9.2 million of public and US$ 4 million of private in RE projects | None |
| | Costs | **300,000,000** | **302,070,000** | **2,070,000** |
| Wind resource assessment and capacity development | Global Benefits | None | Assessment of wind resources permit the use of wind energy; national capacity to carry out resource assessments created. | Barriers related to lack of wind resource information and capacity to measure the resource removed |
| | Domestic Benefits | None | None | None |
| | Costs | **0** | **300,000** | **300,000** |
| Development of a hybrid project portfolio | Global Benefits | None | The profitability of investment for change from diesel system to hybrid investments demonstrated. | The profitability of investment for change from diesel system to hybrid investments demonstrated. |
| | Domestic Benefits | None | None | None |
| | Costs | **0** | **200,000** | **200,000** |

| *Component* | *Benefits/Costs* | *Baseline* | *Alternative* | *Increment* |
|---|---|---|---|---|
| Coordination, monitoring and evaluation | Global Benefits | None | Barriers removal project successfully executed; global benefits monitored and evaluated | Barriers removal project successfully executed; global benefits monitored and evaluated |
| | Domestic Benefits | None | None | None |
| | Costs | **0** | **500,000** | **500,000** |
| ***TOTAL*** | **Global Benefits** | **Various barriers impede the use of RET and only a limited number of RE projects are realized in Chile** | **- Barriers to the use of RET in rural electrification removed;<br>- Over 90,683[3] tons of $CO_2$ emissions avoided directly in 20 years because of the project activities;<br>- Potential to abate 1,754,740[4] tons of $CO_2$ by the year 2020 unleashed** | **- Barriers to the use of RET in rural electrification removed;<br>- Over 90,683[3] tons of $CO_2$ emissions avoided directly in 20 years because of the project activities;<br>- Potential abate 1,754,740[4] tons of $CO_2$ emissions by the year 2020 unleashed.** |
| | **Domestic Benefits** | **Rural Electricity coverage reaches 90% by the year 2005** | **Rural Electricity coverage reaches 90% by the year 2005** | **None** |
| | **Costs** | **315,974,000** | **321,958,900** | **5,984,900** |

[3] See Annex E, Table E3
[4] See Annex E, Table E2

## ANNEX B – PROJECT PLANNING MATRIX

| Project Strategy | Indicators | Means of Verification | Assumptions |
|---|---|---|---|
| Project Development Goal:<br>Reduction of $CO_2$ emissions resulting from the generation of electricity in Chile | $CO_2$ emissions from the electrical sector decrease on a 62.61Gg | National Broadcasting<br>Official Statistics | Development of an Investment Plan for the REP |
| Project Purpose:<br>Incorporation of NCRE in the REP | Percentage of NCRE in the REP | Official Statistics<br>Reports of the Project | Incorporation of NCRE in the Institutional Frame |
| **RESULT 1:**<br>Structured Portfolio of NCRE Projects | 1.1 Each year 10 new NCRE projects will be included in the BIP | 1.1 BIP Database<br>1.2 National Investment System | Existence of renewable resources for their application |
| **RESULT 2:**<br>Establishment of Technical Regulations | 2.1 Four new Regulations, per technology, will be Published: PV, wind, small power-houses, and biomass/agricultural residues | 2.1 Chilean Official Newspaper | Effective Application of the Regulations |
| **RESULT 3:**<br>Implementation of Certification Mechanisms | 3.1 Number of realized Certifications (depending of the number of effectively executed projects) | 3.1 Superintendent of Electricity and Fuel | Certification Procedures are Effectively applied |
| **RESULT 4:**<br>Operational Dissemination and Promotion Campaign | 4.1 Increase in the need - from rural communities -of electrification projects with NCRE | 4.1 Reports from the municipality (City Hall) | Existence of means to Apply the Campaign in Chile |
| **RESULT 5:**<br>Operational Training Program | 5.1 Number of courses implemented for the following levels:<br>▪ Regional politics (project creators)<br>▪ Engineers and technicians<br>▪ Users | 5.1 Reports of the Project<br>5.2 SENCE | Existence of Institutions Training on NCRE |
| **RESULT 6:**<br>PV Commercial demonstration | 6.1 One thousand (1000) systems will be Installed each year | 6.1 Report of Projects<br>6.2 Databases | Existence of Co-financing State-Privates-Users |
| **RESULT 7:**<br>Establishment of a Financial Risk Mitigation Mechanism | 7.1 At least one executed project per type of technology | 7.1 Bimonthly Reports | Existence of an Institution Assuming the Responsibilities of the Project |
| **RESULT 8:**<br>Implementation of a Portfolio of Hybrid projects | 8.1 At least two Hybrid Projects in the BIP | 8.1 Official Statistics | Existence of Wind Resource<br>Existence of an Institution Assuming the Administration of the Projects |
| **RESULT 9:**<br>Generation of Technical and Practical Knowledge to Implement wind resource Measurements | 9.1 Measurements Taken at established Stations | 9.1 Reports of the Project | Existence of Institutions to develop measurements |

