Progress Report #4

NRECA Cooperative Development Program

January 1, 2006 – June 30, 2006

NRECA International Ltd.

Your Touchstone Energy® Partner

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January 1, 2006 – June 30, 2006

Prepared for:

Office of Private and Voluntary Cooperation
Bureau for Democracy, Conflict and Humanitarian Assistance
U.S. Agency for International Development
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List of Acronyms

ADB – Asian Development Bank
AKFED – Aga Khan Fund for Economic Development
BANRURAL – Banco de Desarrollo Rural (Guatemala)
CAS – Corporate Advisory Services (IFC)
CFC - National Rural Utilities Cooperative Finance Corporation (U.S.)
CDP - Cooperative Development Program
CLARITY – Cooperative Legal and Regulatory Initiative
DBP - Development Bank of the Philippines
DfID – Department for International Development (DfID)
ECs – Electric Cooperatives (Philippines)
ERC – Energy Regulatory Commission (Philippines)
ESMAP – Energy Sector Management Assistance Program (World Bank)
FFP - Food for Progress (USDA)
IFC - International Finance Corporation (World Bank Group)
INDE – Instituto Nacional de Electrificacion (Guatemala)
MCC – Millennium Challenge Corporation
MDB – Multilateral Development Bank
MoP – Ministry of Power (India)
NCBA – National Cooperative Business Association (U.S.)
NEA – National Electrification Administration (Philippines)
NEP – NRECA Electricity for Progress, LLC
NRECA - National Rural Electric Cooperative Association
OCDC – Overseas Cooperative Development Council
PHILRECA – Philippines Rural Electric Cooperative Association
PIC – Philippines Infrastructure Corporation
PFC – Power Finance Corporation (India)
REFC - Rural Electrification Financing Corporation (Philippines)
TAG – Technical Assistance Guide
USDA - U.S. Department of Agriculture
USAID – U.S. Agency for International Development
USTDA – U.S. Trade and Development Agency

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1. CDP Purpose and Overview

The purpose of NRECA's Cooperative Development Program is to promote the electric co-op model as a proven system for delivering electricity to serve local development on a commercially successful basis. We are using the CDP to access electric utility sector and rural electrification development policy-making in order to gain opportunities to demonstrate how the electric cooperative business model can fill the gap between failed state-owned utilities and the shortcomings of privatization.

Our primary strategy, encompassing **Component 1, CDP Partnerships,** is to establish alliances with the major multilateral agencies, who provide most of the policy influence and financing for rural electrification, together with other strategic partners who share similar goals. We will support this strategy in **Component 2, CDP Source-kit**, which will accumulate and disseminate comprehensive and usable documentation of NRECA's lessons learned and tools for designing and implementing successful cooperative electrification enterprises.

Our overall CDP objective is to increase the number of national rural electric cooperative development programs. There have been many instances where new electric cooperatives have been established in ones and twos, but there have been no new national-scale electric cooperative development and investment programs in over 25 years. Cooperative-type electrification offers the possibility of scale and replication through aggregation and standardization. Achieving our strategic goal will require establishing a successful co-op development and investment model supported by policy mandates and national institutions dedicated to creating the proper enabling environment for cooperatives to operate effectively in the electric utility sector.

The intended outcome of the 5-year CDP is to create new instruments to fill the institutional gap left by failed conventional solutions—government and private for-profit investor-owned utilities. The initial challenge is to raise the cooperative solution higher on the list of policy options considered by governments and donors; once this is achieved, we will use CDP through our alliances and know-how to partner with these key constituents in raising up commercially viable electrification enterprises and markets. This outcome will be demonstrated by the establishment of new national-scale cooperative electrification programs.

The expected 5-year CDP outputs are summarized follows:

(a) Creation of at least one institutional partnership with multilateral development banks (MDBs) to promote electric cooperative development.

(b) Resulting from (a), the adoption of a basic cooperative development and support policy/strategy for addressing rural electrification needs in the MBDs'

member countries, which will be manifested by the execution of engagement agreements to carry out programs for this purpose and with this result.

(c) Creation of a comprehensive set of practical guides relating to the design, development, and support of successful cooperative electrification enterprises.

(d) Development of successful national cooperative electric investment programs including setting up of electric cooperative development agencies and of local electric cooperatives that meet established norms for commercial electric services utilities and that provide salient social and economic value to their consumer members.

2. Accomplishments to Date

Activity 1: Institutional Strategies and Agreements

- We explored a new program for electric cooperative development in Africa in meetings with the Department for International Development in London and the Cooperative College based near Manchester, England. As part of this prospective initiative we are coordinating with the World Bank, which has several power sector reform initiatives underway in Africa, and other donor agencies.
- We initiated a partnership with the Aga Khan Fund for Economic Development (AKFED). This will initially focus on supporting an expansion of AKFED's existing electrification program along the Tajikistan/Afghanistan border area.
- Under our agreement with the Corporate Advisory Services (CAS) department of the World Bank Group's International Finance Corporation, we continued to develop a demonstration program for a new approach to electric cooperative development in several Indian states. A Memorandum of Understanding was executed between IFC, NRECA and the Power Finance Corporation, which finances electric distribution and rural power as well as being the lead financier of power generation and transmission.
- We continued implementation of an ADB-funded demonstration project in Assam, India.
- We continued working on the development of a national electric cooperative strategy for Yemen under a World Bank-funded rural electrification restructuring initiative.

Activity 2: Country/Regional Initiatives

India: Following an extended delay in negotiating a satisfactory agreement with the Rural Electrification Corporation (REC), in January the Ministry of Power (MoP) invited the Power Finance Corporation of India (PFC) to join with IFC and NRECA in the planned rural electrification "franchising" advisory program to the states receiving Union government funding aid with rural electrification and on April 26 a preliminary agreement was signed between the IFC, PFC and NRECA at IFC headquarters in Washington (see Attachment 1). This was followed by a PFC/IFC/NRECA workshop held in Delhi in May to which 18 utilities were invited

to lay out the principles of the partnership's joint purpose and review key issues and lessons learned on developing successful rural electrification businesses (see discussion in "Learning Agenda" below).

The initial project will be in West Bengal. A formal proposal was presented to the state Ministry of Power to implement a demonstration project in Basanti Block southeast of Kolkata where less than 5% of the population of 50,000 households currently has electricity service from a combination of public service connections from the State Electricity Board and private solar and diesel services. The WBSEB has begun work on completing the construction of a block-wide distribution network using federal grant funding. The IFC-NRECA Partnership will take over from the completed 11kV network and will complete the local distribution networks, set up a consumer-owned corporation to own the system, and recruit and train profession service contractors to assist in the construction and operation of the system during a three-year start-up phase. In July we hope to complete the negotiations with PFC and MoP to finalize the funding and contracting for the project, which will be funded with a combination of $1.6 million in IFC trust fund support and $550,000 of PFC counterpart funding. Project capital construction funds will be requested from the Indian government to complete the system.

Visits to other states whose utility representatives attended the May workshop are scheduled for August-September to evaluate similar project opportunities in other states.

We also continued work on a demonstration project in Assam to demonstrate methods of reducing losses and improving electricity service on a rural distribution feeder serving an area populated by tea estates with funding from the Asian Development Bank, as reported in previous progress reports. This project will produce only limited results due to the State government's decision not to pursue an institutional change in the operation of the rural distribution sector. In completing this project over the next several months, we will focus on demonstrating distribution system technology improvements to reduce energy loss and theft. However, this experience should prove useful in our larger India initiative working in other states.

Bolivia: Progress on projects in the Beni continued in 2006, albeit at a slowed pace due sweeping political changes resulting from presidential elections, and preparations for the upcoming constitutional convention in mid-2006. Planning for the project to interconnect Riberalta and Guayara-Merin continues, but financing now appears to be in question, after the change of government and the revised priorities of the national and regional governments. NRECA continues to coordinate with the Prefecture of Beni for this project and may yet provide technical assistance and supervision of design/construction of the transmission linkage between these two large, important regional population centers.

The second CDP involving interconnection of four small, islanded cooperatives in Santa Ana, Magdalena, San Joaquin and San Ramon is progressing into the

procurement/construction stage. The agreement that was signed with the Prefecture of Beni for this project to co-finance a 100 km interconnection for the four cooperatives was modified to increase funding by the Prefecture by $800,000 to expand coverage to additional, unelectrified community members, and to centralize generation in a single generation station. As agreed, project includes upgrading distribution systems in each of the four cooperatives, and merging of all management and operation functions into a single, larger entity. NRECA's role in this process will be to provide guidance and technical assistance to the new cooperative entity to strengthen management, engineering, and operational capacity in service to all four communities.

Dominican Republic: Work has continued to establish two pilot electric cooperatives, one in the Las Flores neighborhood of the capital city of Santo Domingo, and a second co-op in a rural area bordering Haiti that has been legally established under the name "Cooperativa Electrica Fronteriza."

Inscription of members in Fronteriza continued during the first half of 2006. Over 665 additional members have formally signed membership agreements, paid their membership fees, and have been qualified to participate in board elections. The total number of members now exceeds 1600.

The board of directors of Fronteriza, now in the second year of their inaugural term, visited the NRECA Annual Meeting in Orlando, Florida, and attended several sessions designed to provide training for them with NRECA cooperative board members. They also participated in a field visit to an electric cooperative of similar size to the newly formed Fronteriza Cooperative in Central Florida. The experience was designed to illustrate the role and importance of professional standards, the benefits of a focus on promotion of economic development, and the importance of membership involvement in the future of Fronteriza.

Material procurement began in early 2006, and the first shipments of materials have been received. Construction will begin in the third quarter of 2006.

Preparations for final approval of the formation of Las Flores Cooperative were delayed once again due to bureaucratic difficulties with the Dominican cooperative oversight institution, IDECOOP. This has resulted in final approval of the statutes, and endorsement of the petition for legal formation to the Office of the President, where final approval will be granted in the coming months.

Interest in formation and membership continues in this small, but well-organized urban community. Membership is expected to exceed 1000 members, but inscription has slowed due to the delays in authorization of the statutes of the cooperative. Completion of all registration activities is expected the third quarter of 2006, while inscription of new members will continue through the end of the year with a membership drive.

Tajikistan: The Aga Khan Fund for Economic Development, through its subsidiary company, Industrial Promotion Services, is currently operating a series of small hydropower and local electric distribution systems in southern Tajikistan, initiated with funding support from IFC. We have been working with AKFED for several years, assisting them with a private electrification initiative in Uganda and in January we visited AKFED headquarters in Europe to discuss their interest in NRECA assistance in a planned expansion program in their Tajikistan operations. A Memorandum of Understanding is being negotiated between NRECA and AKFED and we are currently seeking funding support from the World Bank and other potential supporters to provide partial funding for NRECA's work. This new partnership activity will start with NRECA studies aimed at identifying solutions to on-going operational problems with the existing distribution system, evaluating identified sites for expanded hydropower development, and planning for expanded distribution development. AKFED is interested in exploring the role of electric cooperatives for taking on the expanded distribution program, to include distribution areas inside Afghanistan that are adjacent to the AKFED electrification area.

Yemen: We continued working on a national rural electrification strategy study for the Ministry of Electricity, as part of a World Bank-led electrification reform and expansion program. The study will define a national rural electrification service territory map as the basis for developing electric cooperatives as the preferred service provider. NRECA's responsibility is to segment the country further into areas that will be served by the grid or by isolated systems, and to develop a policy for reforming the institutional system for future rural electrification development, which has suffered due to the poorly devised organizational system that is now in place. Follow-on funding by the World Bank is planned to implement a pilot electric cooperative project which will be developed by NRECA as part of the on-going activity. We expect to complete the strategy study this coming fall, and are working with the government and the Bank to plan and fund continued NRECA assistance toward implementing the strategy.

Philippines: NRECA's initiative with the electric cooperatives to establish a functioning, cooperative-owned financing agency continued to go well. As of the end of the reporting period, there were 48 EC stockholders in REFC with a total paid-in capital of over $3 million, of which approximately one-third was owned by NRECA Electricity for Progress, LLC, NRECA's Philippines subsidiary. Some 90 EC loans had been released, with a 100% collection rate on debt service and a growing demand for new financing. As reported previously, NEP completed a $1.125 million loan to REFC for imported utility components (transformers and hotline maintenance equipment). This completed the disbursement of NEP's monetization proceeds from a 2001 USDA Food for Progress project. REFC and NRECA also completed a $890,000 technical assistance project with 50% funding contribution from USTDA to help REFC-member ECs carry out comprehensive analyses of their investment requirements.

REFC continues to explore opportunities, with NRECA's assistance, to attract debt and equity financing from outside sources. REFC will have completed eight consecutive quarters of profitable operations by September 30, 2006 which will put it within one year of the required three-year period of profitability that the Development Bank of Philippines requires for making loans to new intermediary lenders. IFC also continues to be interested in lending to REFC, and discussions were opened with the Philippines Infrastructure Corporation (PIC) and the U.S. Export-Import Bank aimed at building on the successful NEP "commodity" loan targeting US imported products.

REFC does continue to face several challenges, as follows:

- *Rate regulation.* The new electric utility regulatory regime under the revamped Energy Regulatory Commission has established a far-reaching set of regulatory rules including tariffs which are aimed at forcing distribution utilities to achieve cost controls and rate reduction. Since its inception in 1969, this function was largely controlled by the National Electrification Administration (NEA) as the single lender to the ECs, a role it no longer serves. The system that has been adopted by ERC does not fit well with the cooperatives' investment requirements, however, since it is based on a cash accounting system that does not anticipate debt service margin requirements of REFC and other lenders. NRECA funded a study by a US co-op rate expert which proposed a new rate-making methodology that assures co-ops have adequate rates to meet REFC's credit eligibility requirements which establishing incentives to the ECs to undertake the necessary investments to improve loss control and system reliability (see Attachment 2). We will continue to work with ERC and the Philippines electric co-op association, PHILRECA, to make the needed changes in the ERC rate approval policy that will enable the ECs to remain eligible for the needed borrowings so that such investments can go forward.

- *Equity growth.* The estimated demand for financing by REFC ECs runs in the tens of millions of USD annually. As noted, for REFC to begin to meet this level of credit demand, REFC will have to obtain much larger capital inflows, primarily debt financing. To meet banks' debt-equity ratios, REFC must find additional sources of equity to permit any meaningful negotiations on debt financing. This must come from its member ECs, as well as from other potential REFC investors, such as PIC and DBP. In the coming year, NRECA will work closely with REFC to mobilize additional investment from its EC base and also to work with the potential investors, meaning that we will seek to obtain a combination debt and equity from these sources. One promising source of equity growth could be developed by establishing a carbon emissions program between REFC and its borrowing ECs and toward this end, a Japanese consortium has approached REFC with a general proposal to use REFC as a project aggregator (energy loss reduction and fuel substitution from renewable

energy projects), withy the idea of using emission credit rights as the basis for supplying risk capital to support new debt financing for such projects.

- *Internal capacity strengthening.* While REFC has managed to develop a modest and healthy lending portfolio, it has done so without the benefit of a full staff, relying largely on NRECA/NEP's on-going management and technical assistance contract to supplement its small staff. REFC still does not have a fulltime CEO. Now that REFC is generating a larger revenue base from its increased lending, it must fill this position with a competent financial institutions expert in order to advance to the next stage of its growth plan.

CFC continues to be an important partner in the REFC program. Martin Crowson of CFC's staff will continue to serve on the REFC Board as NEP's shareholder representative on the REFC board for the foreseeable future, traveling periodically to Philippines for REFC board meetings and to fulfill a range of advisory support functions to the REFC staff and board.

Africa: Our efforts to establish a cooperative development program continued on a number of fronts. We see a common thread of interest in the electric cooperative model in a number of countries, all of which are at differing stages of their electric sector reform process but together with their donor partners, including the World Bank and MCC, are seeking new solutions for stabilizing and extending electric utility service on a national scale as part of their millennium development strategies. As reported previously, we have initiated strategies in two countries, Sudan and Senegal. One of our critical challenges is to formulate funding strategies to for these and several other countries aimed at the specific goal of electric cooperative development.

- *Tanzania.* In February NRECA met with the MCC country manager for Tanzania, who is considering the potential for an electrification component as part of the planned compact with Tanzania. MCC is concerned about the government's preparedness to accommodate new investment in electric distribution development and is awaiting the formulation of an acceptable power sector reform policy. In August, NRECA will send a delegate to an East Africa electrification conference to be held in Tanzania to explore the idea of developing a new cooperative-based approach for expanding grid service into each of 12 regions.

- *Ghana.* The World Bank is financing a series of power sector improvement activities including a component to increase electricity access in rural areas, where 70% of the people do not currently have service. The government's rural electrification policy, as part of its millennium development goal, is to provide universal access by the year 2022. This would be a reachable target only if a highly proactive, standardized system of rural electric subscription and construction is put in place. In January, NRECA's Executive VP who

service on the NCBA board visited Ghana as part of a Board field visit and met with cooperative leaders regarding the potential for establishing rural electric co-ops. NRECA meanwhile met with senior Ghanaian energy sector officials at the World Bank in March and schedule a brief reconnaissance visit in May at the government's request to evaluate the potential for electric cooperatives as part of the on-going reform process. We found the economic and institutional environment for cooperatives to be reasonably positive, and offered recommendations to the Government and the Bank staff to consider funding a demonstration project. Also, an MCC compact was executed with Ghana in June which includes a $10 million rural electrification component. We will explore matching MCC funding with the proposed electric co-op demonstration scheme.

- *Nigeria.* In March NRECA met with senior Nigerian electrification planning officials and with a World Bank team to explore a program of tangible steps to develop rural electric co-ops as part of that country's on-going electric sector reform program. NRECA retained the services of a consultant who assisted in preparing a World Bank funded rural electric sector policy "white paper" for the Bureau of Private Enterprise, which is leading the country's power sector privatization plan. The Ministry of Energy has indicated an interest in exploring the development of two pilot projects in each of the six political districts.

- *Uganda.* The World Bank assisted the government in establishing a new electrification program several years ago which involved the creation of a separate electrification agency similar to the U.S. REA model, but without having considered the potential role of cooperatives. To date only one significant project has been implemented, by AKFED with NRECA's technical assistance, centered in the northwestern town of Arua. NRECA had proposed a project with USTDA funding support which was not accepted; however the government has since signed an assistance agreement with the Swedish government to evaluate the potential for cooperatives. NRECA will schedule a visit to Uganda in July to explore further the basis for involving NRECA in this effort.

We are also continuing to explore similar programs in several other African countries, including Senegal, Kenya, Mozambique, and the Republic of South Africa. In August we will visit Johannesburg to meet with the regional headquarters office of the IFC, for the purpose of pursuing a program similar to our initiative in India. We are also exploring the potential for DfID support for pursuing cooperative electrification, and in January we visited DfID in London to initiate this discussion. Following our visit to RSA, we will consider our options for pursuing demonstration programs in one or more of these countries, depending on the interest of our prospective partners, DfID, IFC/CAS, and MCC.

Activity 3: Source-kit

Final drafts of the source-kit modules were completed in early 2006. The drafts were completed in Spanish, given that the source-kit materials were developed to provide training and technical assistance initially to recently-formed rural electrification program offices in Bolivia and the Dominican Republic where NRECA is currently completing long-term projects financed by USAID and USDA. The ten modules that have been completed are as follows:

1. Description of methodology used to evaluate new (Greenfield) RE projects, as well as expansion of service to new areas for existing electrification systems.
2. Electrical engineering design guide for medium and low voltage distribution systems.
3. GIS-based design and evaluation methodology.
4. Guidelines to establish rural electric cooperatives.
5. Description of cooperative board functions, descriptions of duties, and scope of overall board activities.
6. Description of a business plan to establish a rural electric utility.
7. Rural electrification engineering design standards for 15 kV, 25 kV, and 35 kV class service.
8. Productive uses program components, program methodology, & program management.
9. Willingness to pay and demographic survey methodology and analysis guideline.
10. Methodology to evaluate the financial viability of rural electrification projects.

During the second quarter of 2006, efforts began to translate the source-kit modules from Spanish to English. Of the ten modules, eight will be translated, given that module 3 is a user-guide developed specifically for the programs in Bolivia and the Dominican Republic, and therefore not useful as a guideline for other programs. Moreover, module 7 is comprised of AutoCad drawings that already exist in English.

Modules 2 and 10 have been translated into English; Module 2 has been edited and has been printed, while Module 10 is in the final stages of editing. At least three more modules will be translated in the second half of 2006, with the last three modules scheduled for translation in the first half of 2007. Attachment 2 provides a sample of Module 2.

Activity 4: Learning Agenda

NRECA participated in rural electrification best-practices workshops and seminars in Washington, D.C (World bank "Energy Week"), India and Yemen.

- *India.* A two-day workshop was held in Delhi May 29-30 as an initial activity under our new partnership with IFC and PFC. Utility officials from Madhya Pradesh, Punjab, West Bengal, Rajasthan, Gujarat and Orissa were attended to

present their rural electrification plans and conditions and to hear from a number of Indian and international experts on the principles relating to technology, planning, organization and operations from worldwide rural electrification experience based on the World Bank/ESMAP case study series of rural electrification success stories that featured three national co-op electrification programs, Costa Rica, Bangladesh, and Philippines (see workshop agenda, Attachment 3). The afternoon of Day 2 was devoted to one-on-one meetings with the utility delegations to discuss the PFC-IFC-NRECA advisory assistance program in detail and to determine their interest in pursuing projects. State visits will be scheduled in the second half of 2006 to evaluate potential demonstration sites and initiate the process of negotiating advisory agreements.

- *Yemen.* As part of our National Rural Electrification Strategy initiative, we held a two-day stakeholders conference on the specific issue of the institutional and organizational options for implementing the new strategy (see Attachment 4). Attendees from government, cooperative community, donor agencies, and parliament attended. NRECA presented a number of cases worldwide as well as key findings form the Strategy Study. The key outcome was the stakeholder's consensus decision to adopt the electric cooperative format as the preferred service provider.

- *Energy Week.* We participated in two panels during the World Bank's week-long conference on energy issues, attended by senior electric sector delegations worldwide, focusing on elements of our source-kit as well as experience with cooperative development in various countries.

Activity 5: OCDC Legal/Regulatory Collaboration

NRECA participated in the final stages and workshop relating to the CLARITY activity, which was finalized and published in June. We plan to follow-up with the development of a Sourcekit module including a model law, regulatory framework, and chartering system for electric cooperatives.

ATTACHMENT 1

MEMORANDUM OF UNDERSTANDING

between

POWER FINANCE CORPORATION, LTD.

and

INTERNATIONAL FINANCE CORPORATION

and

NRECA INTERNATIONAL, LTD.

This Memorandum of Understanding ("MOU") is entered into this 25th day of April, 2006 in Washington, D.C., U.S.A., by and between the Power Finance Corporation Ltd. ("PFC"), a Government of India company incorporated in India in 1986 under the Companies Act 1956; the International Finance Corporation ("IFC"), an international organization established by Articles of Agreement among its member countries; and NRECA International Ltd., a wholly-owned subsidiary of the National Rural Electric Cooperative Association ("NRECA"), a non-profit membership organization incorporated under the laws of the District of Columbia, in the United States of America. PFC, IFC and NRECA are collectively hereinafter referred to as "the Parties" and each a "Party".

WHEREAS:

A. The Government of India ("GoI") has established as a priority undertaking the widespread and rapid development of access to electricity service in rural areas of India, with the objective of achieving universal electrification in India by the year 2012.

B. Achieving this national goal will involve enormous resources, requiring the collaborative efforts of many stakeholders, including the State governments and their electric power agencies, the rural consumer communities themselves, and others such as interested and capable private-sector participants.

C. PFC is a public financial institution dedicated in development of power sector. It provides financial assistance for all types of conventional and non-conventional power generation projects, transmission and distribution projects. It also plays a catalytic role in the institutional development including reform of State power sector. PFC is implementing a scheme of Ministry of Power (MoP), GoI for conducting of Pilot studies and schemes for Delivery through Decentralized Management (DDM) including Distributed Generation projects, for showcasing participatory models of excellence in distribution predominantly in rural areas. PFC is also associated as financial intermediary for implementation of Indo-US initiative in Distribution1 Reform, Upgrades and Management (DRUM) project, to undertake distribution pilot projects in rural and urban areas to demonstrate the best technological, institutional and commercial practices and also capacity building by way of imparting training to the officials of State power utilities.

D. India would benefit from international experience and best practices that have been developed and documented in numerous other countries that have undertaken such programs. These best practices can render the rural electrification sector in the various States increasingly viable and credit-worthy through the design and implementation of new, more commercially sustainable rural electrification markets and intermediaries.

E. IFC and NRECA have entered into a Memorandum of Understanding on whereby IFC and NRECA confirm their interests to share their respective institutional experience, knowledge and skills in a common program with the objective of bringing about effective rural power reform, including specialized advisory assistance and start-up program implementation support, and creating model rural power investment programs in selected IFC's member countries;

F. The goal of the specialized advisory services would be to define, design, and implement sustainable, expandable and replicable rural electric service enterprises based on internationally tested and proven public-private partnership models involving a central role of the beneficiary electrification communities themselves, including cooperatives and similar user associations, coupled with other private-sector participants. (Hereinafter referred to as the "Program")

G. The IFC/NRECA team have submitted a proposal to the Government of India (Ministry of Power) to collaborate for the purpose of jointly identifying, developing, funding, and implementing a series of rural-area electrification enterprises in selected States of India that will serve as models for wider application in India, which includes, *inter alia,* a description of the general approach for implementing the electrification programs, indicative timetables, fees and terms of reference, etc.

NOW, THEREFORE, THE PARTIES HAVE THE FOLLOWING UNDERSTANDINGS:

1. The envisioned Program will focus on the creation of specialized rural-area electric service enterprises in selected states, hereinafter referred to as "Candidate States". The Candidate States and rural "blocks" will be evaluated for potential participation in the Program. The new rural utilities will be fundamentally demand-driven, scaled and operationally oriented to be commercially sound, technology-neutral, and capable as models for solving the major portion of electricity service needs of rural populations in currently unserved and/or underserved areas of the selected States.

2. The envisioned Program will be developed under a collaborative, joint decision-making process amongst the PFC, IFC, NRECA and the States. The sub-programs will be implemented under formal contractual arrangements with the appropriate State authorities, stipulating specific program activities, objectives, timetables, resource requirements and funding responsibilities, and otherwise any and all pertinent terms and responsibilities of the Parties and other stakeholders. The modalities for implementing the Program have been outlined in the document entitled "IFC and NRECA Advisory Services Proposal to Ministry of Power Government of India, Regarding Rural-Area Electric Distribution Improvement and Electrification Expansion Assistance" given in the Annexure to this Memorandum.

3. The envisioned Program will be conducted in several modules to be decided mutually among the Parties. The initial module of the envisioned Program will entail a joint consultative process in the Candidate States to ascertain the interest and commitment level in participating in the Program on the part of key stakeholders, including the State's electric power ministries and sub-agencies, as well as potential private participants, and the target communities that are identified. consistent with the following core principles, *inter alia*:

   (i) Rural electric distribution entities are developed within parameters of economic scale and financial viability, including the ability to obtain affordable capital financing as well as to set tariffs sufficient to meet their operational and financial obligations.

   (ii) Legal and regulatory enabling environments are established at the State and local levels to accommodate the recommended institutional model.

   (iii) The availability of reliable and affordably-priced power supply for the target project areas is assured.

   (iv) Local communities in the identified project target areas play a key role in the ownership and operation of the envisioned enterprise(s).

   (v) Financial resources and other resources needed for enterprise and project implementation, including required personnel and implementation agencies, are allocated for projects according to need and merit under generally accepted and transparent procurement processes.

4. The initial priority Candidate States to be assessed during the consultative phase will be selected from amongst the States of West Bengal, Bihar, Orissa, Madhya Pradesh, Gujarat, Punjab, and Rajastan. After these initial states, other states may be approached. All states will be approached jointly by PFC, NRECA and IFC.

5. In implementing the Program, subject in each case to the relevant advisory services agreement among the Parties and the State, it will be the primary responsibility of the PFC to:

   (i) Coordinate the initial consultative module;

   (ii) Participate in the decision-making process in concert with State authorities; and

   (iii) Orchestrate and facilitate the allocation of government funding support prescribed for implementation of the envisioned Program, covering both capital expenditure and advisory services.

6. In implementing the Program, subject in each case to the relevant advisory services agreement among the Parties and the State, it will be the primary responsibility of the IFC/NRECA team, *inter alia*, to:

   (i) design and develop all necessary plans and documents, select consultants as needed and conduct the necessary technical, financial and other analyses, and carry out other prescribed project development activities during the due diligence and project preparation modules of the envisioned Program;

   (ii) present options and recommendations for State decisions or concurrence when required;

   (iii) identify, assemble and prepare implementation agents and counterpart project implementation funding sources as defined by approved project plans and budgets for enterprise start-up and pilot project implementation, such procurement to be carried out under an open solicitation and selection procedure;

   (iv) provide technical assistance and oversight during the enterprise start-up and stabilization module;

   (v) lead efforts to solicit and arrange donor funding, as possible, of the advisory services as further defined by this MOU and by subsequent Program implementing agreements; and

   (vi) provide or arrange, on a best efforts basis, the mobilization of any long-term funding on commercial terms that may be required to fund the capital costs and operations of the start-up utilities.

7. A Project Approval and Monitoring Committee will be established to oversee the activities and facilitate their timely implementation; this Project Approval and Monitoring Committee will consist of the following:

   (i) CMD, PFC – Chairman
   (ii) JS Rural, Ministry of Power - Member
   (iii) Representative of IFC – Member
   (iv) Representative of NRECA – Member
   (v) Representatives of Partner States – Members (to be nominated by the State Governments)
   (vi) Representatives of other stakeholders – Members (to be co-opted by the Chairman, and subject to agreement of IFC and NRECA)

8. By agreeing to the terms of this MOU, each of the Parties resolves to mobilize appropriate resources and personnel to undertake the initial investigations in each respective State that has been heretofore identified, as necessary.

9. Contact information for each Party is as follows:

For PFC:	Chandra Lok 36, Janpath New Delhi-110001
Facsimile:	+ (91) (11) 2331 5822
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For NRECA:	4301 Wilson Boulevard Arlington, Virginia 22203
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10. No Party shall take any action which could be construed as creating a partnership or any legal obligation upon any other Party. No Party will represent any other Party's views on any matter, or use any other Party's name in any written material for third parties, without prior written consent of such other Party.

11. Notwithstanding anything else to the contrary herein, this MOU (including the Annexure) does not, and shall not be construed to, constitute a binding contract or commitment by any of the Parties to enter into any contract or assume any obligation or commitment of any kind and shall not give rise to any claim by any of the Parties hereto against the others. Any of the Parties is entitled to withdraw from further discussions or involvement in connection with the envisioned Program at any time without being liable to the other Parties hereto.

IN WITNESS WHEREOF, the Parties hereto have signed this MOU on the day and year first above written.

For the PFC:

By: _____
Authorized Representative
DR. V.K. GARG
Dated: 4/25/06

For the IFC:

By: Farida Khambata
Authorized Representative
MRS. FARIDA KHAMBATA
Dated: 4/25/06

For NRECA:
Authorized Representative
By: _____
MR. VIVEK TALVADKAR
Dated: 4/25/06

ATTACHMENT 2

NRECA International Ltd.

Your Touchstone Energy® Partner

DESIGN AND COST ESTIMATION FOR RURAL ELECTRIFICATION PROJECTS

Module 2 of NRECA's Technical Assistance Guide

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NRECA International, Ltd.

April 2006

Version: MOD S02.01

TABLE OF CONTENTS

PROLOGUE ..... **III**

ACKNOWLEDGMENTS ..... **IV**

EXECUTIVE SUMMARY ..... **V**

1. INTRODUCTION **1**

2. BACKGROUND AND JUSTIFICATION **2**

3. PROJECT DESIGN **3**

3.1 COMPILATION OF INFORMATION FROM THE ELECTRIC OPERATOR. 3
3.2 FIELD INSPECTION 9
3.3 EVALUATION OF LOADS 16
3.4 ANALYSIS OF ELECTRIC SYSTEM BEHAVIOUR 19

4. ESTIMATION OF PROJECT COSTS **37**

4.1 MATERIALS DATABASE 37
4.2 LABOR DATABASE 37
4.3 DATABASE BY CONSTRUCTION UNIT 38
4.4 DATABASE ON PREVIOUS DESIGNS 38
4.5 DATABASE ON THE COSTS OF SERVICE DROPS 40
4.6 DATABASE ON THE COST OF STAKING 40
4.7 TOTAL INVESTMENT COST OF THE PROJECT 40
4.8 TABLES OF INDICATIVE LINE COSTS 41

5. REQUIREMENTS FOR THE PRESENTATION OF THE PROJECT **42**

5.1 DESCRIPTION OF THE PROJECT 42
POWER FLOW 42

ANNEX A. LIST OF REQUIRED CHARACTERISTICS IN AN ENGINEERING SOFTWARE PACKAGE (POWER FLOW) **44**

ANNEX B. CALCULATION OF FACTORS FOR THE ECONOMIC ANALYSIS OF CONDUCTORS **46**

ANNEX C. EXAMPLE OF PROTECTION COORDINATION CONSIDERATION FOR THE TOMOYO SYSTEM **50**

ANNEX D. TABLES OF RESULTS OF POWER FLOWS FOR THE TOMOYO PROJECT **56**

BIBLIOGRAPHY **59**

GLOSSARY **60**

PROLOGUE

The United States National Rural Electric Cooperatives Association (NRECA) was founded over 60 years ago and is a trade association of approximately 1000 rural electric cooperatives in the United States. These cooperatives supply electric energy to more than 37 million people, mainly in small rural communities, in 47 of the 50 United States of America, covering 75% of that country's geographic area.

However, its working area is not limited to the United States. Since 1962, NRECA, through its International Programs Division (IPD), has coordinated and provided technical assistance to many developing countries. Managers, engineers, technicians and specialists from NRECA, in various branches of the electric sector, have provided technical assistance for the organization, as well as development, administration and project management for rural electrification to electric companies throughout the world.

This guide is part of a series of modules, the whole denominated "NRECA Technical Assistance Guide", whose aim is to document the experience of specialists from NRECA and of other expert colleagues in this field. The modules have been prepared as teaching aides for application to the benefit of cooperatives and electric companies.

The purpose of these modules shall have been accomplished if their recommendations result in better management and service of higher quality and efficiency for the users of those companies.

ACKNOWLEDGMENTS

The authors thank the United States Department of Agriculture (USDA) for providing the funds to finance this guide and the set of complementary ones. They also thank all those who contributed to this work through the revision of drafts, enhancing it with their comments; especially the engineers of the Electricity Vice-ministry of the Bolivian Government, the Bolivian IBNORCA Rural Electrification Committee, and the Dominican Republic CDEEE Rural Electrification Unit.

EXECUTIVE SUMMARY

This guide sets forth the principles and establishes the recommendations for the electrical design of a rural electrification project or system. It also describes the procedure for the determination of costs, which is the basis for the feasibility analysis.

The design of electrical configuration has a primary influence on the cost of the project to be developed and on the quality of the service for the final user. An optimal design ensures the supply of service at minimum cost and under adequate technical conditions. Cost estimation on the basis of an optimal system ensures that the feasibility study uses the appropriate figures and that the lines, if constructed, have the required technical capacity to supply energy to final users.

This guide is linked to others of the same series, e.g. it broadens the information and procedure described in Guide N°1 – Analysis of Rural Electrification Project Feasibility and provides further information for Financial Analysis (Guide N°13). Likewise, the costs presented in this Guide assume an optimal mechanical design, such as developed in the "Simplified Staking Manual for Overhead Distribution Lines" and also the use of economical line structures, as included in Guide N°9 -Construction Standards.

The norms, parameters and design criteria used in this guide derive from the rules established by the Rural Units Services (RUS) of the United States and have been adapted to rural electric systems in several countries. Their fundamental characteristics are the following:

a. Configuration of the three-phase system: four wires, with multi-grounded physical neutral.
b. Application of single-phase primary lines consisting of phase and neutral, as the main mechanism for rural distribution.
c. Application of single-phase transformers sized from 10-25kVA. Use of modules over 25kVA only for specific cases in three-phase banks.
d. Limis on the length of low voltage networks, to reduce technical losses, improve service quality and reduce possibilities for illegal connections.
e. Universal metering.

This system of design represents an integrated philosophy for development of rural electrification projects, thus it should be considered as a whole. Its main purpose is to present a basis for design and to provide the professional user with the necessary tools for its application.

The order of proposed procedures for project design consists of the following steps:

a. Compilation and documentation of technical information on the existing system that is serving the project area.
b. Surveys in the field on the consumer quantity and characteristics; preparation of georeferenced information on the geographic layout and concentration of users' housing, in relation to the existing system. To obtain geographic information, the design system proposes use of only modern instruments for satellite positioning or

GPS, instead of older techniques based on approximate measurements by means of vehicle odometers or distance estimations.

c. Development and application, on the part of the operating electric company, of a study of the economic selection of conductors, to establish standard conductor sizes for use in multiple rural projects.
d. Design of the specific project, using a power flow model with suitable characteristics, so as to accurately simulate system performance.
e. Consideration of coordination of protection against overcurrents and as an integral part of project design.
f. Estimation of project costs.
g. Presentation of the project in a sufficiently well-grounded and documented manner, so as to ensure that the technical aspects previously enumerated have received due consideration.

This guide presents and develops methods, adding application examples to put into practice the integrated system design approach.

DESIGN AND COST ESTIMATION FOR ELECTRICITY PROJECTS

Module 2 of NRECA's Technical Assistance Guide

1. INTRODUCTION

This guide presents the steps to follow in the procedure for the electrical design of a rural electric distribution project, as well as in estimating of its cost, which is the basic calculation for the feasibility study.

The definition of the electric configuration is of vital importance for the future project because it has a fundamental influence on its cost and on the quality of the service for the final user. An optimal design should ensure that service may be provided at minimum cost, while maintaining standardized levels of service quality. Therefore, the estimation of costs on the basis of an optimal system ensures that the feasibility study uses the appropriate figures and that the lines, if constructed, shall have the necessary capacity to supply the users with the service quality required, at the lowest level of technical losses that is economically achievable, at least during the period of project analysis.

The subject of mechanical design of the lines to be constructed is not dealt with in this guide. Mechanical design should be done only after determining and defining the feasibility of a project and after confirming its execution with the interested parties, whether they are the financial entities or the beneficiaries. An appropriate mechanical design ensures that lines work reliably and safely and that they do not cost more than necessary. For the mechanical design of electric lines there is a manual: "Simplified Staking Manual for Overhead Distribution Lines" upon which the designs used to develop the reference costs in this guide are based. .

This guide is closely related to others of the same series. For example, it provides information to the Financial Evaluation (Guide N°1) and to the Feasibility Analysis (Guide N°3). Besides, the costs presented imply an optimal mechanical design, as developed in the "Simplified Staking Manual for Overhead Distribution Lines", and the use of economically preferred structures, as shown in Guide N°9.

2. BACKGROUND AND JUSTIFICATION

The design fundamentals presented in this guide derive from the rules established by the US Rural Utility Service (RUS). These approaches have been adapted to rural electric systems in several countries, and their fundamental characteristics are:

a. Configuration of the three-phase system, with four wires and multi-grounded neutral. This configuration permits the application of protections against overvoltage, with protection levels lower than the phase to phase voltage of the system, which, in turn, permits the use of basic insulation levels (BIL), lower than the levels applied in three-phase systems without neutral, or with a neutral grounded only at the source. It also permits a significant reduction of the investment cost of transformers and other equipment.
b. Application of single-phase primary lines consisting of phase and neutral as a principal means of rural distribution. However, three-phase lines are required to maintain system balance between phases in the system and to serve specific concentrated three-phase loads. The use of single-phase lines, as compared with wholly three-phase systems, reduces construction cost by nearly 50% and provides adequate service for most uses and for the existing demand for electricity in the rural area.
c. Application of single-phase transformers. The application of single-phase, 10-25 kVA transformers is preferred, leaving the modules of over 25kVA only for specific uses in three-phase banks. The use of relatively small transformer modules, as compared with the typical module size used in an urban system, increases the total cost of transformers, but improves the quality of the service for scattered users. However, the total system installation cost is reduced owing to the reduction in the cost of construction of low-voltage networks.
d. Limit the length of low-voltage networks. This is mainly to reduce technical losses, improve service quality and reduce the possibility of illegal connections.
e. Application of universal metering. An individual meter should be installed for each customer, to ensure measuring of each customer's own electric energy consumption. The universal metering rule is applied to public consumers, schools and municipal buildings, as well as to private consumers.

This design methodology for a rural electrification project represents an integrated philosophy, and it should be considered as a whole. Its main purpose is to present a basis for design and to provide the professional user with the necessary tools for its application.

3. PROJECT DESIGN

The process of electrical design for rural electrification projects consists of several steps that are described below:

a. Compilation of available information on the area to be electrified. The initial information source is the electric company or jurisdictional institution in charge of supplying the electric service in the adjoining area, especially if the project is connected with this entity and if the service is to be operated by said entity once the project is executed. This information is necessary, but not sufficient to characterize the area, for reasons to be explained herein.
b. Analysis of the area to be electrified, i.e. determination of the location of consumer concentrations, based on the actual conditions of the project area. During this process the information gathered from the electric service operator in the adjoining area should be confirmed, to the extent possible.
c. Analysis of the loads and configuration of the proposed system. During this step, the loads represented by the concentrations of potential users must be determined and the system configuration to supply them must be designed, including route design, the features of primary lines and the location of transformer points.
d. Analysis of the proposed system, to confirm that it fulfills requirements forservice quality, particularly with respect to the delivered voltage levels. In this step a determination will be made as to whether it is necessary to include improvements in the existing system to permit the extension of the new system to be constructed.

The details of the process of analysis development will now be explained, as well as the use of the necessary tools. Furthermore, an example is given to show its application in a real project. The project used as an example is an electrification project in the Tomoyo region, near the city of Sucre in Bolivia.

The Tomoyo project consists in the supply of electric energy to nearly 1000 potential users, scattered among 11 Communities. The project includes the construction of approximately 30km of 14.4kV single-phase lines , up to a and end point 77km distant from the supply substation. It is clear that this project poses a challenge in maintaining an adequate profile of service voltage and in achieving the coordination of system protection, and justifies a more detailed study.

3.1 Compilation of Information from the Electric Operator.

It is very important to start the electric design of a project with the information from the company that will undertake the role of operator upon completion of the work, in order to obtain all existing data available on the project area and to take into account the rules of the company that is to maintain and operate the lines.