## ANNEX C – STAP ROSTER TECHNICAL REVIEW

**STAP Roster Independent Technical Review**
**by Dean Abrahamson, 21 June 2000**

Minneapolis, MN

Re: Review of Chile Project Brief "Chile: Removal of Barriers for Rural Electrification with Renewable Energies"

### CHAPTER 1: Background and Context

The Brief at 1.1.5 notes the susceptibility of hydropower to changes in the hydrological regime. It is outside of the scope of the present project, but attention should be given to the range of hydrological changes that appear likely with additional climatic change. The impacts on Chile could be serious.

### CHAPTER 2: Project Objectives & Description

The Project Objectives, section 2.1, are clearly stated as is the Rationale for GEF Financing, section 2.2.

Section 2.3, The Barriers to the Utilization, . . . , has many words but is obtuse. I think that I have decoded the section, and it makes sense. It is curious that while the Brief relates the long history of Renewable Energy in Chile, section 1.3, paragraphs 23-25, the Barriers section implies that there is not much in the way of infrastructure to develop new NCRE.

### Chapter 3: Project Activities, Components, and Expected Results

[I have noted financing from Table 6.1: GEF/Government Cash/Government In-Kind, in 1,000s US$)

Activity 1: $300/200/37 -- looks o.k.

Activity 2: $365/0/165 -- looks o.k.

Activity 3: $555/0/37 -- looks o.k.

Activity 4: $400/60/37 -- this description is rather vague. It is by no means clear that this activity, as described in the Brief, is central to the overall project. More detail on the "promotional campaign," would be welcome particularly given that it involves a very high ratio of GEF:Government funding.

Activity 5: $500/0/37 -- looks o.k.

Activity 6: $795/5,814/110 -- looks good.  I suggest that the activity be expanded to include both short- and long-term follow up on the PV systems' performance.

Activity 7: $2,070/10,385 -- looks o.k., but a bit more detail on criteria for dipping into, and the management of the "Guarantee Fund" would be helpful.

Activity 8: $200/0/111 -- looks o.k.

Activity 9: $300/0/111 -- looks o.k.

**CHAPTER 4: Risks and Sustainability**

Paragraph 91 deals with the issue of projects being "economically competitive with grid extensions."  A bit more detail would be welcome.  I hope that social benefits are given weight at least equal to strictly economic benefits.  This is an issue faced by all rural electrification programs.

**CHAPTER 5: Participation, Sustainability & Implementation**

It looks o.k.

**CHAPTER 6: Incremental Costs & Project Financing**

Lacking a very detailed budget, and sufficient time for a review of budget items, it is impossible for me to provide detailed commentary on costs and financing.