When the project designer visits the office of the operating company, he should gather the following information:

3.1.1 Gather information on the standards and materials used.

Every distribution company has its own preferences as to the use of materials and line hardware. Some of them use, for example, wooden poles, others use concrete or metal or a variety of all. Normally, electric companies have standardized structures, often based on RUS standards (such as the structures in Guide N°9). It is also usual to have standardized conductor sizes for their distribution systems. Therefore, the project engineer should start the electric design from the standards established by the electric company, provided that they comply with the technical criteria included in this guide.

3.1.2 Gather information on the plans for network extensions in the project area.

It must be considered that the electric company may have plans to extend its lines to the area contemplated in the project and they might even have a final design for the extension project.. Many times these studies have been conducted by local governments, such as the prefecture or the municipality, from a clearly political perspective. The designs prepared under these conditions usually have many flaws and cannot be applied directly, whether because the electrical design may have been based on social pressure (such as the decision to install three-phase lines, though the demand does not justify this configuration), or because the mechanical design did not contemplate the criteria of the mechanical design guide. However, these studies may contain useful information to elaborate a final design according to the procedures of this guide. Useful and usable information is generally obtained from the identification of communities in the project area and the number of potential users. It is always necessary, however, to verify and validate the data received (as these often prove to be biased to force the viability of the project, the distance between towns and communities and the technical information on the existing system to which the project is to be connected.

3.1.3 Find out about options or alternatives for extension of the electric system to the project area.

It is quite possible that the electric company may have or know about some expansion plan for the present system, which would affect the project being considered. Examples of possible expansion plans are the construction of new sub-transmission lines, substations and/or generating plants. In this case it would be of great value to take advantage of the compiled information to plan the project and take into account its implications for the design of the new system. Some caution is necessary during this investigation process, because most distribution companies have expansion plans for rural areas that are either too general or without financing, or, in other cases, are not based on updated information as to major configurations for transmission systems. Though it is true that it is important to take into account the plans of other companies, so as not to make unnecessary expenditures in the development of a project, it is also important not to condition the design on the existence of other projects that may not be executed in time.

It is a valid rule to consider, in the planning of a rural electrification project, those associated projects that have received the necessary approval from financing sources for their execution and also have, approval related to the environmental impact.

3.1.4 Gather information on the point of origin or supply for the project

During the visit of the project designer to the office of the electric company, all available information must be obtained on the source or supply point for the new project. The electric company may not have all the necessary information so in any case it is necessary to pay a visit to the place to verify the data. The data to be obtained from the electric company are the following:

3.1.4.1 Voltage level of the existing distribution lines

Existing voltage levels may be of the 15kV, 25kV o 35kV class, each of which has a number of options. For example, the 15kVvoltage class includes 11kV, 12.47kV, 13.2kV, and 13.8kV. The 25kV level includes voltages of 20kV, 22kV, 24.9kV, etc. The 35kV level includes voltages like 33kV, 34.5kV, etc. It is possible for an electric company to have more than one voltage level in its system, e.g.12.5kV and 34.5kV. Then, even if a line is currently energized at a lower voltage, for example at12.5kV, the company may be willing to consider a conversion to 34.5kV, if technically justifiable. In Bolivia, the system voltage used by distribution companies is in the process of being standardized at 35kV, 25kV and 15kV. Few companies are still maintaining systems in other voltages.

3.1.4.2 Number of phases available?

It is important to know how many phases are available in the project sector: one, two or three phases. If there are not three phases available in the initial point (usually end of the existing line), one must find out how far the three-phase line goes, so as to take it into account if a conversion to a three-phase line is necessary (We will elaborate on this point further ahead)

3.1.4.3 Is there a physical neutral?

Some rural area distributors have adopted systems without physical neutral. The system used for single-phase configurations without physical neutral, denominated "MRT"system or ground return, or "SWER" (Single Wire Earth Return), must still comply with and respect various design criteria, according to section 6.4.4. If no physical neutral exists at the initial point, it is necessary to determine where the neutral of the existing system ends, so as to take into account the costs if the addition of the neutral is required for the project.

3.1.4.4 Distance from substation

If the electric company has updated, and sufficiently detailed maps, one can determine, with their help, the distance from the substation to the initial point of the project, then model the voltage drop in the existing line, and simulate the power flow and the voltage drop in the proposed project.

3.1.4.5 Existing conductor size from substation to the project

In order to carry out a power flow system, one needs to know the cross section of the existing conductor in the line from the substation onwards up to the initial point of the project to be studied. The cross section of the neutral conductor (if it exists) must be determined, as well as the cross section of phase conductors. If there are conductors of more than one cross section in the line between the substation and the initial point, each cross section of the conductor must be recorded in the corresponding stretch, as well as its respective length.

3.1.4.6 Load in the existing line

The load in the existing line is another critical component in defining the conductor cross section and/or number of phases of the system that will be analyzed in the power flow study that determines the voltage drop in the existing line. If there are important loads, it is necessary to record their location to be able to model their effect in the power flow study.. If the existing line has to be divided into segments, for the reasons indicated in section 3.1.4.5, it will also be necessary to divide the existing load among the same segments.

3.1.4.7 Average energy consumption in the last electrified community

In rural electrification projects it is possible to estimate energy consumption in the communities to be electrified by taking into account the energy consumption in the nearby communities that already have electric service. Besides, quite probably the electric company may give information on the energy consumption of existing users in these nearby communities. The interesting data is the kWh of energy consumption.

If the electric company furnishes data such as reports on energy sold (the monthly amount collected), the kWh consumption should be calculated using to the current tariff structure.

3.1.4.8 Existing penetration rate in the electrified area

In order to size the new project, it is necessary to know how many users out of a total of potential users will be connected to the project in the first year, and the period over which the rest are likely to take service. The proportion of potential consumers who will receive service the first year and then in subsequent years, is called the penetration rate. It is possible to project a penetration rate for the area of the proposed project by knowing the penetration rate in nearby areas that have already been electrified.

3.1.4.9 Substation Characteristics

Another piece of important information for the electrical model of the system regards the characteristics of the substation. The following characteristics must be obtained from the electric company:

3.1.4.9.1 Source Impedance

To conduct a fault current or short-circuit study and be able to specify the overcurrent protection scheme, it is necessary to obtain the impedance on the high-voltage side of the substation. Many times, the electric distribution company will have to resort to the company in charge of

transmission in order to obtain this information. The data may come directly as impedances of positive and zero sequence, but very often it is shown as magnitude of the fault current, as a three-phase fault and a single-phase fault, whence the impedances may be calculated according to the formulas 3.1 and 3.2:

Formula 3.1: $Z1 = \frac{Vf}{I3f}$ **Formula 3.2:** $Z0 = \frac{3xVf}{I1f} - (2xZ1)$

Where: Z1 = positive sequence impedance, [ohms]
Z0 = zero sequence impedance, [ohms]
Vf = nominal phase to ground, [volts]
I3f = magnitude of three-phase fault current, [amperes]
I1f = magnitude of single-phase to ground fault current, [amperes]

It is understood that the reference voltage should be of the same voltage level as the fault current. That is, if fault currents are obtained at the 69kV busbar of a substation, the Vf value that should be used to derive the fault impedances in ohms is 39.837 volts. If the engineer does not have the data on the phase angles of the faults, –72° for Z1 and –75° for Z0 are average values.

3.1.4.9.2 Capacity of the substation

Information must be compiled on the kVA capacity of power transformers at the substation. If there is more than one transformer it is necessary to compile data on all of them and record whether they are connected in a bank, in parallel, in series or independently (serving separate low voltage buses).

3.1.4.9.3 Available capacity at the substation?
After recording the capacity of each transformer at the substation, one must record the maximum demand of each transformer to be able to calculate the capacity available for the proposed project. If there is a lack of capacity in the substation transformers, an increase of capacity would have to be budgeted at the existing substation, or perhaps installation of a new substation closer to the project area.

3.1.4.9.4 Voltages on both sides of the transformer
In every transformer at the substation, nominal voltage on both sides should be recorded, on the high side (transmission side) and on the low side (distribution side). Many times, the nominal voltages of transformers are not the nominal voltages of the system and the difference may influence the results of power flows.

3.1.4.9.5 Available taps in the transformer
The presence of voltage adjusting taps on both sides of the transformer must always be recorded, as they influence the transformation relationship and therefore the outlet voltage of the transformer. There are usually five taps of +/- 5% on the high voltage side, i.e. +5%, +2.5%, 0% (nominal), -2.5% and –5%, but this varies according to the manufacturer and the purchase specification of the transformer.

3.1.4.9.6 Existence of automatic voltage regulation

Another important factor to model in the power flow is the presence or absence of devices for voltage regulation. If the voltage regulation equipment exists at the substation, it is necessary to verify whether it is incorporated into the transformer or separated, and whether it is automatic or manually operated.

3.1.4.9.7 Impedance of the transformer and ground connection

One of the most important pieces of information in the substation electrical model is the impedance of transformers. This information is usually presented on transformer name plates as %Z at the self cooled or OA rating. . If it is an autotransformer, or a three-winding transformer, three impedances must be recorded: primary-secondary, primary tertiary and secondary tertiary. In some substations, where it is necessary to limit the magnitude of the fault current to ground, an impedance may be installed in the ground connection. If such impedance exists, its value must be recorded, so as to include it in the power flow model. If the relation X/R of the transformer impedance is not specified, a relation 10:1 may be adopted.

3.1.4.9.8 Transformer connections

All three-phase transformers, or single-phase transformers connected in three-phase banks, can be defined by the connection configuration of delta or star windings, both on the high voltage side and on the low voltage side. The configuration of the connection on both sides of the transformer must be recorded. This configuration does not influence the power flow model, but it does influence in the fault current model, which is normally calculated using the same model of the electric system. The calculation of these fault currents influences the determination of the protection system that the project will need so as to be reliable.

3.1.4.9.9 Characteristics of overcurrent protection devices

At every substation there should be overcurrent protective devices (such as fuses, reclosers, breakers, etc.) both on the high voltage side and low voltage side. The important characteristics to be recorded for each device are:1) the type of device, 2) the brand, 3) the pickup current, 4) relay settings (if any) and 5) the current transformer taps (if any). This information must be recorded for two reasons: 1) To ensure that all devices are properly coordinated and 2) To ensure that with the loads of the new project, the load currents in the feeder do not exceed the pickup current of the protective device.

3.1.4.9.10 Characteristics of other substation equipment

There may be other equipment in the substation that could have a great influence on the power flow model, such as capacitors and reactors, so their capacity and form of connection to the system should be recorded. For capacitors, it is important to record the control mode, whether it is automatic or manual and if automatic, what are the operation criteria (voltage, phase current, power factor, or time of day).

3.2 Field Inspection

Once the available information has been compiled at the office of the electric operator, it is necessary to visit the project area to establish the geographic relationship between the loads to be electrified, so as to confirm and complement the information obtained in the office. It is during this visit that the basic configuration of the system to be installed will take shape, subject to modification during the process of analysis. For this reason, it will be necessary to have in hand during this visit, some way to establish distances and locations of towns and probable loads. The traditional way to perform this task is to get the best map available of the area and measure the distance between key points with the odometer in the vehicle. Though it is true that this procedure meets the needs of the project, it is also true that modern technology affords a more accurate and advantageous option making use of the Global Postioning System satellites for establishing geographic references. This instrument is known as GPS and units may be obtained at low cost, with geographic accuracy of +/- 7 meters in autonomous operation. There are additional technologies that offer the capacity for greater accuracy, but for the purposes of project design of this kind they are not necessary. Apart from their ability to accurately locate key points, most GPS allow for the recording of a "track" which serves as a basis to construct a power flow model. Given the availability of these instruments at low cost and the advantages of their application in laying out a plan for rural systems, there is no reason to resort to old techniques. This guide will assume the use of this instrument during the field visit. Therefore, the field visit includes the following steps:

3.2.1 Georeference of all sites with GPS

During the visit to the site, the engineer should use the GPS to obtain georeferenced data of the routes followed (and/or the probable route for electrical lines to be installed) and of all the points of interest, such as the substation, the end of the three-phase line, the initial point of the project and the center of each community to be considered in the project. As to the use of GPS, the following concepts should be mastered:

3.2.2 Tracks or routes

All along the route, the GPS can mark out and record the route followed. The engineer must make certain that the GPS is in the right mode to mark and record the route, because upon returning to the office, this information will be very useful in determining the length of both the existing lines and those to be installed.

3.2.3 Waypoints

Another GPS capacity is the location of points of interest for the project, such as the location of the substation, the end point of the three-phase line, the initial point and the center of each community to be considered in the project. Every point should be recorded with an indicative name, which could be the complete name of the community (according to GPS capacity) or a simple indicative name. In any case, the engineer must keep a written file to take down references such as the indicative name, the real name of the community and the additional characteristics of each point.

3.2.4 Files vs. active memory

During the registration of points and routes, the active memory of the instrument fills up. The engineer must ensure that the memory does not become full, because then the GPS will erase the older data or simply stop recording new data; in either case data is lost. Depending on the model the active memory may be filled in half a day, or perhaps after one whole day. In either case, when the memory is full, the engineer should download the data to the computer, so as to make room in the memory. If the GPS model permits it, the instrument operator should transfer the data of the active memory to a GPS internal file, so as to empty the active memory later, without losing data. Most GPS models have room in their memory for at least eight files of route data, besides their active memory.

3.2.5 Keep a record of km and users per community

While recording the route followed and the points of interest in the memory of the GPS, a record should be kept of distances between all points, with the accumulated distance up to the point (to calculate distances later). This record will give the engineer the distances between communities or other points of interest, without having to measure them again. The number of users in each community should be included in the same record.

The following table is an example of a record of points of interest, associated with distances. (Points of the Tomoyo project).

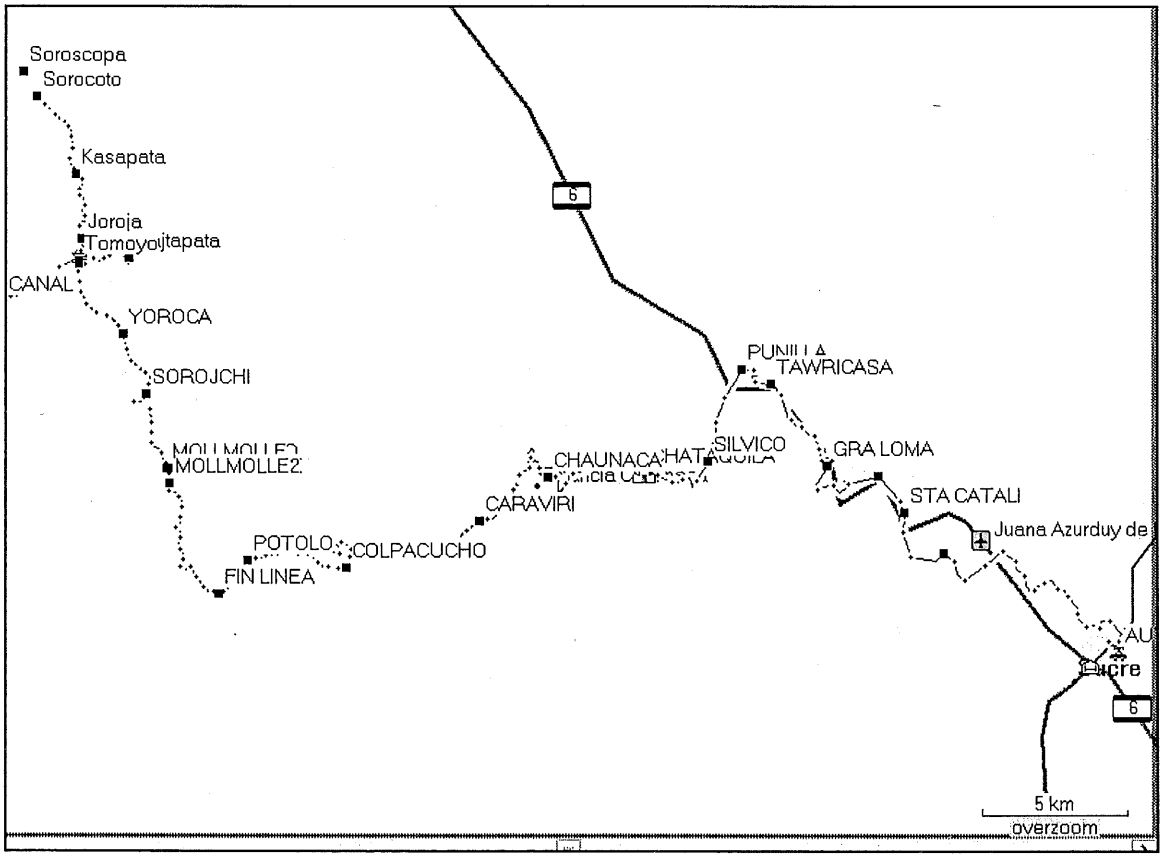
TABLE 3.1 Record of km and users per community (example of Tomoyo)

Point of interest/community	km	Number of users	Notes
Substation Aranjuez	0.0	-	
Industrial Park	6.0	(3500kW)	(existing load)
Airport	8.0	(100kW)	(existing load)
Santa Catalina	13.3	(50kW)	End of three-phase line
Gra Loma	18.5	8	
Tawricasa	22.6	15	
Punilla	24.3	41	
Silvico	27.8	5	
Chataquila	30.6	1	Convent
Chaunaca	36.6	10	
Caraviri	41.4	30	
Colpacucho	48.9	30	
Potolo	54.3	300	End of line
Molle Molle	59.7	38	Chuquisaca
Molle Molle 2	60.0	102	Potosí
Sorojchi	62.6	73	
Isluco	64.6	22	
Yoroca	65.1	69	

Tomoyo	68.5	84
Joroba	69.3	41
Llatapata	70.6	35
Kasapata	72.5	35
Sorocoto	76.2	108
Soroscopa	77.2	41

The following picture shows the file on routes and points recorded in the GPS for the Tomoyo Project:

Figure 3.1 Graphic GPS Data (points and routes) of the Tomoyo Project



3.2.6 Substation

To gather the necessary data for the power flow, it may be necessary to visit the substation, if permission for access can be obtained. In any case, all the necessary information can be obtained in the office of the electric company, but it is often necessary to pay a visit and verify personally

all the data on the equipment name plates, in particular to obtain data that is often not archived in the office, such as the voltage taps in the transformers.

3.2.6.1 Verify the above mentioned characteristics

If the substation is visited, the engineer must verify all data compiled in the office and obtain all the missing data. The following table shows the minimum data to be obtained:

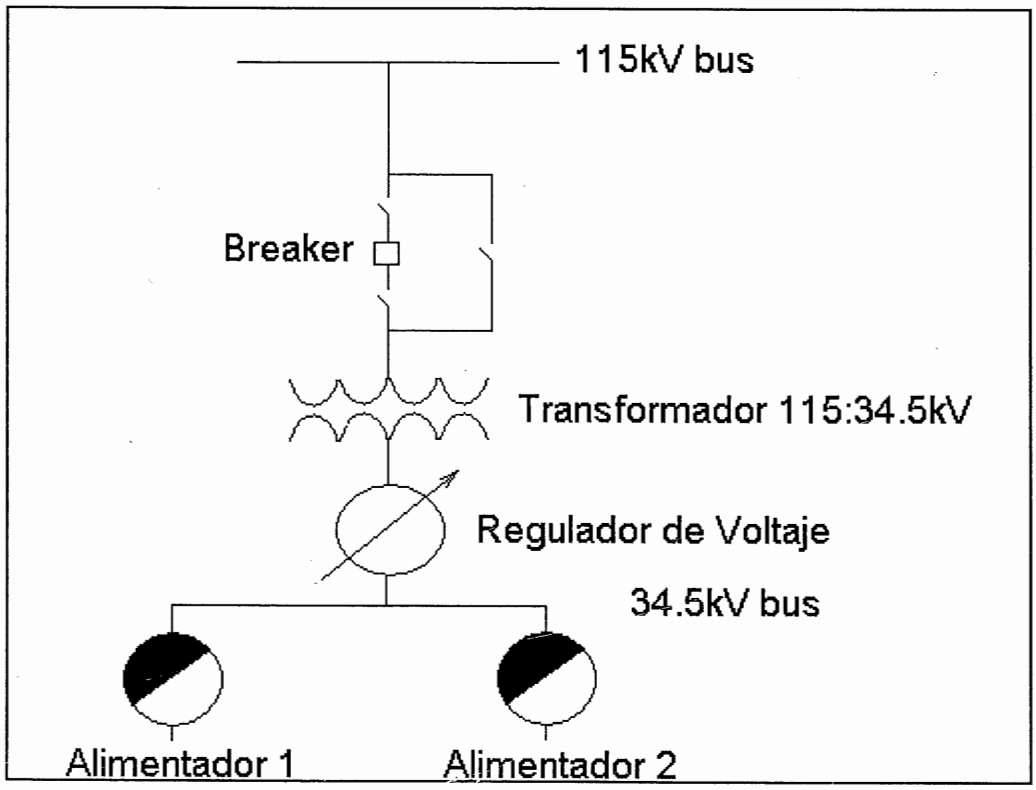
TABLE 3.2 Data Record of the Substation

Item	Data
Capacity of the transformer	
Maximum load in the transformer	
Nominal high voltage rating	
Nominal low voltage rating	
Existence of tap changer in the transformer	
Present position of the tap, if any	
Winding configuration of the transformer (delta-wye, autotransformer, etc.)	
Type of Voltage Regulation	
Impedance of the transformer	
Overcurrent protection and settings	
Other equipment?	

3.2.6.2 Draw a single line diagram of the substation

To help him remember how the substation is configured, the engineer must draw a single lilne diagram of the substation, showing the connections of all the equipment in the substation. The following is a practical example:

Figure 3.2 Single Line Diagram



3.2.7 Between substation and initial point

After obtaining the data on the substation and in particular the georeferenced location, the engineer has to survey the existing line between the substation and the initial point of the project. Along the way he must record the route track with the GPS and mark the points of interest, such as the center of the communities already electrified, the significant existing loads, the end of the three-phase line and the initial point of the project (if it is not the same). All along, the expert must keep the record as previously described in 3.2.5

3.2.8 Initial point of the project

At the initial point, the project designer must verify the data on the existing line, such as the available voltage level (15kV, 25kV o 35kv), number of phases available (1, 2 or 3), existence of a physical neutral and the cross section of the existing conductor. The engineer must also verify the characteristics of the existing users in the last electrified community, such as the following:

3.2.8.1 Consumption of energy in the last electrified community

It is quite probable that the communities that will benefit from the project have the same patterns of electric energy consumption as the neighboring communities that already have an electric energy supply; then it is worth conducting a quick investigation on this aspect, in the electrified community nearest to the initial point. The engineer must ask several community members about the present electricity consumption of each, especially at schools (if any), shops (if any) and in some houses. The average consumption obtained may be applied to potential users in the communities of the proposed project.

3.2.8.2 Present penetration rate in the electrified area

In the electrified community that is nearest to the initial point, the engineer must perform a quick evaluation of the penetration rate. One can check how many houses there are in the town and how many have been connected to the electric system and in what time span. With this sample it is possible to define the penetration rate to be applied to the communities contemplated in the new project.

3.2.9 Survey the proposed project and georeference with GPS

The project designer must survey the whole project, visit all the communities and georeference the roads, the central point of communities (the square, the church or the school, etc.) Along the way, the engineer must spot and note down the features of the land that he will have to cross with his lines, so as to have an idea of the construction difficulties, as well as to estimate the costs adequately (many curves, gorges or streams, rocky ground, etc.) During his survey of the project, the project designer must keep a record of the distances between communities and of the number of potential users in each community, as shown on Table 3.1.

3.2.10 Survey of potential users in each community, by category

During the visit made to each community, the engineer has to estimate the potential users in each category of consumption. He must also visit some of the most important loads to get an idea of the probable demand on the electric system.

The project designer may base his estimation of the demand on small generators or diesel engines that are installed and working, and the energy consumption according to the liters of fuel the motor needs (daily, weekly or monthly). The following Table presents typical consumers and categories, with different loads, that may be found in rural areas.

TABLE 3.3 List of Classes of Users

Residencial
Shop
Workshop
Church
School
Sanitary Post
Water System
Lumberyard
Hotel
Industries
Three-phase Loads

The following table shows an example of categorized users and loads for the Tomoyo Project.

TABLE 3.4 Count of Users by Class for the Tomoyo Project

		CONSUMERER CLASS						
	Community	Residence	Shop	School	Mill	Medical Center	Phone kiosk	Total
	kWh/month	25	75	100	250	150	120	
1	Molle Molle (Chuquisaca)	54	1	1	1	-	-	57
2	Molle Molle (Potosi)	146	2	1	1	1	1	152
3	Sorojchi	105	2	1	-	1	1	110
4	Yoroca	98	3	1	1	-	-	103
5	Tomoyo	114	4	1	3	1	1	124
6	Llajtapata	50	1	-	-	1	-	52
7	Isluco	30	1	1	-	-	-	32
8	Jirota	60	1	1	-	-	-	62
9	Kasapata	50	1	-	-	1	-	52
10	Sorocoto	160	2	1	-	1	-	164
11	Soroscopa	60	1	1	-	-	-	62
	TOTAL	927	19	9	6	6	3	970

3.3 Evaluation of Loads

After the visit to the project area, the engineer should process all the data compiled. The first step of data processing is the calculation of the demand in each community. The best way to calculate the demand is to introduce all data in an Excel worksheet. The first part of the sheet must contain the data illustrated on Table 6.4 above, which includes the number of users per community, consumer category and monthly consumption per category. From those data one can calculate the energy consumption for the entire community. The demand of each community can then be estimated, using the methodology explained in the following section:

3.2.11 Calculation of total energy consumption per community

The next step is to calculate the total energy consumption per community, by multiplying the number of potential users in each category by the specific consumption of that category; this information is included in the demographic study described in the guide relevant to that subject. Table 3.5 shows the results of this step, taking as an example the data of the Tomoyo project, illustrated on Table 3.4.

TABLE 3.5 Consumption of Energy per Community – Tomoyo Project

	TOTAL CONSUMPTION PER COMMUNITY		
	Community	Users	kWh
1	Molle Molle (Chuquisaca)	57	1,775
2	Molle Molle (Potosi)	152	4,420
3	Sorojchi	110	3,145
4	Yoroca	103	3,025
5	Tomoyo	124	4,270
6	Llajtapata	52	1,475
7	Isluco	32	925
8	Jirota	62	1,675
9	Kasapata	52	1,475
10	Sorocoto	164	4,400
11	Soroscopa	62	1,675
	TOTAL	970	28,260

3.2.12 Estimation of the demand according to the REA formula

The methodology to calculate the demand of communities of predominantly residential consumer groups, described in formula 3.3 below, is based on extensive studies of the characteristics of electric consumption in relation to the demand. It takes into account the number of consumers and the average monthly consumption, in kWh/consumer. The method preferred defines the Consumer Factor (Factor A) and the kWh Factor (Factor B), where Factor A reflects the fact that diversity increases as a result of the increment in the number of consumers, and Factor B reflects the improvement in the load factor with the increment in specific consumption.

Formula 3.3: Demand (D) = (Factor "A") * (Factor "B")

Where:

Factor A = C*(1-0.4*C+0.4*(C^2+40)^0.5)
Factor B = 0.005925*(kWh/month/consumer)^0.885
C = number of consumers

This method is empirical in the sense that its derivation was based on statistical correlation of measurements of loads in kW for consumer groups with different levels of specific consumption.. The method has been verified for its use in countries with limited residential penetration of air conditioning.

In Bolivia, for example, a program of measuring and correlation indicated that the equation projects the demand of a mixed residential/commercial group, with an error margin not over 5%. This is a very good correlation indicating that the method is reliable. Table 3.6 shows an application of this method to calculate the demand of the communities in the Tomoyo project.

TABLE 3.6 Demand Calculated per Community – Tomoyo Project

DEMAND CALCULATED PER COMMUNITY				
	Community	Users	kWh	kW
1	Molle Molle (Chuquisaca)	57	1,775	8
2	Molle Molle (Potosí)	152	4,420	19
3	Sorojchi	110	3,145	14
4	Yoroca	103	3,025	13
5	Tomoyo	124	4,270	18
6	Llajtapata	52	1,475	7
7	Isluco	32	925	5
8	Jirota	62	1,675	8
9	Kasapata	52	1,475	7
10	Sorocoto	164	4,400	19
11	Soroscopa	62	1,675	8
	TOTAL	970	28,260	124

3.2.13 Estimation of the demand using data from existing generation (if any)

Sometimes there is isolated power generation in some of the communities to be included in the project. In these cases, one can gather generation data to estimate current demand, which may help to make more realistic projections. In that case, the power plant or system administration should be visited, to obtain the actual data available. The next two points explain the data that may be used for the calculation of demand and energy.

3.2.13.1 kWh per litre of fuel

The key information for calculating the energy consumed by the community is the record of fuel consumption (diesel or others), in litres or gallons per day or month. In many cases, particularly in countries where the government subsidizes the price of fuel, there are thefts and clandestine sales of the subsidized fuel, so that the engineer must try to determine how much fuel is actually used for electricity generation. With this information, the project designer can estimate the electrical energy generation, using the following formula:

Formula 3.4: 10 kWh/gallon or 2.64 kWh/litre diesel

3.3.3.2 Generator size

Another point to consider is the capacity or size of the generator in HP, kW or kVA. This is not a direct indicator of the real demand of a town, because generators are usually oversized, but it does indicate the maximum possible demand of a community supplied by this generator. One way to evaluate whether the generator is oversized or not is to calculate the energy generated as described in 3.3.3.1 and then calculate the demand using the methodology indicated in 3.3.2, and comparing the results.

3.3.3.4 Line length

After projecting the energy consumption and calculating the demand per community, it is necessary to record on the Table the length of primary line required between each community. This information may be compiled from the data record obtained during the visit to the site, as explained in 3.2.5. This information will be necessary to estimate the costs of the project, according to Section 4 of this guide. Table 3.7, shown below, shows the calculation sheet, filled in up to this point:

TABLE 3.7 Demand Calculated and km per Community – Tomoyo Project

DEMAND & DISTANCE PER COMMUNITY					
	Community	Users	kWh	kW	Km
1	Molle Molle (Chuquisaca)	57	1,775	8	6.4
2	Molle Molle (Potosi)	152	4,420	19	-
3	Sorojchi	110	3,145	14	2.7
4	Yoroca	103	3,025	13	2.5
5	Tomoyo	124	4,270	18	4.2
6	Llajtapata	52	1,475	7	2.0
7	Isluco	32	925	5	2.0
8	Jirota	62	1,675	8	1.0
9	Kasapata	52	1,475	7	3.0
10	Sorocoto	164	4,400	19	3.5
11	Soroscopa	62	1,675	8	1.0
	TOTAL	970	28,260	124	28.3

3.4 Analysis of Electric System Behaviour

With all the information about communities available, such as distances between them and energy demand, the engineer should base the electric design of the system on an analysis of power flows or voltage drops, to ensure that the project may withstand, without deficiencies, the anticipated maximum demand and render an efficient service.

Apart from serving to determine the voltage behavior of the project, the power flow study permits one to examine the required number of phases, the eventual need to reinforce the existing

supply systems, or the requirement to establish a distribution system with a different voltage level from the existing one in the area.

3.2.14 Criteria for Analysis

To determine whether the study has met its objective, it is necessary to establish criteria for the evaluation and acceptance of results. The reasoning normally applied to planning studies are divided into criteria to determine the level of voltage, the capacity of equipment and lines, the reliability of the service and the level of losses. They may be summed up as follows:

3.2.14.1 Voltage Level

Minimum voltage levels are normalized in most countries, with the measuring point for purposes of application of regulations at the interconnection node between the supply system and the client's, i.e. in the client's energy meter. Usually, the regulations set a range of acceptable voltage, both above and below a nominal value. Sometimes two ranges are included, one for normal conditions and another for contingencies. In Bolivia, for example, the acceptable range is +4%/-7.5% for normal conditions and +7%/-10% for emergencies. Logically, in case there should be regulations on the voltage level, the analyst should apply the regulated values. The acceptable values for normal conditions must be applied for planning purposes, leaving the additional margin for emergency conditions for use during the operation of the system. In case there are no rules in a given country, the values +5%/-10% may be established as practical values for planning purposes.

It is important to point out that the limit values for voltage level have been set at the point of delivery to the client at low voltage, i.e. at the meter. For planning studies it is not customary to perform the analyses down to this level, so it is necessary to refer the limit value to a system level so that it may be used as criteria for the study. Those planning studies that use the methods presented in this guide are based on the voltage at primary level, i.e., before the voltage drop represented by the distribution transformer, the low voltage (secondary) lines and the service drop.. As reference criteria, the following values may be used:

Voltage Drop in Transformer		2%	
Voltage Drop in Secondary network	2%		
Voltage Drop in Service Drop			1%
Total Drop in LT	**5%**		

Taking into account an acceptable range of +5%/-10% for the service voltage, these values imply that the range to be applied to the study of the voltage drop in the primary system will be +/-5%. It must be made clear that the values submitted correspond to the RUS system design i.e. with single-phase transformers, whose impedance is limited by standards to 2.5%, and with very limited extensions of low voltage lines.

3.2.14.2 Capacity of equipment

For a power flow study of loading in the first year of the project to be acceptable, maximum demand must be limited to no more than 50% of the nominal capacity of the equipment and conductors. This criterium leaves a margin for growth without establishing an excessive level of overcapacity. In a situation where the project is an additional load on a line or existing substation, the criteria may be modified so as to maintain a margin of global capacity in the line or existing substation of 50% of the project load in the first year. In the last year of the analysis, the criteria adopted will be only that the loads projected on any line or equipment should be within their normal capacity, i.e. allowing 100% demand in relation with the capacity.

3.4.1.3. Service Reliability

Service reliability, i.e. the frequency and duration of interruptions, depends more on maintenance of the system during operations than on the decisions made during the design, with one exception. This exception is the provision for a coordinated protection system against faults, the design of which is the result of planning considerations. The objective of a coordinated system is to ensure that for phase -to -phase faults, as well as for phase- to- ground faults, there should be protection elements sensitive enough to detect and clear the fault, and also that the system should be sectionalized in a planned manner, not only to help identify the location of the fault, but also to limit the number of affected consumers.

Since the most common type of fault in electric systems is the ground fault, with an incidence of nearly 85% of all faults, it is important that reliable mechanisms be defined to detect and clear this type of fault. Ground faults often involve contact between one phase and some not very conductive element, like a tree or dry soil, so this is not an easy task. The criteria used by the RUS design system to identify and clear ground faults allows for a nominal resistance of 40 ohms in a series with the fault, which represents the resistance of the tree or soil contacted. This resistance is logically in a series, with the line impedances between the source and the fault, tending to reduce the minimum fault current. The coordination of elements that clear the fault is then designed to respond to this reduced fault current. The system used to clear faults may consist simply of fuses, or may be a combination of reclosers and fuses, provided that the rule of fault resistance is respected.

The minimum level of fault current for coordination purposes is practically a function of the nominal voltage of the system. Taking into account the resistance of 40 ohms specified and the impedance of only 5 km of line, the minimum fault current would be:

For systems of 12.5kV phase to phase – 165 Amp.
For systems of 24.9kV phase to phase – 330 Amp.
For systems of 34.5kV phase to phase – 460 Amp.

Annex C presents an example of analysis of the effect these limitations have on a 24.9kV system. This example uses the recloser/fuse coordination system, which is very common for protection of long distribution systems. By applying the normal rules of this system one can derive the maximum load capacities for the circuit and branches. By applying a similar reasoning to the

other systems and considering the features of the commercially available fuses and reclosers, the following results may be obtained:

For systems of 12.5kV between phases
Maximum load, main circuit – 70 amp
Maximum load, branches with fuses – 25 amp

For systems of 24.9kV between phases
Maximum load, main circuit – 140 amp
Maximum load, branches with fuses – 65 amp

For systems of 34.5kV between phases
Maximum load, main circuit – 200 amp
Maximum load, branches with fuses – 80 amp

These limitations are substantial when dealing with circuit loads, especially for systems of 12.5kV. There are devices for the electronic control of reclosers, which allow this range to be extended, but the important point is that protection coordination should be an element in the integral design of the system.

3.4.1.4 Control of Technical Losses

The control of technical losses has many aspects to be weighed and not all of them are part of the system design process. An example is limitation of losses in the distribution transformers. When purchasing distribution transformers and evaluating their cost, a formula must be considered which determines a financial value for losses, both for no load losses and load losses. This procedure must be applied during the process of purchasing the equipment, not at system design level.

However, one decision that is within reach of the designer is the selection of the conductor cross section. The aim of this selection process is to optimize investment expenses and guarantee more efficiency in the distribution of energy, considering both the cost of construction and the cost of technical losses resulting from the energy flow through the line. The process consists in applying the following equation for several levels of loads and of line construction costs with several alternative cross sections of conductors.

Formula 3.5: $\mathbf{C_A = K_A*(Const) + K_L*(Loss)}$

Where:

C_A = Total annual cost of one kilometer line

K_A = Fixed charge rate for investment costs, typically = 0.15

Const = Construction cost of one kilometer line with a specific conductor cross section

K_L = Acquisition cost of one kWh energy at the beginning of the project

Loss = Annual loss in kWh of one kilometer line with the specific conductor cross section for a specific peak demand and load factor.

$= (LLF)(n)(I^2R)*8.76$

Where:

LLF = Load factor of losses = $(\text{Load factor})^2 *0.84 + (\text{Load factor}) *0.16$

n = 3.0 if the line is three-phase, 2.0 if the line is single-phase
I = Current in the phase for the specific load
R = resistance in ohms of one kilometer of the specific conductor

The development of this equation and the recommended way to calculate its components is submitted in Annex B of this guide.

The result of the repetitive application of this equation for different conductors and levels of demand is a matrix of annual costs that determines the range of loads for which each conductor is optimal, thus representing the conductor with the minimum annual cost.

This seems to be a cumbersome effort, and it would be if it were necessary for every project, but the truth is that the best application of this tool is to conduct a generalized study over the entire electric company system. The aim would be to select a group of no more than four cross sections for conductors, which could reasonably cover among them the range of anticipated loads. This will limit the inventory of connectors and other accessories without losing the capacity to meet the requirements of the system.

Once the group of optimal conductors has been selected, it is not necessary to repeat the analysis until there is a substantial change in one of the factors, such as an important increment in the cost of energy, or a change in line design that seriously affects construction costs.

As an example of procedure we show the result of a comparative analysis of annual cost for three-phase lines of 24.9kV under the following conditions:

Cost of Energy: US$ 0.08/kWH
Load Factor: 40%
Power Factor: 90%
Annual Fixed Charge Rate: 0.15
Cost of line construction based on 2005 prices of materials.

Table 3.8 Comparison of Annual Costs for Three-phase lines of 24.9kV

Conductor	#4 ACSR	#2 ACSR	#1/0 ACSR	#2/0 ACSR	#4/0 ACSR	397.5 MCM
Costo Construcción $/km	$8,961	$9,140	$10,766	$12,941	$15,073	$24,314
Carga kW.	Costo Total Annual $/km					
400	$1,406	$1,410	$1,639	$1,961	$2,273	$3,654
600	$1,483	$1,458	$1,670	$1,985	$2,288	$3,662
800	$1,591	$1,526	$1,713	$2,019	$2,310	$3,673
1000	$1,730	$1,614	$1,767	$2,062	$2,337	$3,688
1200	$1,900	$1,720	$1,835	$2,115	$2,371	$3,706
1400	$2,101	$1,846	$1,914	$2,178	$2,411	$3,727
1600	$2,332	$1,992	$2,005	$2,251	$2,456	$3,752
1800	$2,594	$2,157	$2,109	$2,333	$2,508	$3,780
2000	$2,888	$2,341	$2,225	$2,425	$2,566	$3,811
2500	$3,756	$2,887	$2,568	$2,698	$2,738	$3,903
3000	$4,817	$3,553	$2,988	$3,031	$2,948	$4,015
3500	$6,071	$4,341	$3,484	$3,424	$3,196	$4,148
4000	$7,519	$5,251	$4,056	$3,878	$3,483	$4,301
4500	$9,159	$6,281	$4,704	$4,393	$3,807	$4,475
5000	$10,992	$7,433	$5,428	$4,968	$4,170	$4,669
5500	$13,018	$8,706	$6,229	$5,603	$4,571	$4,883
6000	$15,237	$10,100	$7,106	$6,300	$5,010	$5,118
6500	$17,648	$11,616	$8,060	$7,056	$5,487	$5,374
7000	$20,253	$13,252	$9,089	$7,873	$6,002	$5,649

The grey values are the minimum costs for the load indicated. A #4 ACSR conductor has an application range of only 400kW, which indicates that it should not be considered as a conductor for standard use. Instead, #2 ACSR has an application range from 600kW to 1,600kW, which indicates that this should be a standardized conductor. A #1/0 ACSR conductor has an application range of 1,800kW to 2,500kW, although its range of advantage over #2 is not too marked below 2,000kW. A #2/0 ACSR conductor has no preferred application range, while the #4/0 conductor is preferred from 3,000kW to 6,000kW. For loads over 6,500kW, the optimal conductor is 397.5 MCM. The company given as an example would then remain with four normalized conductors, each one with a substantial application range, as follows:

For loads up to 1,600kW: #2 AWG ACSR
For loads of 1,601kW up to 3000kW: 1/0 AWG ACSR
For loads of 3001kW up to 6500kW: 4/0 AWG ACSR
For loads of 6501kW and over: 397.5MCM ACSR

There are other criteria that may affect the selection of a normalized conductor. For example, the RUS recommends that 1/0 AWG ACSR be taken as the minimum standardized conductor for lines of the 35kV class, such as 33kV or 34.5kV$_{LL}$. (ref. RUS 1724E-200, page 9-5) Another factor to be considered for the choice of conductor is the influence of safety standards in mechanical design. For instance, in conductors for primary lines, all conductors smaller than #2

AWG ACSR may be eliminated from the analysis, according to rule 235.B.1.b of NESC. This rule, which requires more horizontal separation for conductors smaller than #2 AWG ACSR, has the effect of making the spans shorter in primary lines with conductors smaller than #2 AWG ACSR, which increases its cost per kilometer as compared with the lines using #2 AWG ACSR or those of greater sections.

After determining the cross section of the phase conductor, the engineer must determine the cross section of the conductor in the neutral. If the line is single-phase, the neutral should be of the same cross section as the phase conductor, because there will be the same current in both conductors. If it is a three-phase line, one may consider the use of a conductor with a smaller cross section for the neutral, because in a three-phase line with balanced loads, a reduced current flows through the neutral.