**CHAPTER 7: Monitoring, Evaluation & Dissemination**

Please note comment above on Activity 6.  Otherwise it looks o.k.

**GENERAL COMMENTS:**

This seems to be a good project.

The cost of avoided tonne of carbon is very high.  I am certain that many projects in Chile, e.g., in increasing the efficiency of large electric motors in the mining sector, would have much lower costs per avoided emissions in cost/tonne of carbon.  Rural electrification, however, must be judged on a number of criteria.  I grew up on a Minnesota farm that did not have electricity until I was in high school and I well remember the enormous benefits that electricity brought to my family.  Many of these benefits would be exceedingly difficult to quantify, let alone value in monetary terms.  (This relates to comment above at Chapter 4, paragraph 91.) [I note that carbon emission reduction, per se, is not stressed in Section 2.2, "Rationale for GEF Financing."]

A bit more detail regarding Activities 4, 6 & 7 would be welcome (as noted above).

This project could form a model for similar activities in many other countries in Central & South America and elsewhere. I urge that it be carefully documented and evaluated to that end.

Dean Abrahamson, M.D., Ph.D.
Professor Emeritus
tel: (612) 623-9449
fax: (612) 623-9449
dabrahamson@hhh.umn.edu

## ANNEX C (CONTINUED)
## RESPONSE TO STAP ROSTER TECHNICAL REVIEW

The STAP roster reviewer suggested that “Removal of Barriers for Rural Electrification with Renewable Energies” seems to be a good project overall. It is suggested that this project could form a model for similar activities in many other countries in Central & South America and elsewhere, and the reviewer urges that the project be carefully documented and evaluated to that end.

However, as outlined below, the STAP roster reviewer made several suggestions as to how the project could be improved.

- ***It is curious that while the Brief relates the long history of Renewable Energy in Chile, section 1.3, paragraphs 23-25, the Barriers section implies that there is not much in the way of infrastructure to develop new NCRE.***

  Chile has had some experience in developing the use of NCRE, in particular with the objective of quantifying the resources and establishing some isolated thermal solar projects. However, these experiences have failed to develop a NCRE market mainly because they were isolated experiences and were not part of a global politics in this issue.

  In the last decade, pilot projects were implemented under the political framework with the intent of evaluating technologies and organizational issues. The nature and scope of the barriers, as discussed in the project brief (see Section 2.3 Barriers to the Utilization of NCRE in Rural Electrification), did not allow for the development of a sufficient infrastructure for NCRE.

- ***Activity 4: $400/60/37 -- this description is rather vague. It is by no means clear that this activity, as described in the Brief, is central to the overall project. More detail on the "promotional campaign," would be welcome particularly given that it involves a very high ratio of GEF:Government funding.***

  The activities involves in the promotional campaign include: design of the national promotion campaign; developing advertisement production for TV, radio and the news media; developing advertisement campaign during the project execution; promotion through workshops and specialized events; promotion through specialized media; design and support of the project webpage; promotion of specific outcomes of the project, such as standards, certification procedures, Guarantee Fund, among others; and evaluation and monitoring of the promotional campaign. This additional detail has been added to the project brief under paragraph 67~~676767676769~~.

  The implementation of this activity will make use of institutional agreements that the

Government has with different media. Although these institutional agreements exist, this activity is totally incremental because the resources used for promotion focus on other sectors with more social impact, such as health and education, among others.

The following is a breakdown of resources used for the promotional campaign:

- Design of national promotion campaign. US$ 20,000
- Advertisement production for TV, radio and the media. US$ 35,000
- Advertisement campaign during the project execution US$ 300,000
- Promotion in Workshops and specialized events US$ 10,000
- Promotion in specialized media US$ 20,000
- Design and support of Project WEB Page US$ 25,000
- Promotion of specific outcomes of the project, such as standards, certification procedures, Guaranty Fund, among others. US$ 25,000
- Evaluation and monitoring US$ 25,000.