In the RUS Bulletin N° 61-4 it is recommended that the neutral conductor should have at least 20% of the capacity of the phase conductor in three-phase lines with balanced loads, and that they have similar characteristics in their sagging. Considering all the above, the following Table 3.9 shows a table of conductors with a reduced cross section for the neutral.

TABLE 3.9 Reduced Cross Section of Neutral Conductors in Three-phase Lines

Phase Conductor	Neutral Conductor
#2 AWG ACSR	#2 AWG ACSR-minimum size
1/0 AWG ACSR	#2 AWG ACSR
2/0 AWG ACSR	#2 AWG ACSR
3/0 AWG ACSR	1/0 AWG ACSR
4/0 AWG ACSR	1/0 AWG ACSR

3.4.2 Considerations in Power Flow Studies

There are several ways of conducting a power flow study: with the help of a personal computer with specialized software, with a computer and electronic calculation sheets, hand calculations, or with tables. However, to obtain reliable data, power flows should be carried out with a specialized engineering software package. Annex A shows a list of features to be found in an analysis package. Among them are some important aspects of the model method:

3.4.2.1 Model by Constant Load instead of Constant Current

One of the approximations applied in power flow studies based on computerized calculation sheets and simplified equation systems for manual application, is the assumption of a constant load current in a given node, determined by dividing the load on the node by the nominal voltage. Unfortunately, at the end of the line, the voltage is different from the nominal; i.e. it is the voltage at the source less the voltage drop. Then, if the current is multiplied by the voltage at the end of the line, one can observe that the model of constant current has effectively reduced the load in kVA of the node and the voltage drop has a significant error.

The method that comes closer to reality is to calculate a solution to the power flow, assuming a current that varies inversely with respect to the voltage of the node, to keep the load in kVA at that node constant. This model requires an iterative solution, i.e. that the calculation should be repeated until the differences between one solution and the previous are minimal. The requirement of an iterative solution is difficult to implement in power flows based on calculation sheets or manual equations, but it is very common in specialized analysis packages.

The error caused by the difference in the load model is not very significant for voltage solutions close to the nominal, but it becomes important when voltage drops are substantial, and thus the difference in the current applied to the system is greater.

In the Tomoyo example of power flow, detailed in another section, with a line of 77 km, conductor of #2 AWG ACSR and 4 MW load and using the constant load model, one could find a voltage drop of 10.3% and 38 kW of losses. But, using the constant current model, there would be a voltage drop of 9.87% and 37 kW of losses. These data represent an error over 4% in a rather small system and it makes a significant difference in the evaluation of the system. The rate of error substantially increases when increasing the size and load of the system. Finally, the program for power flow calculation should take into account a model based on constant loads and not on constant currents.

3.4.2.2. The Capacity to Calculate the Capacitive Charging Current of Overhead Lines

Another simplification used by tables of voltage drops and calculation worksheets is to ignore the capacitive charging current of overhead lines. This is another source of error especially for long lines with light loads, the most common in rural electrification projects. For example, taking the small system in Tomoyo, with the technical and load characteristics described before, there are 73 kVAR of capacitive effect. If this is not taken into account in the calculation of voltages, there would be an error of nearly 1% in the voltage drop and more than 5% in the calculation of losses. The error will increase for systems with less load. Thus, the program for power flow should take into account the capacitive charging current effect of overhead lines.

3.4.2.3. The Capacity to Model Unbalanced Loads

The reality of rural electrification lines, especially those with long, single-phase branches, is that it is difficult to achieve a balance of currents. The negative effect of the imbalance makes voltage regulation more difficult and thus it is important that the analysis system take this effect into account. Most programs for simplified power flow calculation use methods and equations of positive sequence only, i.e., they cannot take into account the imbalance between phases. Many programs developed for the analysis of transmission systems also use the positive sequence approximation, because transmission lines are always three-phase and therefore always balanced. But this is not the case in distribution systems, so that the capacity to model unbalanced loads is essential.

Coming back to the Tomoyo project, the feeder for this project has 83% single-phase lines from the substation. Therefore, trying to study this system with a power flow based on values of positive sequence would not give a reliable result. Thus the power flow program for a

distribution system should always have the capacity to make calculations with unbalanced loads, either with symmetrical components (an approximation) or with matrices (preferably).

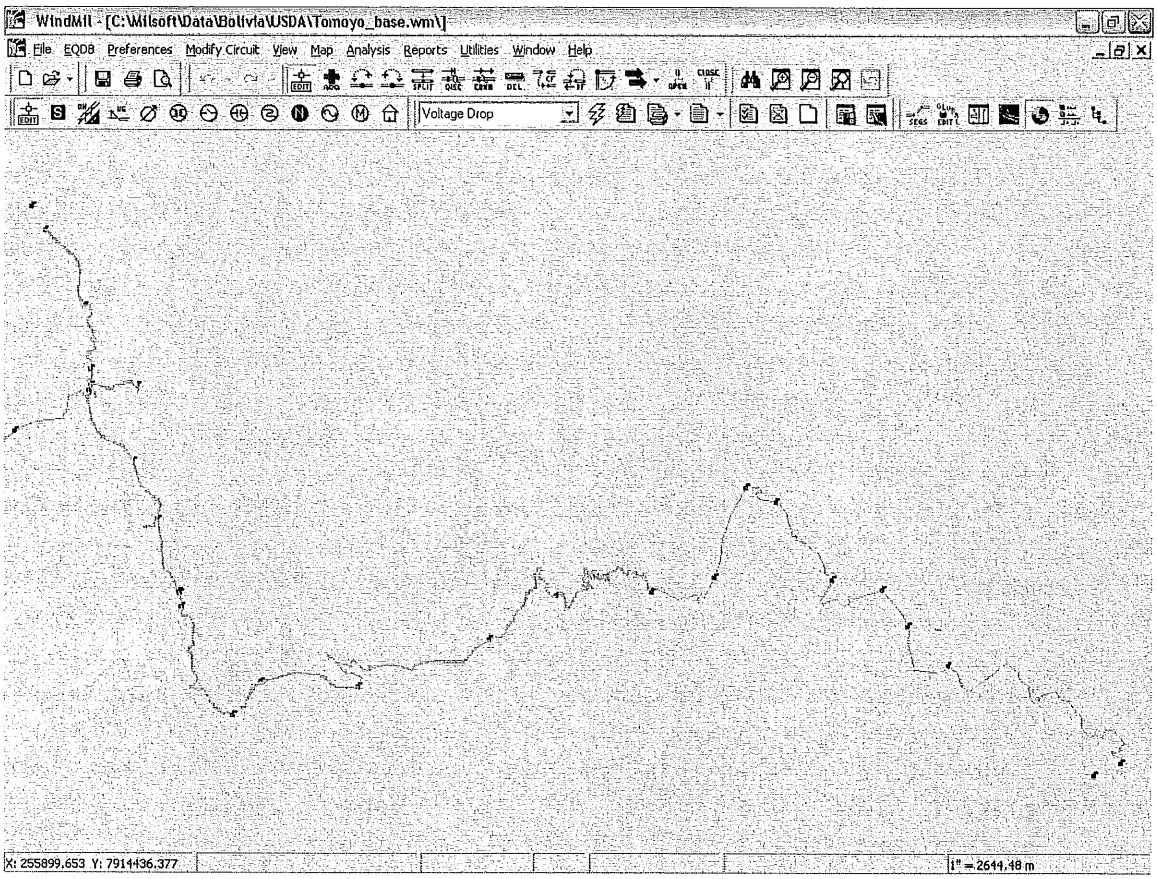
3.4.2.4. Capacity to Calculate Unbalanced Impedances

Analysis programs using positive sequence approximations, apart from their inability to model unbalanced loads, have no capacity to model unbalanced impedances. It is possible, though not very common, for a three-phase line to have different conductors in the different phases, i.e. if it were constructed originally as a single-phase line with a given conductor cross section, and then converted into a three-phase line with another conductor cross section for the two new phases. Another, still more common case of unbalanced impedances, is a bank of single-phase transformers in which impedances are very similar but seldom exactly alike. Thus the power flow program for a distribution system should always have the capacity to calculate unbalanced impedances, preferably by using matrices.

3.4.2.5. Considerations for the Power flow Model for the Tomoyo Project

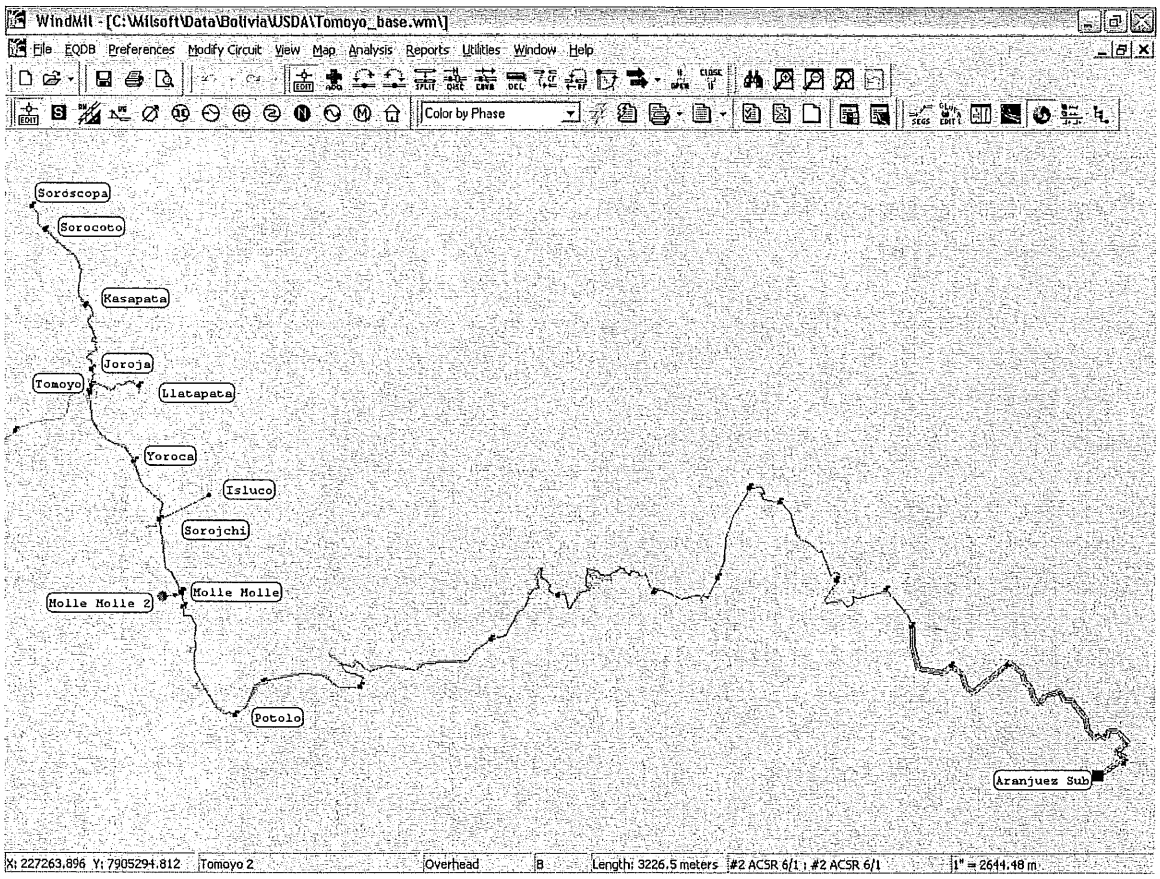
The power flow analyses for the Tomoyo project, used as an example for this guide, were performed with the Windmil analysis package (Milsoft Utility Solutions,. Texas, USA). This package has all the required technical features for a power flow program and has an additional function called "LandBase", which is very useful to create the model of the system by directly importing the tracks and waypoints from GPS recievers. Figure 3.3 below shows the Windmil screen with the GPS data of the Tomoyo project imported by LandBase.

Figure 3.3 Windmil Screen with GPS Data of the Tomoyo Project



The points of interest, such as communities included in the project and the routes between them are shown along the line. In the lower part of the screen the scale of the drawing appears along with geographic coordinates of a selected point. Figure 3.4 below shows the database of the Tomoyo project superimposed on GPS data.

Figure 3.4 Windmill Screen with Database of the Tomoyo Project



3.4.3. Selection of Primary Voltage Level

Once the geographic model has been created, it is necessary to determine the voltage to be used for the new extension. The choice of a voltage level for a given project depends, to a large extent, on the levels already used in the area. Obviously, the selection of a voltage that is different from the existing one, implies the utilization of substation equipment, possibly of transmission, and should not be lightly recommended. Having said that, the introduction of a voltage level of the 25kV or 35kV class may be a reasonable alternative in the following circumstances:

a. If the existing voltage (whether 5kV or 15kV) cannot be extended to serve the new project, without investing in substations and sub-transmission lines.
b. If it is a system that has to serve large specific loads, which are scattered over a wide area, such as an irrigation project, it may merit the establishment of a different voltage level from the existing one that serves residential loads in the same area.
c. If the client or group of clients to be served represents a pilot project for a more extensive development of similar projects in the area.
d. If there is a sub-transmission voltage within the same company that may be used for distribution. In those cases in which the electric company has historically utilized a

34.5kV or 22kV as a sub-transmission voltage, it is possible that these lines may be converted to fit distribution applications at an attractive cost.

In the Tomoyo project, none of these considerations were applicable and so the project was developed at 14.4 kV (class 25kV) as an extension of the existing system.

3.4.4. Determination of the Number of Phases

After determining the length of the proposed system and calculating the demand of potential loads in existing lines and those proposed for the project, the engineer must determine the number of phases required in the proposed lines of the project. As indicated at the start, the basic assumption of the RUS integrated design system, presented in this guide, is that rural lines should be single-phase, for economic reasons, i.e. phase and neutral. However, there are situations in which it will be necessary to consider the extension of two -phase lines (two phases and neutral), or three-phase lines, for the following reasons:

a. The current in one of the single-phase branches exceeds the limit established for a system of coordinated protection, according to section 3.4.1.3.
b. The result of the power flow studies indicates that it will not be possible to maintain voltage levels within regulatory limits using a single-phase system for the projected loads.
c. The existence of three-phase loads in the project area that are large enough to make a conversion into single-phase impossible. Generally, motors of over 10HP are three-phase, though the technology exists to overcome this limitation.
d. The nature of the loads to be covered by the project rules out the use of single-phase systems. For example, a project that consists in the development of an extensive irrigation system, with electric pumps of over 10HP each, should be designed from beginning with three-phase lines.
e. The need to distribute the loads among phases, to ensure a better balance of phase currents at the source. This is a necessary consideration in cases in which the permissible percentage of current imbalance is regulated by law, as in Bolivia.

In every situation, the need for alternative solutions to the extension of single-phase lines must be justified on the basis of economic and/or regulatory considerations. It must be pointed out, in case the requirement for a three-phase service is only potential and not immediate, that the design of the single-phase lines standardized by RUS facilitates the conversion to a three-phase configuration, with the addition of a crossarm and two-phase conductors. With the services of a properly trained contractor and with adequate equipment, it is possible to realize this conversion without de-energizing the single-phase line. For certain cases, it is possible to plan, initially, single-phase construction, to be converted to three-phase in the future, without losing the economic benefits of the initial single-phase solution.

In the Tomoyo project it was not necessary to modify the initial design and the system was designed with single-phase lines.

3.4.5. Determine the Application of a Physical Neutral

In situations where loads are scattered and with little growth potential, some companies and electric authorities have applied the MRT system (Monofásico c/retorno por tierra-in Sp), or SWER (Single Wire Earth Return), which consists in a single phase conductor without physical neutral. This system is also applied in areas where there are problems with the theft of the neutral conductor. The MRT system has been successfully applied in Brazil, Australia and Africa.

The main considerations in its application are:

a. For situations in which there is no hope of load growth beyond a very low initial level (8 amperes per circuit), it is possible to use steel conductors, long spans of around 250 meters and narrow right of way. Its application represents a 50% reduction in the construction cost of a conventional single-phase line with aluminum conductors steel reinforced (ACSR).
b. If conventional ACSR conductors are used in order to maintain capacity and facilitate service to higher loads or to permit the future conversion to three-phase systems, the economic benefits are lower. Savings would be around 12% due solely to eliminating the neutral conductor.
c. MRT/SWER systems produce higher levels of interference with telephone circuits than a conventional single-phase line. This is not as important as previously, as there is a trend towards the elimination of wired telephone systems.
d. To control neutral to ground voltages in the service drops, it is necessary to implement a system of double grounding at the transformation points. A double grounding system uses a separate ground for the primary neutral of the transformer and another, at a certain distance, for the neutral of the low voltage system and the service drop. This increases the cost slightly for transformation points.
e. To limit the voltage gradient to an adequate value for the safety of persons and pets, it is recommended to limit the maximum value of the resulting voltage in the grounding of the primary winding of the transformer, to 20 volts. To obtain this value for transformers of different capacities, it is necessary to ensure that ground resistances do not exceed the values indicated in the table below:

Table 3.10 Maximum Resistances for MRT/SWER Ground Systems

Voltage of the System	7.2kV	14.4kV	19.9kV
Module	Maximum Ground Resistance- Ohms		
10 kVA	15	30	30 (regulations)
15 kVA	10	20	27
25 kVA	5	10	16

It is to be noticed that, particularly for the 7.2kV MRT/SWER system, achieving these values may increase the cost of grounding, especially in difficult types of soil.

f. Another consideration is the separation between the primary system grounding and that of the low voltage system and service drop. The regulations used by the Australian Electrification Authority require that a 3 m separation be kept between the grounding of the primary winding of the transformer and the user's ground system, and that no interconnections exist between them. To obtain this separation, the ground wire of the secondary neutral must be insulated from the ground conductor of the primary neutral and separate fields of ground rods should be installed.

Taking into account the advantages, disadvantages and limitations of the MRT/SWER system, the decision for the Tomoyo project was to use a conventional single-phase system. i.e. with phase and physical neutral, owing to the demand of the project being 15 amperes for the year 20.

3.4.6. Determination of the Conductor Cross Section

The conductor cross section should be determined according to the criteria set forth in section 3.4.1, i.e., based on an economic choice and limited by considerations of protection coordination and voltage drops. For conditions of energy costs, load factor and power factor described in Section 3.4.1, the matrix of economic conductors for 14.4kV single-phase lines is:

Table 3.11 Comparison of Total Annual Cost for 14.4 kV Single-phase Lines

Conductor	#4 ACSR	#2 ACSR	#1/0 ACSR	#2/0 ACSR	#4/0 ACSR
Costo Construcción $/km	$5,668	$6,015	$7,138	$8,163	$9,839
Carga kW.	Costo Total Annual $/km				
100	$873	$917	$1,080	$1,232	$1,480
150	$902	$935	$1,091	$1,241	$1,486
200	$943	$960	$1,107	$1,253	$1,494
250	$995	$993	$1,128	$1,270	$1,504
300	$1,059	$1,033	$1,153	$1,290	$1,517
350	$1,134	$1,080	$1,183	$1,313	$1,532
400	$1,221	$1,135	$1,217	$1,341	$1,549
450	$1,319	$1,197	$1,256	$1,371	$1,569
500	$1,429	$1,266	$1,300	$1,406	$1,590
550	$1,551	$1,342	$1,348	$1,444	$1,614
600	$1,684	$1,426	$1,400	$1,486	$1,641
650	$1,828	$1,517	$1,457	$1,531	$1,669
700	$1,985	$1,615	$1,519	$1,580	$1,700
750	$2,152	$1,720	$1,586	$1,633	$1,734
800	$2,332	$1,833	$1,656	$1,689	$1,769
850	$2,523	$1,953	$1,732	$1,749	$1,807
900	$2,725	$2,081	$1,812	$1,813	$1,847
950	$2,940	$2,215	$1,897	$1,880	$1,889
1000	$3,165	$2,357	$1,986	$1,951	$1,934

Again, the grey results represent the most economical conductors for the load indicated. The #4 conductor has an application range up to 200 kW; #2 conductor an application range of 250 kW

to 550 kW, #1/0, from 600 kW to 900 kW. Again, #2/0 conductor has practically no application range and #4/0 conductor is applicable only above 1000 kW. Taking into account that the limitation owing to the coordination of 14.4kV single-phase branches is 65 amp, or nearly 1000 kW, it is clear that a #4/0 conductor cannot be considered for this application. Preferred conductors for 14.4kV single-phase lines are#2 ACSR for loads up to 550 kW and #1/0 ACSR for loads from 600kW to the coordination limit, i.e. 1000kW. Since the load projected for the Tomoyo project is 124 kW for the first year, with a projection to be increased up to 250 kW until the year 15, the standardized, utilized conductor is #2 ACSR.

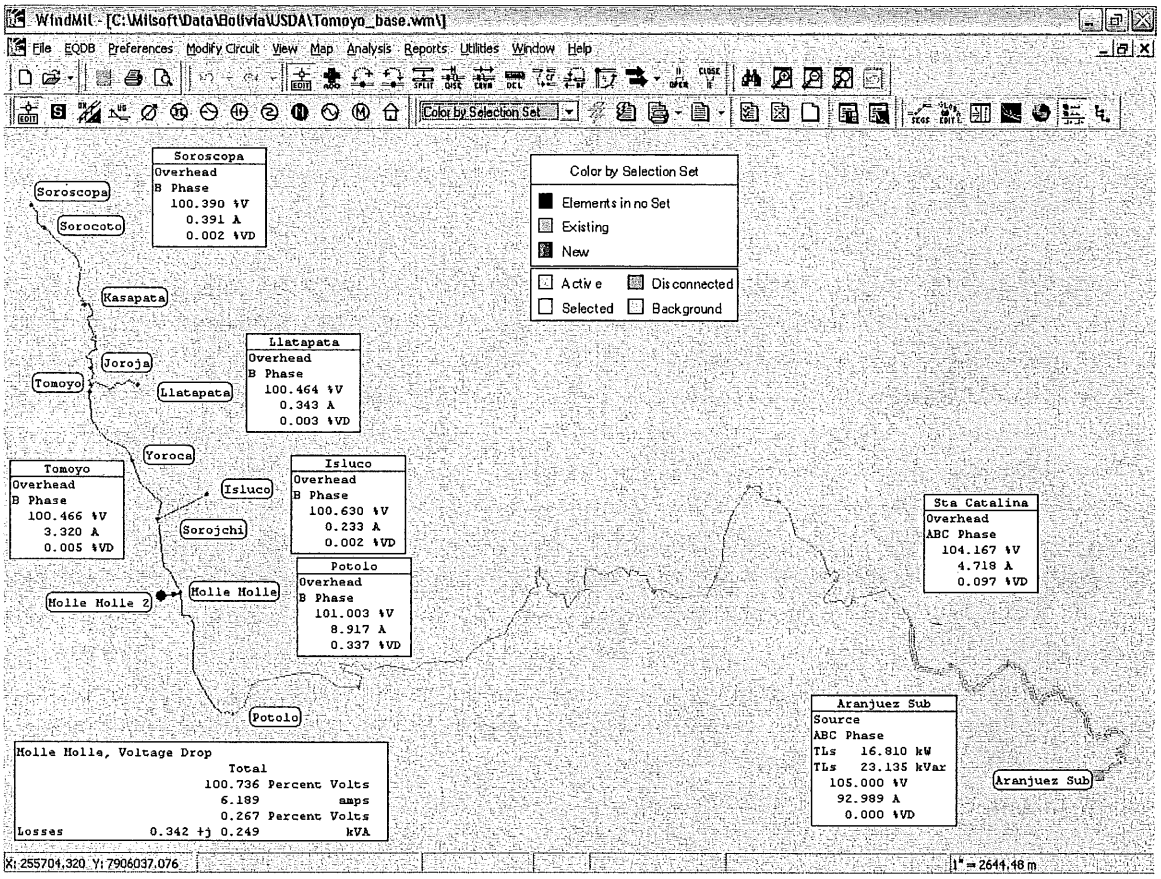
Minimum Voltage Calculation

Once the number of phases and cross section of the conductor have been selected, one may run the power flow model to determine if the selections made are adequate, or if they have to be adjusted by increasing the number of phases and/or the conductor cross section. Decisions should be based on the criteria specified as follows:

3.4.6.1 Voltage in the first year

Upon running the program, with the projected load for the first year, the result should show voltage levels of +5%/-5% with respect to the nominal voltage, according to Section 3.4.1.1. The loads applied come from the Analysis of the Demand, which takes into account a certain penetration rate for potential users. If values under 95% of the nominal voltage are found at any point in the model, one should either increase the number of phases or the conductor cross section, according to the parameters specified in previous sections. No voltage regulators should be applied in the first years. Fig. 3.5 shows the result for the first year of the Tomoyo project analysis.

FIGURE 3.5 Three Line Diagram of the Tomoyo Project Power flow at Year 1

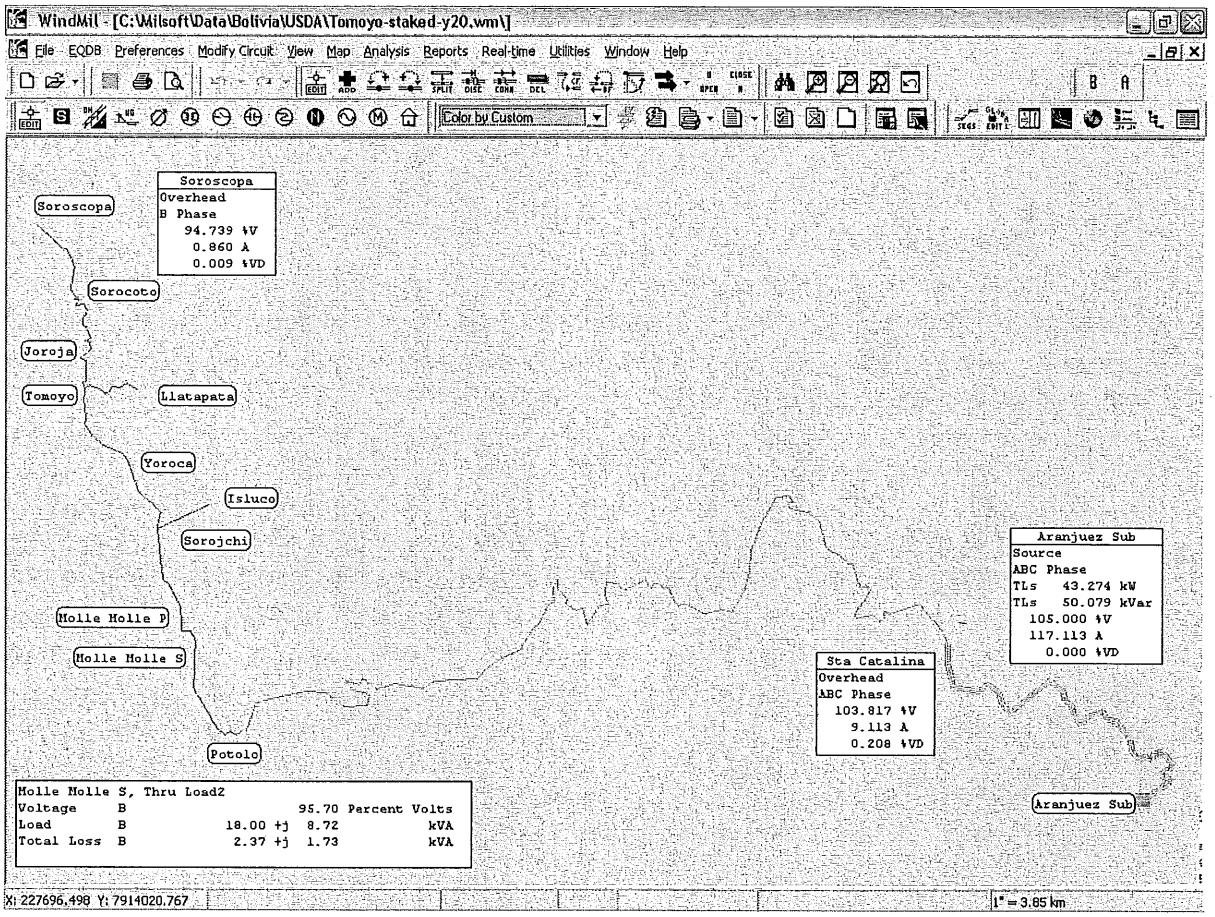


The Table of results of the Tomoyo project power flow is illustrated in Annex D as an example.

3.4.6.2. Voltage in the final year

Upon running the power flow program with the projected demand for the last year considered in the analysis of the project, usually 20 years, the result should show that 90% of the nominal voltage is the worst situation. The loads to be applied come from the Analysis of Demand, which takes into account a certain penetration rate for potential users and the vegetative growth rate. As from the year 20, the use of regulators is acceptable to maintain 95% of nominal voltage for final users, so as to comply with the profile of regulated voltage during the useful life of the line (usually 30 years). If a level below 90% of nominal voltage is observed at any node of the model, either the number of phases, or alternatively, the conductor cross section should be increased in the first year, according to the parameters specified in previous sections. Fig 3.6 shows the result for the year 20 of the analysis, in the Tomoyo project.

FIGURE 3.6 Three Line Diagram of Power flow for the Tomoyo Project in the year 20

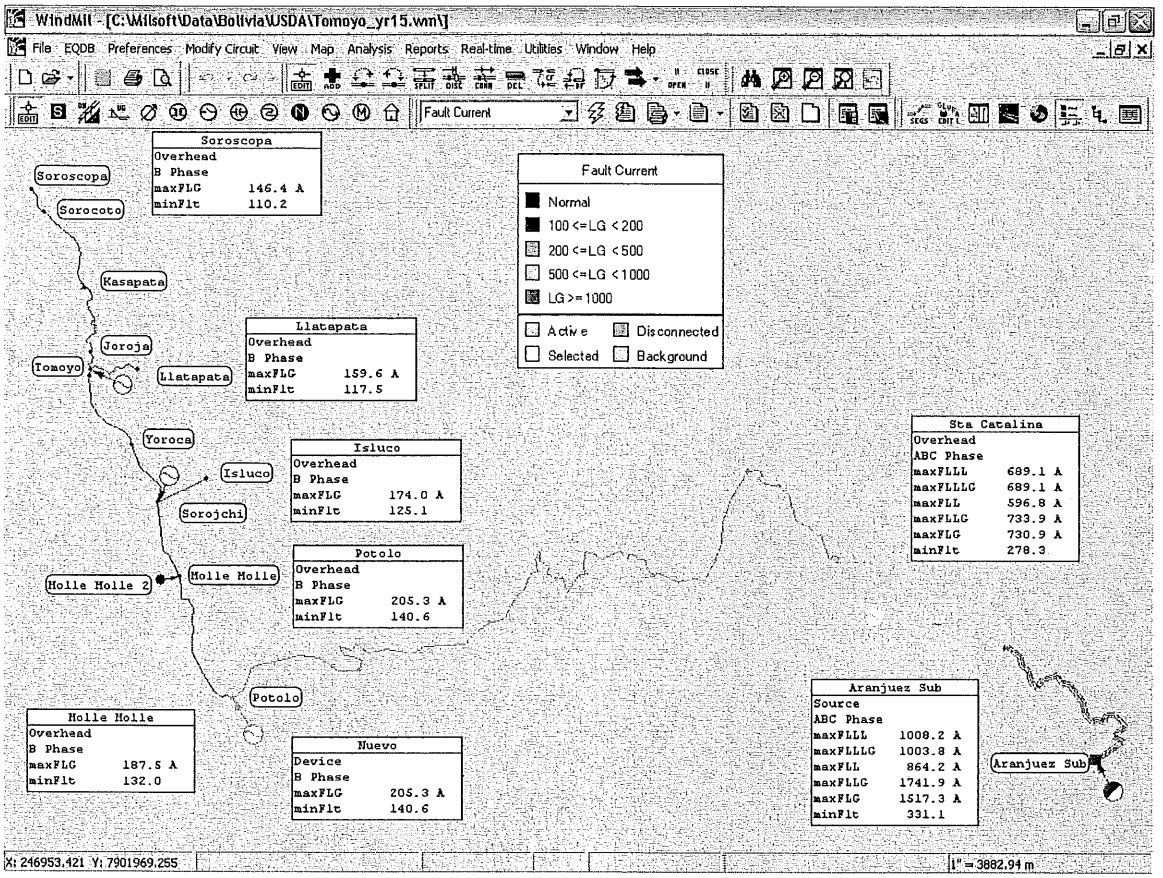


The table of results of power flow in the Tomoyo project is illustrated in Annex D as an example.

3.4.7. Coordination of Protection for Overcurrents

With the same database as for the power flow, the engineer will be able to calculate the magnitudes of the fault currents, in order to conduct the coordination study on protection devices for overcurrents. Fig.3.7 shows the values of fault currents calculated for the Tomoyo project.

FIGURE 3.7 Three Line Diagram of the Values of Fault Currents for the Tomoyo Project



Once the fault currents have been calculated, the engineer may coordinate the protection devices. For this purpose, he should start the coordination process with the fuse devices of the distribution transformers. These fuses must be coordinated with the fuses of the laterals, then with the main line and finally with the recloser in the substation. Although a detailed explanation of the coordination procedure for the various protection devices is outside the scope of this guide, Annex C presents some considerations on the procedure for protection coordination in the Tomoyo project.

4. ESTIMATION OF PROJECT COSTS

After following the procedure detailed in section 3, the project engineer will already have an electrical pre-design including the determination of line lengths, the number of potential users, primary voltage, number of phases, conductor size and whether a physical neutral will be used or not. With these data, it is possible to make a detailed estimation of project costs. The following presentation lays out the procedure for estimating the cost of rural electrification projects.

3.5 Materials Database

The first step towards the estimation of project costs consists in maintaining a database of the cost of materials, according to purchases or previous quotations. This database should include the unit price of each item of material and the total amounts for each purchase. Unit prices always depend on the volume of purchased materials. Greater volumes usually result in lower unit prices. This database must make a difference between materials for projects of 15, 25 or 35kV, because some items differ according to their voltage level (insulators, transformers, etc.). Apart from the purchase cost of materials, one must consider the taxes, if applicable to the project in question. Most projects financed with external aid are exempt from local taxes, but in other cases, the applicability of taxes and their amount must be determined. Another very important factor in being able to apply historical costs to future projects, is the projection of the cost itself. The historical cost of materials may be projected to the future by using an inflation rate or the percentage of increase in the cost of metals. A good database for metals is the London Metal Exchange in the Internet: http://www.lme.co.uk.

Table 4.1 below shows a simple format for a materials database:

TABLE 4.1 Format for a Materials Database

Description of Item	Historical Unit Price	Taxes	Inflation	Projected Unit Price

3.6 Labor Database

Apart from a database for the cost of materials, the professional responsible for the design should maintain a database on the cost of labor, according to the historical construction costs of previous projects. The costs on this database must be disaggregated by construction unit and not by kilometer, to be able to differentiate lines with different features. To apply historical costs to future projects, the engineer has to apply an inflation rate to historical costs. Table 4.2 below shows a typical format for a labor database:

TABLE 4.2 Format for a Labor Database

Description of the Unit	Historical UnitPrice	Inflation	Projected Unit Price

3.7 Database by Construction Unit

The next step to determine project costs consists in calculating the investment costs by construction unit. These costs are formed by adding the cost of materials for all the items included in the unit, plus the cost of labor for that unit. Table 4.3 below shows a typical format for the database on cost by construction unit:

TABLE 4.3 Format for a Database on Cost by Construction Unit

Unit: ZA1

Description	Quantity	Unit Cost	Total Cost
Square washer, 2-1/4"(5/8")	3	$ 0.13	$ 0.39
Locknut, 5/8"	2	$ 0.11	$ 0.23
Spool insulator, 1-3/4"	1	$ 1.22	$ 1.22
Compression connector, ground to neutral	1	$ 0.33	$ 0.33
Preformed armor rods, single support, phase	1	$ 3.01	$ 3.01
Preformed armor rods, single support, neutral	1	$ 2.17	$ 2.17
Machine Bolt, 5/8" x 10"	2	$ 0.55	$ 1.10
Spool bolt , 5/8" x 10"	1	$ 2.43	$ 2.43
Pin-type insulator, ANSI 56-3	1	$30.22	$ 30.22
Pole top Pin , 20"	1	$ 3.68	$ 3.68
Aluminum tie wire, feet	15	$ 0.07	$ 1.04
Total Material Cost			$ 45.81
Labor Cost			$ 5.79
Total Unit Cost			$ 51.60

3.8 Database on Previous Designs

Apart from maintaining a database on costs by construction unit, the engineer in charge needs to maintain another database on construction units by kilometer of line, for the feeders between communities (called trunk lines or main feeders) and on construction units for distribution networks in the communities (taps off the primary line, transformation points and low voltage distribution networks). The database for feeders between communities must include poles, primary structures, conductors, anchors and all the primary line hardware. The database on distribution networks for the communities must include all the units used in primary lines,

underbuild and secondary lines, and the transformation points in the communities. In the database on feeders between communities, the engineer must distinguish between three-phase and single-phase lines. Likewise, in the database on feeders between communities he must distinguish between lines in flat, level areas and broken terrain or areas with many line angles; because construction costs of electric lines differ greatly between these two types of land. Then, when going to the field, the engineer will evaluate the line to be built and will be able to determine the cost to be applied per unit.

Table 4.4 below shows a format for a database on construction units by kilometer/feeder:

TABLE 4.4 Format for a Database on Construction Units by kilometer

Unit	Quantity		Unit Cost	Total Cost
ZC1	71	$	165.28	$11,734.65
ZC1-1	1	$	310.71	$ 310.71
ZC2	9	$	311.45	$ 2,803.08
ZC3	5	$	221.28	$ 1,106.41
ZC6-10	2	$	490.96	$ 981.92
ZC7-1	6	$	230.48	$ 1,382.86
ZC7H	1	$	259.57	$ 259.57
ZC8H	3	$	422.10	$ 1,266.30
E1-2	49	$	22.95	$ 1,124.64
E6-2	6	$	38.80	$ 232.79
F1-12	61	$	20.46	$ 1,247.79
M2-11	48	$	17.71	$ 849.93
ZM3-3	1	$	455.90	$ 455.90
ZM5-7	3	$	42.79	$ 128.36
ZM5-18	1	$	42.24	$ 42.24
Poste 11-6	78	$	107.22	$ 8,362.93
Poste 12-6	10	$	130.67	$ 1,306.73
Poste 13.5-5	6	$	144.30	$ 865.79
1/0 ACSR	35,679	$	0.55	$19,671.74
#2 ACSR	11,893	$	0.46	$ 5,527.81
RM6	10,225	$	0.44	$ 4,547.43
TOTAL				**$64,209.60**
Units	12	Km		
Unit Price		**$**	**5,398.94**	**/km**

3.9 Database on the Costs of Service Drops

After developing the cost by kilometer of primary lines for feeders between communities and the cost by user for the distribution network in each community, the engineer has to develop cost estimations for the service drops. As in the preceding steps, these estimations must be based on a database of historical data, which includes the cost of materials and labor. There are various types of service drops and the person in charge of the design must know the particularities of the

different types of service drops included in the historical database. Table 4.5 below shows an example of a database on the distribution of different types of service drops:

TABLE 4.5 Distribution of Different Types of Service Drops

Type of Servcice Drop	K10M	K10E	K10L	K10P	K10P-X	TOTAL
Description	Fixed on wooden wall	Embedded in earth wall	Fixed on brick wall	On 6 mt. pole	On 9 mt. pole	
Quantity	414	494	530	3,122	180	4,740
Percentage	9%	10%	11%	66%	4%	100%

3.10 Database on the Cost of Staking

The only cost component still to be determined is that of staking (design) of the proposed project. To have an idea of its cost, the engineer has to keep a database of the historical costs of staking in recent projects. This database must include the cost by kilometer for feeders between communities and the cost by user for the staking of the distribution network in each community. Afterwards, the engineer has to make a projection of the annual cost, taking into account an inflation rate. The Table 4.6 below shows an example of a database on the costs of electric lines markings.

TABLE 4.6 Costs of Electric Line Staking

Project	Cost/km	Cost/User
Nº 1	$ 218.76	$ 7.56
Nº 2	$ 248.25	$ 8.07
Nº 3	$ 246.90	$ 8.97
Nº 4	$ 222.22	$ 9.88
Nº 5	$ 195.00	$ 10.00
Nº 6	$ 215.00	$ 13.00
Average:	$ 224.35	$ 9.58
Inflation rate:		5%
Projected:	$ 235.57	$ 10.06

3.11 Total Investment Cost of the Project

Upon arriving at this step, the engineer already has all the cost components necessary to estimate the total budget for the project.

These estimations may be added to the Excel worksheet described in Section 3.3.

Table 4.7 below shows an example of an Excel electronic sheet which includes the total cost of the project.

TABLE 4.7 Cost Evaluation for the Tomoyo Project

	Tomoyo	km	phases	users	KWh	kW	Staking	Feeder	Distribution	Total Cost	$/User
1	Molle Molle (ambos)	6.4	1	200	6,000	25	$ 4,723	$ 28,160	$ 94,000	$ 126,883	$ 634
2	Sorojchi	2.7	1	105	3,150	14	$ 2,240	$ 11,880	$ 49,350	$ 63,470	$ 604
3	Yoroca	2.5	1	98	2,940	13	$ 2,084	$ 11,000	$ 46,060	$ 59,144	$ 604
4	Tomoyo	4.2	1	114	3,420	15	$ 2,893	$ 18,480	$ 53,580	$ 74,953	$ 657
5	Llatapata	2.0	1	50	1,500	7	$ 1,326	$ 8,800	$ 23,500	$ 33,626	$ 673
6	Isluco	2.0	1	30	900	5	$ 1,086	$ 8,800	$ 14,100	$ 23,986	$ 800
7	Jiroja	1.0	1	60	1,800	8	$ 1,083	$ 4,400	$ 28,200	$ 33,683	$ 561
8	Kasapata	3.0	1	50	1,500	7	$ 1,689	$ 13,200	$ 23,500	$ 38,389	$ 768
9	Sorocoto	3.5	1	160	4,800	20	$ 3,191	$ 15,400	$ 75,200	$ 93,791	$ 586
10	Soroscopa	1.0	1	60	1,800	8	$ 1,083	$ 4,400	$ 28,200	$ 33,683	$ 561
		28.3	10	927	27,810	121	$21,397	$ 124,520	$ 435,690	$ 581,607	$ 627

3.12 Tables of Indicative Line Costs

In line with the above information, the project designer is in a position to have a database on the construction costs of electric lines. Table 4.8 shows costs of projects recently carried out by NRECA in Latin-America:

TABLE 4.8 Costs of NRECA Projects

	Bolivia	Nicaragua	Dominican Republic	Guatemala
Voltage Class	35 kV	25 kV	15 kV	15 kV
Three-phase US$ per km	$ 5,300	$ 9,534	$ 9,365	
Single-phase US$ per km	$ 3,100	$ 6,329	$ 5,472	$ 4,000

5. REQUIREMENTS FOR THE PRESENTATION OF THE PROJECT

Once the engineer has completed the electrical design of the project, which consists briefly of the selection of primary voltage, the determination of the number of phases and conductor section, as explained in Section 3, he is in a position to estimate the total cost of the project, according to Section 4 of this guide.