- ***Activity 6: $795/5,814/110 -- looks good. I suggest that the activity be expanded to include both short- and long-term follow up on the PV systems' performance.***

The reviewer's comment on including short- and long-term follow-up on performance has been added into the project (see paragraph 75757575757577). To help ensure this replicability of this type of project, Activity 6 will involve both short and long-term follow up on the PV systems' performance. This monitoring will assist with problem solving and with promoting and replicating the results of the experience in other areas of the country. Additional information on this activity is provided below.

Activity 6 involves the implementation of a large-scale demonstration project using PV systems, where a private company will be involved to ensure the sustainability of the PV systems. The financing of this project considers contributions from the State, the private company, the users and the GEF. This activity takes advantage economies of scale associated with the provision of 6,000 PV systems, as 1,500 are installed per year over four years. Based on a bidding process, the successful company will be responsible for the installation of the 6,000 PV systems, the technical support, re-investment and operation of the equipment, and energy sale during over 20-year period.

The legal framework that will regulate the participation of the private company is the same as that currently used in the Rural Electrification Program for the supply of electricity in isolated communities using diesel-fueled generators. This considers the subscription of three documents: (i) Administration Contract between the Regional Government and the Private Company; (ii) Service Contract between the Private Company and the customers; and (iii) Agreement for prices and quality of service, between the Private Company and the Mayor of each Municipality. These documents will be adapted to reflect the specific characteristics of the NCRE systems in general and the PV systems in particular.

- ***Activity 7: $2,070/10,385 -- looks o.k., but a bit more detail on criteria for dipping into, and the management of the "Guarantee Fund" would be helpful.***

  Additional information on the Guarantee Fund has been provided in paragraphs 76767676767678 to 83838383828386.

  The Guarantee Fund is needed in order to eliminate or mitigate the economic and financial risks associated with the investment differential in projects using NCRE, opposite to electrification using diesel generators. The Fund will cover the difference in investment amounts between the two project alternatives: the diesel solution and NCRE solution, equalizing costs between alternatives. Also, the Fund will guarantee the investments in hybrid energy projects that will allow for the transformation of approximately 650 households out of potential market of 3,000 households.

  While the specific administration and operation mechanism of this Guarantee Fund will be developed during the project execution, the Fund will support Chile's national financial banking with the application for credits from the private sector, with the intent of only covering the differences between investment costs for the NCRE projects. For each project that is executed under this mechanism, the project will grant an equivalent monetary guarantee for the investment differential to the private banking that will finance this differential.

  When an investor determines cost inequality between alternatives, the Guaranty Fund will be released thereby guaranteeing new projects under this mechanism. During the GEF project execution, the use of this mechanism will allow for the reduction in the uncertainties associated with cash flows and will facilitate the removal of financial barriers in this market. The objective of the Guarantee Fund is to provide backing to the national financing system for awarding credits for project financing of NCRE and the transformation of diesel systems to NCRE. By the end of the project, financial institutions will award credits to projects using NCRE, without having to provide additional guarantees for the assignment of such credits.

- ***Paragraph 91*** **[now 91919191919091 94]** ***deals with the issue of projects being "economically competitive with grid extensions." A bit more detail would be welcome. I hope that social benefits are given weight at least equal to strictly economic benefits. This is an issue faced by all rural electrification programs.***

  The social benefits of the project are considered in the evaluation of each project. According to the "Methodology of Evaluation Projects for Rural Electrification", from the Ministry of Planning and Cooperation (MIDEPLAN), all the rural electrification projects must be evaluated in both economic and social terms. The economic evaluation allows for the calculation of the state subsidy amount required for each project; and, the social evaluation allow permits the best technological alternative to be chosen for implementation in the rural electrification project (i.e., diesel, grid extension or NCRE).

- ***Lacking a very detailed budget, and sufficient time for a review of budget items, it is impossible for me to provide detailed commentary on costs and financing.***

  The budget, provided in Table 6.1, has been revised to show greater detail for Activity 7.

- ***Monitoring and Evaluation: Please note comment above on Activity 6. - I suggest that the activity be expanded to include both short- and long-term follow up on the PV systems' performance.***

  The reviewer's comment on including short- and long-term follow-up on performance has been added into the project description (see paragraph 75757575757577) and also under Monitoring and Evaluation (111111111111110111114). To help ensure this replicability of this type of project, Activity 6 will involve both short and long-term follow up on the PV systems' performance.

- ***The cost of avoided tonne of carbon is very high. I am certain that many projects in Chile, e.g., in increasing the efficiency of large electric motors in the mining sector, would have much lower costs per avoided emissions in cost/tonne of carbon. Rural electrification, however, must be judged on a number of criteria…Many of these benefits would be exceedingly difficult to quantify, let alone value in monetary terms. (This relates to comment above at Chapter 4, paragraph 91.) [I note that carbon emission reduction, per se, is not stressed in Section 2.2, "Rationale for GEF Financing."]***

  Additional information on costs of $CO_2$ reduction is provided in paragraph 107107107107106107110.

  According to Annex D "Calculations of $CO_2$ reductions", Table D2, the global benefits of the project in terms of $CO_2$ emissions reductions will be 1,754,740 tons of $CO_2$. When the GEF contribution of US$ 5,984,900 is considered, the cost of $CO_2$ reduction is US$ 3.41 per ton of $CO_2$. If the amount of US$ 2,000,000 to be used as a guarantee to finance credits is not included, then this figure decreases to US $2,27 per ton of $CO_2$.

- ***A bit more detail regarding Activities 4, 6 & 7 would be welcome (as noted above).***

  As described in the above response, additional information has been added to Activities 4 paragraph 67676767676769), Activity 6 (paragraph 75757575757577) and Activity 7 (paragraphs 76767676767678 to 83838383828386).

## ANNEX D – STUDIES IN THE FRAME OF THE PDF B

~~a)~~

~~a)~~With the purpose of collecting the necessary information for the elaboration of the present project, five different investigations concerning six different subject areas were undertaken through PDF Bs. The following are the objectives and executive summaries of each of these investigations.

~~a)~~

### 1. Estimation of the Rural Electrification Potential with Renewable Energies

***Objective***

~~a)~~Estimate the replication potential, in rural areas of the country, for: PV, small and mini hydroelectric plants, wind systems, biomass/agricultural residues and hybrid systems as alternatives for rural electrification.

***Executive Summary***

An in-country information compilation was carried out. It concerned population data, quantity of urban and rural households, number of households having or not access to electricity, area and economic activity. It allowed to differentiate 16 types of communities. Estimations were made in relation to solar, wind, hydro and biomass/agricultural residues potentials. Finally, a field visit, at least one to each type of community, was carried out to determine the number of households that can be supplied with renewable energies. After applying the results to the rest of the communities of the country, estimations indicate that 30,000 households will never be reached by conventional electricity (power line/grid extension), and therefore, are potentially electrifiable by renewable energies.

### 2. Preparation of a Risk Mitigation Mechanism for Renewable Energies

***Objective***

~~a)~~Elaborate a risk mitigation mechanism in order to counteract technical and financial risks presented by technologies and renewable energy projects.

***Executive Summary***

~~a)~~The study consisted of the implementation of analysis of economic, financial and operational aspects of electrification projects with NCRE, operating in Chile. The purpose of the study was to limit risk perception and to prepare mitigation mechanisms. PV, wind, biomass/agricultural residues and hybrid projects were analyzed. The result was the identification of a series of operational and financial risks, assigned to importance and related to each technology. The investigation also proposes the implementation of actions or activities to decrease the risks associated with NCRE.