With this information, the engineer must prepare the presentation of the project. This presentation must contain a description of the project and a power flow, as explained in the previous sections. It is not advisable that it should contain many engineering tables or catalogues of materials, which only add volume but do not assist in the description of the project.

3.13 Description of the Project

The description should be simple and useful for the evaluation of feasibility of the project. Table 5.1 below shows a scheme to clarify the description of the Project. The numerical values correspond to the Tomoyo Project.

TABLE 5.1 Description of the Tomoyo Project

Name of the Project	Tomoyo
Location of the Project	Department of Potosí
Names of the communities favoured	Molle Molle (ambos), Sorojchi, Yoroca, Tomoyo, Llatapata, Isluco, Joroja, Kasapata, Sorocoto, Soroscopa
Number of users favoured	927
Kilometers of primary lines	28.3
Primary voltage	14.4 kV
Number of phases	One
Section of conductor	#2 AWG ACSR phase and neutral
Estimated cost of parking	$21,397
Estimated cost of feeders	$124,520
Estimated cost of distribution networks	$435,690
Total estimated cost of project	$581,607
Estimated cost by user	$627

3.14 Power flow

The power flow proves that the design is adequate for the project throughout the period evaluated. Consequently there will be at least two power flows: one for the first year of the project and another for the last. A third power flow may be included when the study warrants the inclusion of some voltage regulation equipment during the life of the project, or during the time allowed for project analysis, so as to show where, when and with what capacity this equipment is required to be installed. In these cases, the power flow should include a table of

resultsshowing the data for each point of the study and a three-line diagramto show the results in a graphical format.

ANNEX A. LIST OF REQUIRED CHARACTERISTICS IN AN ENGINEERING SOFTWARE PACKAGE (POWER FLOW)

There are various analysis software packages available in the market, which include the calculations of power flow or voltage drops. Then, for their quotation, it is advisable to take into account the characteristics detailed in the following Table:

Characteristic		Required o desirable?
1. Model with constant load		Required
2. Calculation of line capacitive effect		Required
3. Calculation of unbalanced loads		Required
4. Calculation of unbalanced impedances		Required
5. Graphic Interface for the user		Desirable
6. Updated version each year		Required
7. Nº of users at present	>500	Desirable
8. Availability of documentation in Spanish		Required
9. Application for countries in the area		Required
10. Applicable to available hardware		Required
11. Possibility of support from external interfaces: printers and plotters available		Required
12. Interface with GPS?		Required
13. Interface GIS? Which?		Desirable
14. Presents and prints geographic results without GIS?		Desirable
15. Unlimited number of sections or nodes?		Desirable
16. The package should perform the following functions a. Power flows and voltage drop b. Calculation of fault currents c. Calculation of fault current flow d. Protection coordination e. Optimal location of capacitors f. Rebalancing of the system g. Analysis of motors start-up h. Optimization of load distribution among feeders i. Incorporates distributed generators j. Permits meshed solution k. Permits distribution of loads based on various criteria		Required
17. Must permit the modeling and manipulation of current/time curves for protection coordination		Required
18. Must permit the modeling of single-phase, three-phase, three-wind transformers and autotransformers		Required
19. Must permit the modeling of transmission lines (132, 69kV), with or without neutrals or guard wires		Required

20. Must model underground cable with concentric neutral	Required
21. Incorporates interface for input of consumer records fromconsumer database packages	Desirable
22. Must permit calculations in metric or English units	Required
23. Permits calculations in 50Hz or 60 Hz?	Required
24. Permits introduction of conductors defined by the user	Required
25. Competitive cost with other options for 1 module of work (example)? For 7 modules (examples) in the same company?	Required
26. Reasonable cost for annual subscription?	Required
27. Available support in Internet?	Required
28. Availability and cost of one week's training?	Required
29. Support and training available in Spanish?	Required

ANNEX B. CALCULATION OF FACTORS FOR THE ECONOMIC ANALYSIS OF CONDUCTORS

The method for the economic analysis of conductors, submitted in Section 3.4.1.4 of this guide, consists in evaluating the following equation for several load levels and for lines constructed with different conductors:

$C_A = K_A*(Const) + K_L*(Loss)$

This Annex presents the application of said equation and some methods for calculating the factors it contains:

C_A= Total annual cost of one kilometer line

The C_A value is the result of the equation, i.e. the sum total of the annual cost owing to the fixed costs of the line, plus the cost of losses in kWh/year, resulting from the flow of a certain level of current in the line conductors. It must be emphasized that this equation gives a specific C_A value, valid only for a specific load level. It is understood that the load on a line is not constant but varies in the long term with the growth of users' demand and in the short term, every hour of the day. It is thus impossible to establish a singlular value for C_A and the objective of the method is to identify a range of loads for each conductor, within which the C_A, or total annual cost, is lower for that conductor than for any other. For a specific conductor, this range is defined as the preferred application range and the meaning for the analyst is that, if the maximum projected demand the line must satisfy is within the preferred range of a certain conductor, then this conductor is the most economical choice for the construction of the line, notwithstanding the variation of demand. To base the conductor selection decision on load ranges allows for a certain margin of error in the estimation of the demand.

K_A= Fixed charge rate for investment costs

Although it is true that a line has an initial construction cost that is paid even before it is energized, the owner or operator of the line incurs regular costs during all its useful life. These costs may be expressed in the form of a proportion of the initial cost of the line. There is a series of values that may be expressed in this way, a list of which will be presented below.. It must be pointed out that this is a process of analysis aiming at a decision on the choice of a conductor. It is not necessary that it should tally in full detail with accounting practice at the company or standard cost-accounting practice. Therefore, this process of analysis could be different from a regular accounting treatment, without losing relevance.

a. Amortization of financing- For those programs in which the company finances the rural electrification asset construction by means of capital loans, it is clear that the amortization (the annual installment including interest and capital) is an annualized cost, even in cases in which financing comes from the government and is non-reimbursable, the capital cannot considered to be free. In general, there are loans (perhaps from the

World Bank to the government) that may be taken as a reference to assign an annual cost of financing. Notwithstanding the characteristics of the source and the financing terms used for the purposes of this analysis, it is still good practice to assume financing over a similar period to that of the study, i.e., no less than 20 years. Usually, the interest rate for development projects covering that period is around 6% annually or less. To determine the annual installment, expressed as a percentage of the total value of the initial financing amount, it is necessary to use an amortization table. For example, for a 20 year loan at 6% interest, the annual amortization installment is 10.3% of the initial value of the loan. There are cases in which the financing of rural electrification projects is really non-reimbursable, i.e., that financing is granted without any obligation to the government and there is no obligation to amortize the amount financed. Even in such a case it is still necessary to include a financial cost of no less than 5%, so as not to distort the analysis.

b. Operation and Maintenance- The cost of personnel to carry out operations and repairs of lines is a cost that varies with the total length of the line in service and therefore this cost may be expressed as a proportion of the investment cost. To calculate this value we add all the operating and maintenance costs of the distribution system, excluding the cost of purchased power. From this amount we subtract the administrative costs and the costs related to the attention to customers. The result is divided by the total original value of all the distribution lines (primary and secondary) in service. A typical value is around 2% to 3%.

c. Taxes- The taxes to be considered are those paid directly on the value of the line, i.e., a tax on asset or property value. The rate to be applied in the analysis is determined by adding all the annual property tax costs of the company and dividing the result by the value of taxable assets. It would be necessary to determine the value in the right jurisdiction, but typical values are around 1%.

d. Insurance- The insurance premium against damage and losses during the operation of the system is a cost usually calculated on the value of insured assets. This cost exists even if the company were self-insured, owing to losses of this nature that often occur. An appropriate rate can be determined by adding the costs (whether of insurance of this kind or for replacement of assets due to losses incurred) and dividing by the original value of the assets in service. The typical rate is around 1% of the initial value of the assets.

e. Typical value of the fixed annual charge rate - In the absence of any actual source of information, the following figures may be used without incurring significant errors:

Concept	Value
Amortization	10%
Operation and Maintenance	3%
Taxes	1%
Insurance	1%
Total Fixed Annual Charge Rate	15%

Const = Cost of construction per kilometer line with a specific conductor

Construction cost is the unit cost (per kilometer) derived from the detailed study in Section 4.0 of this guide. It is necessary to derive unit costs for lines constructed with each one of the conductors under consideration. In general, there is no information on line construction costs for all the range of conductors, but only for a few. It is necessary, then, to modify cost data to properly reflect the impact on the structural design of using heavier conductors than those used historically. For example, the structures normally used for rural lines are limited to conductors of 1/0 AWG ACSR or a smaller cross section it is necessary to use different structures for conductors of greater cross section and this represents a cost. It is also to be assumed that conductors of greater cross section must be supported by stronger poles. These factors have to be analyzed according to the "Simplified Staking Manual for Aerial Distribution Lines" and thus develop appropriate designs for lines with conductors that are not included in the historical database. It is also necessary that the analyst should ensure that the costs adopted for the lines with different conductors are really comparable, i.e., with equivalent consideration of the number of angle structures, deadends and topographic relief.

K_L= Purchasing cost of a kWH of energy at point of project entry

The cost of energy determines the value of losses and thus represents a key assumption for the study. Having said that, it is very difficult to arrive at a reliable projection of the future value of energy. So as not to complicate the study, an approximate value is recommended, which can be calculated by adding up all the costs of purchased power during a recent period, a value that includes the demand charge, any wheeling charges, the basic energy charge and the surcharge for the cost of fuel, if any. This total value for the cost of energy for the company should be divided by the sum total of kWh purchased during the same period. This is a historical calculation, of course, and in case the impact of some factor is known whose future implementation can be anticipated with certainty, it may be included. One must resist the temptation of applying inflation rates to the cost of energy, when they have not been verified by experience, owing to the distortions those rates introduce in the results.

To be able to refer the cost of energy to the point of entry of the project under consideration, one must increase the cost derived in the above paragraph by the rate of technical losses of the company. This value should not exceed 10%, i.e., that the cost of energy used in the analysis should not exceed 110% of the cost of energy calculated in the above paragraph.

Loss= Annual loss in kWh of a kilometer line for the specific conductor and a specific load

To estimate the maximum loss in kW resulting from the flow of current in an electric line, it is necessary to know the current that corresponds to maximum demand, the number of wires in which the current flows and the resistance of the conductor. To convert this value of "power losses" to an annual consumption of energy in kWh, it is necessary to relate the load loss factor with the load factor of the maximum demand in the system. The equation to determine the losses in kWh/year is:

$$\text{Loss} = (LLF)(n)(I^2R)*8.76$$

Where:

LLF= Load Loss Factor = $(\text{Load Factor})^2 * 0.84 + (\text{Load Factor}) * 0.16$

n= number of wires carrying current - 3 if the line is three-phase, 2 if the line is single-phase

I= Current in one phase for a specific load

R= resistance in ohms of a kilometer of the specific conductor

The load loss factor, LLF, is related with the load factor of the demand in the system, but it is necessary to take into account that the power loss value (kW) at any time varies according to the square of the demand in the system, i.e., that when the load is reduced by 50% in relation with maximum demand, the losses in kW are reduced to 25% of what they were at this maximum demand. Therefore, losses in kWh do not have the same load factor as the system demand. Owing to this squared relationship between the load carried by the line and the losses in kW, it is not possible to derive a loss equation in kWh without knowing the daily load curve of the line. The LLF equation previously submitted is empirical, based on the experience of RUS cooperatives for systems with a minimum installed capacity of air-conditioning equipment.

It must be pointed out that the calculation of the other factors follows normal procedures of electrical engineering, i.e., that the current can be calculated according to the nominal voltage of the line, whether it be three-phase or single-phase. The "N' factor reflects the fact that for the hypothesis of balanced phase currents in three-phase lines, current intensity I flows in each phase, but not in the neutral. Instead, for single-phase lines, the current I flows in the phase as well as in the neutral. The "R" resistance of a kilometer conductor may be obtained from tables or catalogues of conductor characteristics. For the purposes of this analysis, one must use the resistance value of the conductor that corresponds to room temperature, normally adopted as 25°C in the tables of conductor characteristics. The loads in the range preferred for selected conductors by applying the method of analysis herein presented, do not normally generate higher temperatures.

ANNEX C. EXAMPLE OF PROTECTION COORDINATION CONSIDERATION FOR THE TOMOYO SYSTEM

To have a reliable system, the electric company should develop adequate coordination between its overcurrent protective devices. Therefore, the fuses should be coordinated with the reclosers, so that under fault conditions, only the necessary devices open the circuit, minimizing the number of consumers affected. The result is a more reliable system.

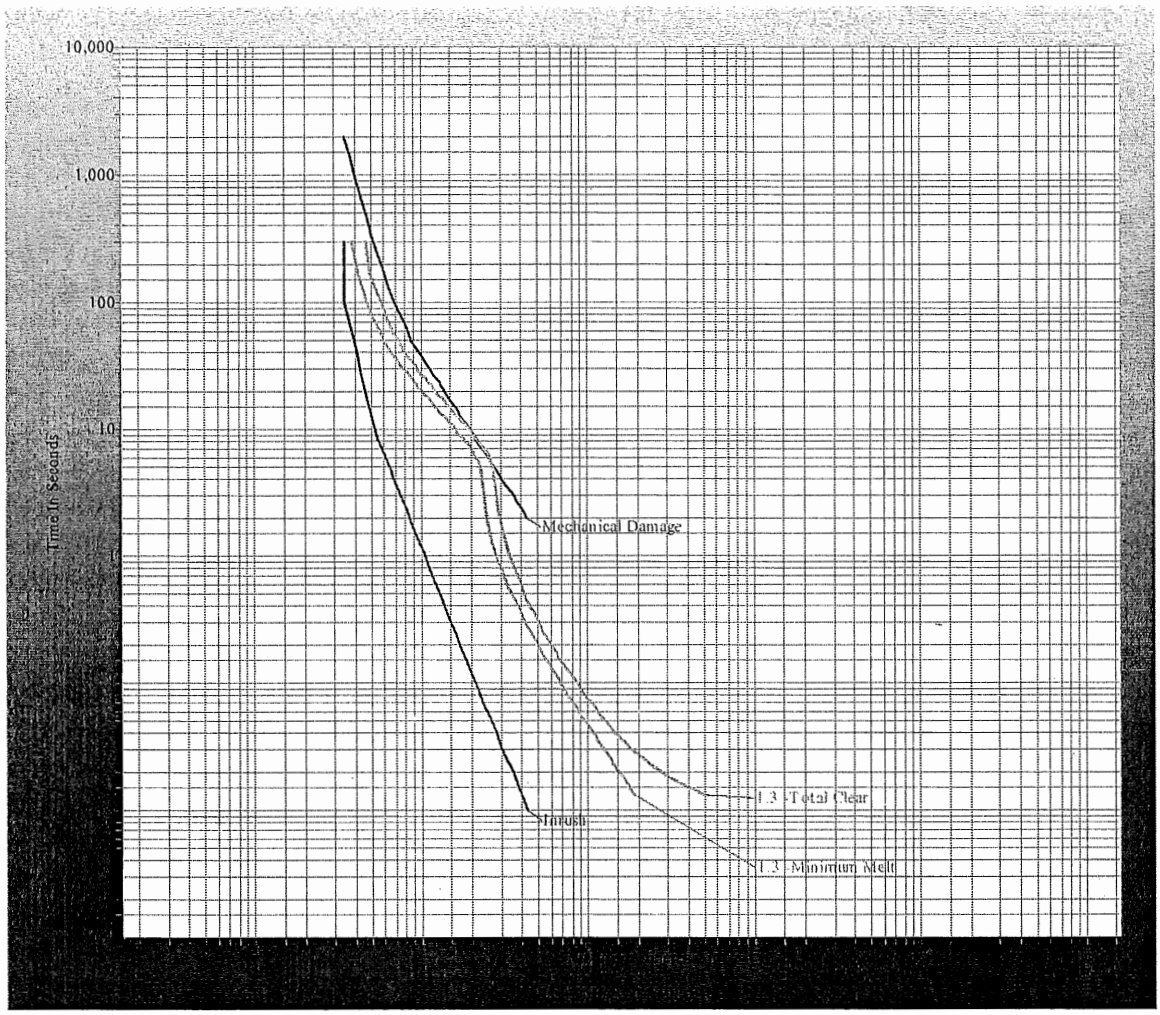
The first step in coordinating protection consists in calculating the magnitudes of fault currents. Only when the fault currents have been calculated can the engineer coordinate protection devices. The process of coordination of protection devices must start with the fuses of the largest distribution transformers. The fuses of taps must be coordinated with this fuse, then with the main line and lastly with the recloser at the substation.

Though a complete explanation of the procedure for coordination among the various protection devices is outside the scope of this guide, there follows a brief explanation of the procedure used to coordinate the Tomoyo system.

Step 1: Coordinate the transformer fuse

The fuses in the transformers have to protect it from destructive currents, but without melting during energization inrush or load currents. To accomplish both functions, industry has developed double-element fuses, such as the SLO-Fast of AB Chance. The following Fig.C illustrates the coordination of a type Slo-Fast fuse with the characteristics of a 25kVA, 14.4kV transformer.

FIGURE C.1 Coordination Slo-Fast Fuse and a 25kVA, 14.4kV transformer

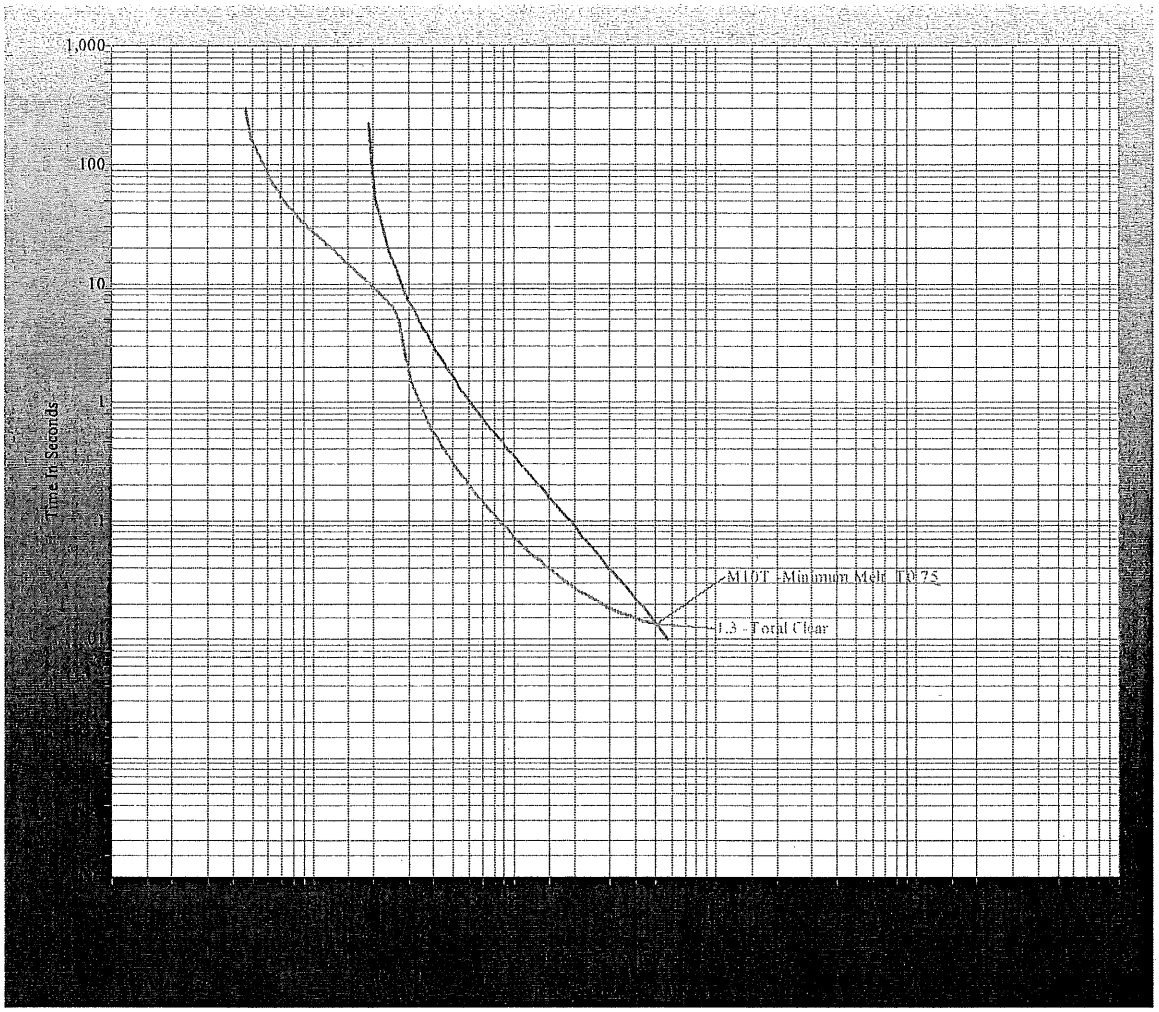


We can see here that the optimal size of Slo-Fast fuse for a 25kVA, 14.4kV transformer is 1.3A.