~~a)~~

### 3. Preparation of a Financial Product for PV Systems

***Objectives***

~~a)~~Elaboration of a financial made-to-order product, for the acquisition of PV systems for rural electrification.

~~a)~~

***Executive Summary***

~~a)~~A compilation of national and international information related to available financing alternatives was carried out. A model PV project was designed, considering investment, operations and maintenance. Finally, the payment ability of the users was analyzed. By analyzing the information collected and generated in the investigation, no conventional financial mechanisms for this type of projects were found. Furthermore, potential users are not to be awarded credits from financial institutions, therefore, the study proposes the utilization of a non-conventional credit, awarded by special programs, and design to facilitate access to institutional credit. This credit will co-finance the investment in combination with state subsidy provided by FNDR and contribution from the users.

### 4. Finalization of Investment Plans to Electrify 3.100 households in the X Region by Means of Wind-Diesel Hydro Systems

***Objectives***

~~a)~~(1) Evaluate technical and economical feasibility to electrify 3.100 families inhabiting the islands of the Archipielago de Chiloé located in region of Los Lagos, which will not have access to electricity through grid extension, using wind-based self-generation systems.

~~a)~~Identify all the potential beneficiaries of each of the projects and enclose social information (CAS II score), for each of them.

~~a)~~(2) Propose a tariff structure, and an administration scheme for the systems.

***Executive Summary***

The study implemented the recollection of the existent information in relation to the objective population of the 32 islands of the Archipielago de Chiloé. Reviewing on field trips, each of the location for wind generation equipment, accessibility, technical and legal feasibility, and utilization. t was visually verified, and by digital cartography, the non-existence of geographical irregularities, or forest that might obstruct the wind from reaching the installation. On the other hand, the study provides the baseline to formulate and calculate a structure and level of tariff in the islands. To that end, the following aspects were considered: form of consumption of the users; alternatives and cost of measuring the supply to each household and group of households; feasibility to apply a fix charge; definition and feasibility of a variable charge; billing cost; periodicity of billing; feasibility of an additional subsidy for cases in which charges are not able to cover Operation and Maintenance cost of the proposed solutions.

### 5. Elaboration of Documents for Investment Plans in the IV and X Region

***Objectives***

~~a)~~(1) Definition of the legal frame in which the projects must be executed, considering the

alternative management schemes designed for them.
~~a)~~(2) Preparation of the documents for investment plans, taking into consideration institutional frames and operationally defined schemes.

***Executive Summary***
~~a)~~The study was divided in three parts. In the first, potentialities and legal restrictions, provided in Chilean legislation, in relation to rural electrification, were identified. Secondly, it defined the minimum content of the documents with which licitation would be implemented. Thirdly, legal and servicing alternatives were studied, along with the types of contract that must be consider upon selecting an alternative. To sum up, the study provides a discussion of the main aspects that influence the implementation of rural electrification projects, its limitations and restrictions, analyzing alternatives and procedures to carry out an international licitation.

## 6. Design of a Training Program for the Introduction of Renewable Energies in the Electrification of Rural Households in Chile

***Objectives***
~~a)~~To elaborate a –use and utilization- training program with renewable energies, for companies, technicians, users, supervisors, and the institutions that participate in rural electrification with renewable energies.

***Executive Summary:***
~~a)~~As a product of an analysis implemented to four ex post evaluation project studies of rural electrification with NCRE, a series of problems and consequences that influence the success of projects with NCRE were identified. To overcome each of the deficiencies found in the evaluation, construction, operation and maintenance of the projects, it is conclusive the need to train the different participants involved in this type of project, -users, installers, and even the creators-, developing different training activities. As a result, a training program proposal was implemented, consisting of 5 courses, specifying contents, objectives, duration, amount of students and profile of the participants for each of them.

## ANNEX E – CALCULATION OF $CO_2$ REDUCTIONS

### GENERAL METHODOLOGY

#### *Households*

Households bound to growth, increase at a 1.48% rate.

Households included in the Rural Electrification Program only increase according to the planned program until 2005, and when the numbers become stable.

#### *Emissions Calculations*

Emissions were determined by the IPCC methodology. Emission factors for every fuel were calculated. First, it is necessary to transform fuel consumption into energy units, specifically, Tera calories (Tcal) The emission factor are calculated as described in the section below.

#### a) Gasoline

| | |
|---|---|
| Density of gasoline | 0.81 kg/L |
| Gasoline calorific power | 11,100 Kcal/kg |
| Fuel consumption | 1.5 L/household/hour |

It was estimated that household consumption is 1.5 L/hour. Average use of the equipment is 6 hours per day. With this information, it is possible to calculate fuel consumption per year.

The consumption in a year is transformed to Tcal units, by using the following methodology:

$$\text{Tcal Consumption} = \underbrace{\underbrace{\underbrace{\underbrace{\text{L.Consumption x density (0.81) x Calorific Power (11.110)}}_{\text{Kcal}} \text{ x } 1/\ 1000}_{\text{Mcal}} \text{ x } 1/\ 1000}_{\text{Gcal}} \text{ x } 1/1000}_{\text{Tcal}}$$

The calculation of the emission factor is done as follows:

- Transformation of Tcal to Tera Joule (TJ) by multiplying by 4.1868.
- Transformation of superior calorfic power (PCS) to inferior calorific power (PCI)by multiplying by 0.95.
- Carbon emission factor: 19.6 tonC/TJ.
- Calculation of oxidized carbon: Multiply by 0.99.
- Transformation to $CO_2$: multiply by 44/12.

Emission Factor = 4.1868 x 0.95 x 19.6 x 1/1000 x 0.99 x 44/12

TJ and PCI

Carbon in tons

Carbon in Gg

Oxidized Carbon Calculation

Transformation of Carbon to $CO_2$

Emission Factor = 0,283 Gg $CO_2$/Tcal

**~~a)~~b) Diesel**

Density of gasoline 0,84 kg/l
Gasoline calorific power 10.900 Kcal/kg
Fuel consumption 0.16 L/household/hour

Consumption was estimated at 1.6 L/per equipment per hour. Since each equipment supplies 10 households, therefore, total consumption must be divided by 10.

A 3% increase in daily duration of fuel use was assumed, in relation to the economic growth of the country and the ability of the user to buy a larger amount of fuel.

The emission factor is calculated, considering that the emission factor of carbon is 20,2 ton C/TJ. The Emission Factor is 0.292 Gg $CO_2$/Tcal.

**~~a)~~c) Natural Gas**

Calorific power 9341 Kcal/$m^3$
The specified consumption of Natural Gas is GN 0.2 $m^3$/Kwh

The calculation of Natural Gas consumption is done in a different way. An average of 80kwh/ month of electricity consumption per household is assumed. By multiplying for specific consumption, natural gas consumption per household per month is obtained.

The procedure to transform $m^3$ of fuel consumption into Tcal is similar to the one described above. The volume of fuel must be multiplied by the calorific power, transforming it into Kcal, which must then be transformed into Tcal.

The calculation of the emission factor of natural gas, corresponds to the procedure utilized in the calculation of the emission factor in gasoline and diesel, with the following exceptions:

- Transformation of the calorific superior power to inferior calorific power: Multiply by 0.9.
- Emission factor of Carbon: 15.3 tonC/TJ.
- Calculation of oxidized Carbon: Multiply by 0.995.

Therefore, the emission factor = 0.21 Gg $CO_2$/Tcal.

**~~a)~~d) Candles**

The calculation of the emissions of candles, is the only one not corresponding to the IPCC methodology. It was calculated in relation to the GEF's report in Peru.

It did not consider an increase in fuel consumption due to the fact that candles are mainly utilized for illumination.

Consumption of fuel 6 kg kerosene/ household-month
Emission factor 3 kg $CO_2$/month

The total $CO_2$ emissions in the baseline are provided in Table E.1, and these emissions will be produced if this project is not implemented.

**Table E-1. Total $CO_2$ Emissions out of the Project**

| Sector | Fuel | Households Year 0 | Households Year 20 | Volume of Fuel (20 years) | Emission Factor | 20 years Total Emissions Factor (Gg) |
|---|---|---|---|---|---|---|
| Out of the Program | Petrol<br>Candle | 6,009<br>53,276 | 7,952<br>70,523 | 455,978 m3<br>88,622 ton. | 0.283 Gg/tc<br>3 kg/kg | 1,160.17<br>265.87 |
| In the Program | Diesel<br>Grid Extension | 1,703<br>15,324 | 9,824<br>88,420 | 90,674 m3<br>297.8 mill m3 | 0.292 Gg/tc<br>0.210 Gg/tc | 242.13<br>585.14 |
| Electrified | Diesel | 3,000 | 3,966 | 35,817 m3 | 0.292 Gg/tc | 95.64 |
| | | | | | | **2348.95** |

Table E.2 shows the impacts of the project in terms of emission avoidance with respect to the baseline.

**Table E.2 Global Results of the Project in Terms of $CO_2$ Reduction Emissions**

| Sector | Fuel | Households Year 0 | Households Year 20 | Volume of Fuel (20 years) | Emission Factor | 20 years Total Emissions Factor (Gg) |
|---|---|---|---|---|---|---|
| Out of the Program | Petrol<br>Candle | 6,009<br>53,276 | 7,952<br>70,523 | 455,978 m3<br>88,622 ton. | 0.283 Gg/tc<br>3 kg/kg | 1,160.17<br>265.87 |
| In the Program | Diesel<br>Grid Extension | 1,703<br>1,532 | 9,824<br>8,842 | 72,539 m3<br>29,7 mill m3 | 0.292 Gg/tc<br>0.210Gg/Tc | 193.70<br>58.50 |
| Electrified | Diesel | 3,000 | 3,966 | 28,654 m3 | 0.292 Gg/tc | 76.50 |
| | | | | | | **1,754.74** ***or 478,565 ton C*** |

For the entry "out of the program", which are the emissions reduced by the project, this corresponds to 100%, because all of the systems will be transformed to PV systems.

For the entry "in the program", the emissions reduction correspond to diesel use, and are equivalent to 80% of the total consumption in Table E2. Here, the change of a diesel engine to hybrid or other renewable

systems (other than PV), allows for a 80% fuel saving. In relation to those which will be supplied through grid extension, 10% of the households could be electrified through non-PV renewable energy projects.

Table E.3 shows the direct impact of the project in terms of emission reductions. That is, the emission reduction that will be achieved only with the households that will be electrified under the financing of this project.

**Table E.3 Direct Benefits of the Project in Terms of Reductions of $CO_2$ Emissions**

| Sector | Fuel | Households Year 0 | Households Year 20 | Volume of Fuel (20 years) | Emission Factor | 20 years Total Emissions Factor (Gg) |
|---|---|---|---|---|---|---|
| Not in the Program | Candles (1) | 6,000 | 6,000 | 8,640 ton | 3 kg/kg | 25.92 |
| In the Program | Renewable | 3,720 | 3,720 | 26,069 m3 | 0,292 Gg/Tc | 55.69 |
| Electrified | Diesel | 650 | 650 | 4,555 m3 | 0,292 Gg/tc | 9,07 |
| | | | | | | **90.68** ***or 24,730 tonC*** |

In the entry "Out of the Program", 6,000 households using kerosene candles will use PV systems thereby producing a 100% decrease in the emissions.

The direct use of renewables in 3,720 households included in the electrification program implies an 80% decrease of the emissions due to the utilization of hybrid systems. This applies to projects implemented “in the program” and the “electrified” households.