Step 2: Coordinate the branch fuse

The branch fuse, or tap, has to be coordinated with the fuse of the largest distribution transformer installed in this branch (let us consider a 25kVA transformer); it has to withstand the maximum load current and be sensitive enough to detect the minimum fault. In the Tomoyo project there are two branches, one in Isluco and another in Llatapata. In these two cases, the power flow is of 1A and the minimum fault current is of 117A. We can then choose a fuse that coordinates with the 1.3[a] Slo-Fast fuse. To coordinate the time of operation of the two fuses, we must compare the total clearance time of the fuse downstream, with the minimum melting time of the fuse upstream. To have a safety margin, we must consider only up to 75% of the minimum melting time of the fuse upstream. Fig C.2 below shows that a type T, 10A fuse meets all the requirements, because the 10A operation current is higher than the maximum load current of 1A.; the 20A melting current is lower than the minimum fault current of 117A and the 510A coordination current is higher than the maximum fault current of 174A.

FIGURE C.2 Coordination of 10A type T fuse with a 1.3A Slo-Fast Fuse

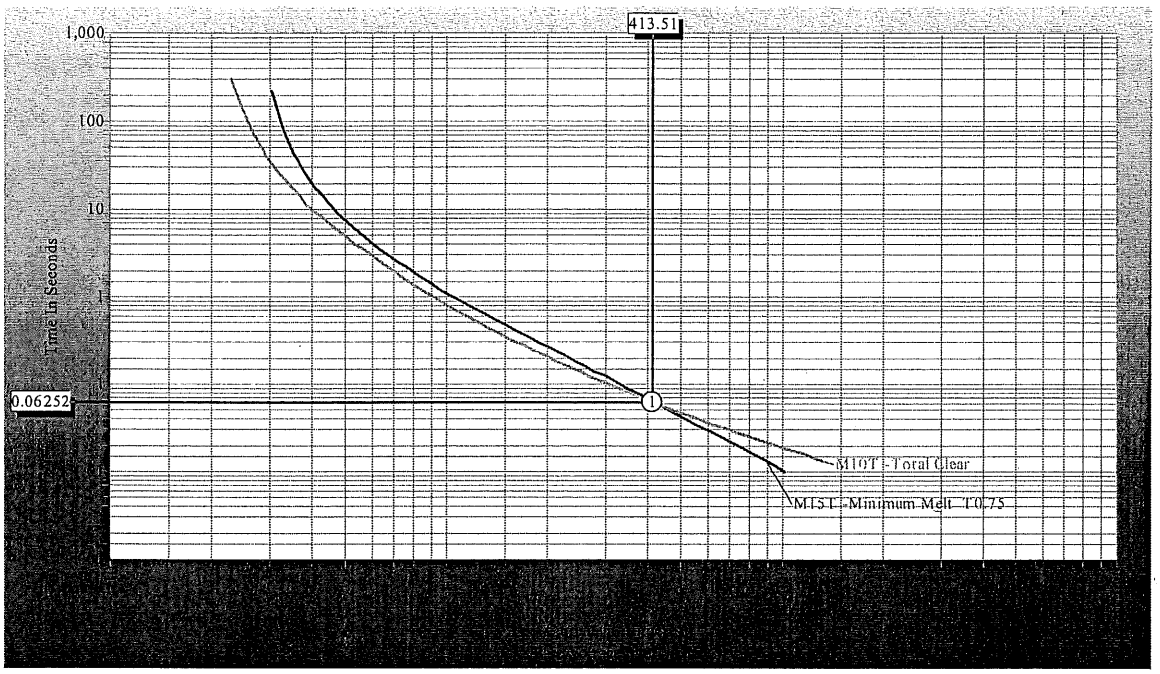


Step 3: Coordinate the fuses in line

The line fuse has to be coordinated with the largest branch fuse installed in this system (we consider a 10T fuse obtained in Step 2); it must withstand the maximum load current and be sensitive enough to detect the minimum fault. In the Tomoyo project there are two fuses on the main line: one ahead of Potolo, where the new lines start and one in Santa Catalina, where the three-phase line ends. Firstly, we must coordinate the fuse on the line downstream i.e. the fuse ahead of Potolo. In this case, the load current is 15 A and the minimum fault current is 110 A. We need to choose a fuse that can coordinate with the 10 T fuse in the Isluco and Llatapata branches. To coordinate the time of operation of the two fuses, we must compare the time of total clearance of the fuse downstream with the minimum melting time of the fuse upstream. To have a safety margin, we must consider only up to 75% of the minimum melting time of the fuse upstream. In Fig.3 below we can see that a type T fuse of 15 A meets all our requirements, because the 15 A operation current is higher than the maximum load current of 14.3 A in the

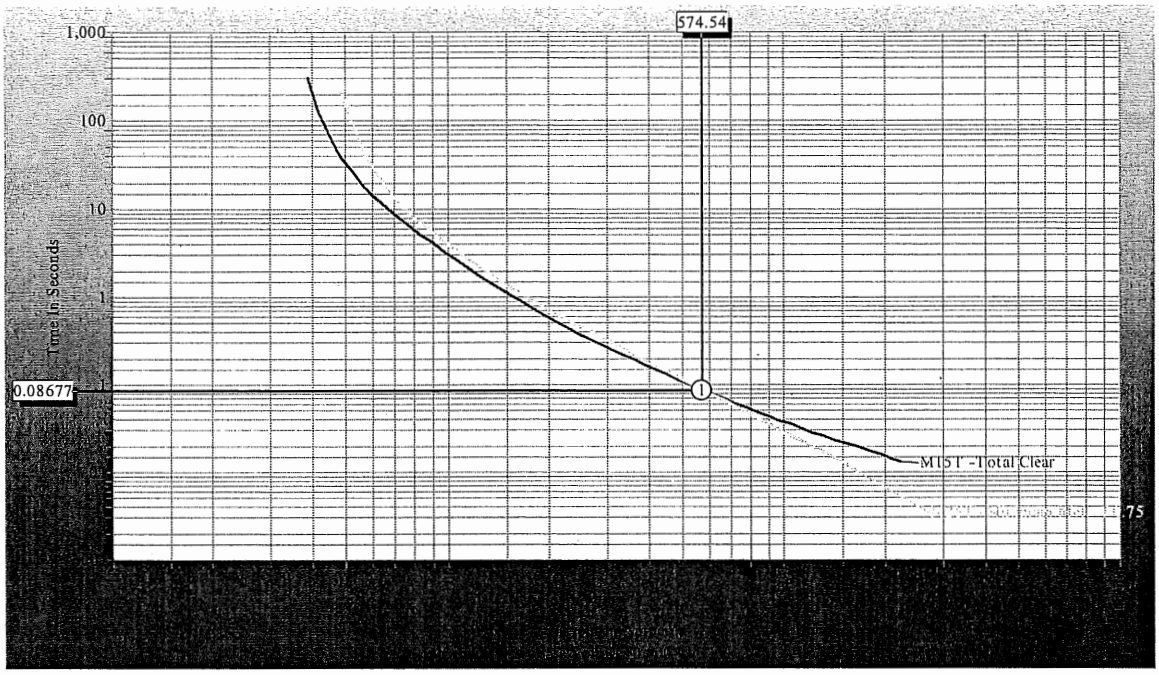
fifteenth year, the 30 A melting current is lower than the minimum fault current of 110 A and the coordination current of 413 A is higher than the maximum fault current of 174 A.

FIGURE C.3 Coordination of 15A type T fuse with a 10A type T fuse



Afterwards we must coordinate the line fuse at Potolo with the line fuse at Santa Catalina. The fuse at Santa Catalina has to coordinate with the 15T fuse previously obtained, withstand that maximum load current and be sensitive enough to detect the minimum fault. In this case, the load current is 21 A and the minimum fault current is 140 A. To coordinate the time of operation of both fuses we must compare the total clearing time of the fuse downstream with the minimum melting time of the fuse upstream. To have a safety margin we must consider only 75% of the minimum melting time of the fuse upstream. In Fig C.4 below we can see that a type T fuse of 25 A meets all our requirements, because the 25 A operation current is higher than the maximum load current of 21.2 A in the fifteenth year; the 50 A melting current is lower than the minimum fault current of 140 A and the 574 A coordination current is higher than the maximum fault current of 205 A.

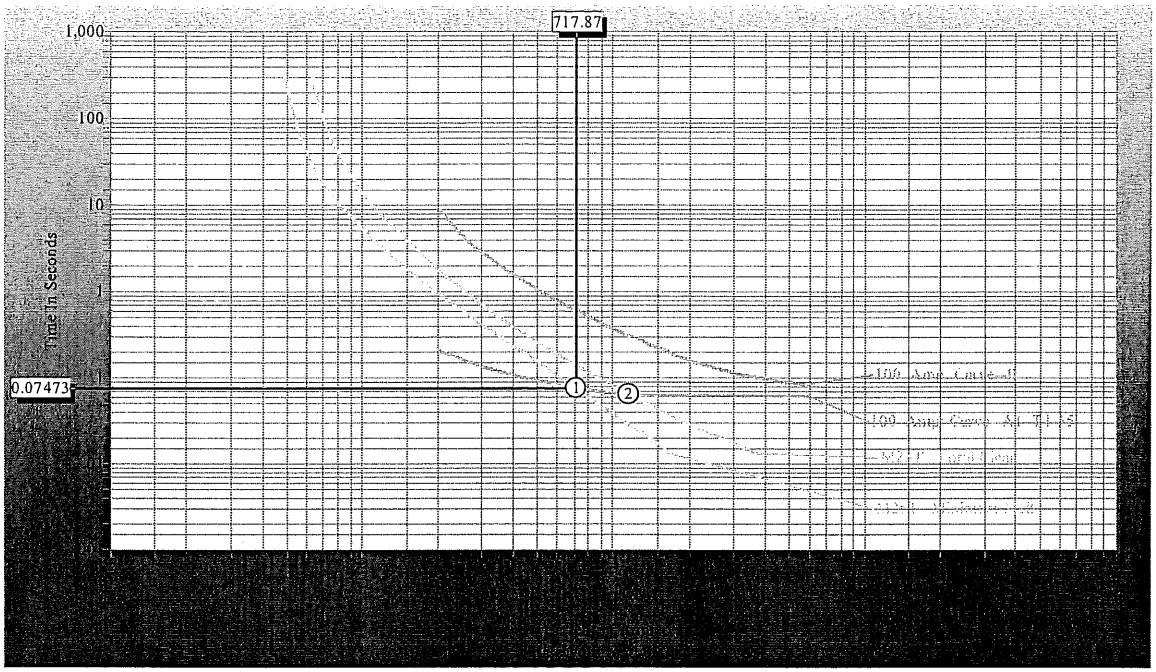
FIGURE C.4 Coordination of a 25A type T fuse with a 15A type T fuse



Step 4: Coordinate the recloser at the substation

The recloser at the substation has to be coordinated with the largest line fuse installed in this system (we consider a 25T fuse, obtained in Step 3), it must withstand the maximum load current and be sensitive enough to detect the minimum fault. Also, if they are correctly coordinated, the recloser may offer protection to the fuse in cases of temporary faults. In this case, the load current in the fifteenth year is 97 A and the minimum fault current is 278 A (for a fault at Santa Catalina). To coordinate the time of operation of the recloser with the fuse, we must compare the minimum melting time of the fuse (downstream) with the minimum operation time of the fast curve of the recloser (upstream), and the total clearing time of the fuse with the slow curve of the recloser. To have a safety margin and protect the fuse from overheating, with a recloser with two fast operations and two slow ones, we need to multiply the operation time of the fast curve by 1.35, In Fig C.5 below we can see that a VW Cooper recloser of 100 A meets all our requirements, because the 100 A operation current is higher than the maximum load current of 97 A; the 200 A activation current is lower than the minimum fault current of 278 A and the 718 A coordination current is almost equal to the 730 A maximum fault current in the fuse; the recloser withstands up to 6000 A and the maximum fault current at the substation is 1742 A.

FIGURE C.5 Coordination of the 100[a], type VW reconnector with a 25A type T fuse



ANNEX D. TABLES OF RESULTS OF POWER FLOWS FOR THE TOMOYO PROJECT

Detail

Balanced Voltage Drop Report
Source: Aranjuez Sub

Database: C:\MILSOFT\DATA\BOLIVIA\USDA\TOMOYO-STAKED.WM\
Title:
Case:
11:51 Page 1 03/06/2006

Units Displayed In Percent
-Base Voltage:100.0-

Element Name	Parent Name	Cnf	Type/ Conductor	Pri kV	Base Volt	Element Drop	Accum Drop	Thru Amps	% Cap	Thru KW	KVAR	% PF	kW Loss	% Loss	km From Src	Length (km)	KW	Cons Cons KVAR On	Thru
Aranjuez Sub		ABC		15.12Y	105.0	0.00	0.00	92.65	0	3806	1783	91	0.00	0.0	0.000	0.000	0	0	884
Parque Industri	Aranjuez Sub	ABC	266 800 AC	15.02Y	104.3	0.70	0.70	92.65	20	3806	1783	91	12.35	0.3	6.000	6.000	3500	1695	0 884
Aeropuerto	Parque Industri	ABC	#4/0ACSR6/	15.01Y	104.3	0.03	0.73	6.78	2	293	85	96	0.05	0.0	8.000	2.000	100	48	0 884
Sta Catalina	Aeropuerto	ABC	#1/0ACSR6/	15.00Y	104.2	0.09	0.82	4.39	2	193	42	98	0.13	0.1	13.300	5.300	50	24	0 884
Gra Loma	Sta Catalina	B	#2ACSR6/1	14.94Y	103.8	0.40	1.22	9.76	5	143	30	98	0.49	0.3	18.500	5.200	4	2	27 884
Tawricasa	Gra Loma	B	#2ACSR6/1	14.90Y	103.5	0.31	1.53	9.52	5	139	31	98	0.37	0.3	22.619	4.119	3	1	15 857
Punilla	Tawricasa	B	#2ACSR6/1	14.88Y	103.3	0.12	1.65	9.34	5	135	32	97	0.14	0.1	24.330	1.711	6	3	41 842
Silvico	Punilla	B	#2ACSR6/1	14.85Y	103.1	0.25	1.90	8.92	5	129	30	97	0.28	0.2	27.816	3.486	1	0	5 801
Chataquila	Silvico	B	#2ACSR6/1	14.82Y	102.9	0.20	2.10	8.88	5	128	32	97	0.21	0.2	30.613	2.797	5	2	1 796
Chaunaca	Chataquila	B	#2ACSR6/1	14.76Y	102.5	0.41	2.51	8.54	5	123	31	97	0.43	0.4	36.599	5.986	2	1	10 795
Caraviri	Chaunaca	B	#2ACSR6/1	14.71Y	102.2	0.33	2.83	8.45	5	120	33	96	0.34	0.3	41.434	4.835	5	2	30 785
Colpacucho	Caraviri	B	#2ACSR6/1	14.64Y	101.7	0.49	3.32	8.13	5	115	33	96	0.48	0.4	48.897	7.463	5	2	30 755
Potolo	Colpacucho	B	#2ACSR6/1	14.60Y	101.4	0.29	3.61	7.85	4	109	35	95	0.24	0.2	54.294	5.396	37	18	300 725
Molle Molle SL	Potolo	B	#2 ACSR 6/	14.57Y	101.2	0.18	3.79	5.13	3	72	20	96	0.11	0.2	58.487	4.193	0	0	0 425
Molle Molle S	Molle Molle SL	B	Node	14.57Y	101.2	0.00	3.79	5.18	0	72	22	96	0.00	0.0	58.487	4.193	6	3	28 425
Molle Molle PL	Molle Molle S	B	#2 ACSR 6/	14.57Y	101.2	0.05	3.84	4.73	3	66	19	96	0.03	0.0	59.912	1.425	0	0	0 397
Molle Molle P	Molle Molle PL	B	Node	14.57Y	101.2	0.00	3.84	4.74	0	66	20	96	0.00	0.0	59.912	1.425	11	5	68 397
SorojchiL	Molle Molle P	B	#2 ACSR 6/	14.56Y	101.1	0.07	3.91	3.92	2	55	15	96	0.03	0.1	62.065	2.153	0	0	0 329
Sorojchi	SorojchiL	B	Node	14.56Y	101.1	0.00	3.91	3.94	0	55	16	96	0.00	0.0	62.065	2.153	9	4	56 329
IslucoL	Sorojchi	B	#2 ACSR 6/	14.56Y	101.1	0.01	3.91	0.28	0	4	1	97	0.00	0.0	64.210	2.145	0	0	0 27
Isluco	IslucoL	B	Node	14.56Y	101.1	0.00	3.91	0.31	0	4	2	89	0.00	0.0	64.210	2.145	4	2	27 27
YorocaL	Sorojchi	B	#2 ACSR 6/	14.55Y	101.0	0.05	3.96	2.99	2	42	11	97	0.02	0.0	64.035	1.970	0	0	0 246
Yoroca	YorocaL	B	Node	14.55Y	101.0	0.00	3.96	3.01	0	42	12	96	0.00	0.0	64.035	1.970	6	3	34 246
Tomoyo 2	Yoroca	B	#2 ACSR 6/	14.54Y	101.0	0.08	4.04	2.56	1	36	9	97	0.03	0.1	68.035	4.000	0	0	0 212
TomoyoL	Tomoyo 2	B	#2 ACSR 6/	14.54Y	101.0	0.00	4.04	2.60	1	36	12	95	0.00	0.0	68.122	0.087	0	0	0 212
Tomoyo	TomoyoL	B	Node	14.54Y	101.0	0.00	4.04	2.60	0	36	12	95	0.00	0.0	68.122	0.087	10	5	47 212
LlatapataL	Tomoyo	B	#2 ACSR 6/	14.54Y	100.9	0.01	4.05	0.50	0	7	2	96	0.00	0.0	70.658	2.536	0	0	0 48
Llatapata	LlatapataL	B	Node	14.54Y	100.9	0.00	4.05	0.54	0	7	3	92	0.00	0.0	70.658	2.536	7	3	48 48
JorojaL	Tomoyo	B	#2 ACSR 6/	14.54Y	100.9	0.02	4.06	1.35	1	19	5	97	0.00	0.0	69.721	1.599	0	0	0 117
Joroja	JorojaL	B	Node	14.54Y	100.9	0.00	4.06	1.37	0	19	6	95	0.00	0.0	69.721	1.599	6	3	38 117
SorocotoL	Joroja	B	#2 ACSR 6/	14.53Y	100.9	0.02	4.08	0.92	1	13	3	97	0.00	0.0	72.960	3.239	0	0	0 79
Sorocoto	SorocotoL	B	Node	14.53Y	100.9	0.00	4.08	0.96	0	13	5	93	0.00	0.0	72.960	3.239	9	4	56 79
SoroscopaL	Sorocoto	B	#2 ACSR 6/	14.53Y	100.9	0.01	4.09	0.28	0	4	1	97	0.00	0.0	75.406	2.446	0	0	0 23
Soroscopa	SoroscopaL	B	Node	14.53Y	100.9	0.00	4.09	0.31	0	4	2	89	0.00	0.0	75.406	2.446	4	2	23 23

KEY-> L = Low Voltage H = High Voltage C = Capacity Over Limit (%capacity or load amps) G = Generator Out of kvar Limits P = Power Factor Low

	Load	Adjustment	Capacitance	Charging	Gen&Motors	Loops&Metas	Losses	No Load Losses	Total
KW	3790	0	0	0	0	0	16	0.00	3806
KVAR	1836	0	0	-75	0	0	22		1783

Lowest Voltage = 100.91 on Element SoroscopaL
Max Accm VoltD = 4.09 on Element SoroscopaL
Max Elem VoltD = 0.70 on Element Parque Industri

Detail

Balanced Voltage Drop Report
Source: Aranjuez Sub

Database: C:\MILSOFT\DATA\BOLIVIA\USDA\TOMOYO-STAKED-Y20.WM\
Title:
Case:
11:54 Page 1 03/06/2006

Units Displayed In Percent
-Base Voltage:100.0-

Element Name	Parent Name	Cnf	Type/ Conductor	Pri kV	Base Volt	Element Drop	Accum Drop	Thru Amps	% Cap	Thru KW	KVAR	% PF	kW Loss	% Loss	km From Src	Length (km)	KW Cons	KVAR Cons On	Thru
Aranjuez Sub		ABC		15.12Y	105.0	0.00	0.00	96.85	0	3973	1874	90	0.00	0.0	0.000	0.000	0	0	1586
Parque Industri	Aranjuez Sub	ABC	266 800 AC	15.01Y	104.2	0.76	0.76	96.85	21	3973	1874	90	14.30	0.4	6.000	6.000	3500	1695	1586
Aeropuerto	Parque Industri	ABC	#4/0ACSR6/	15.00Y	104.2	0.05	0.82	10.90	3	459	173	94	0.16	0.0	8.000	2.000	100	48	1586
Sta Catalina	Aeropuerto	ABC	#1/0ACSR6/	14.97Y	104.0	0.20	1.01	8.48	4	359	130	94	0.56	0.2	13.300	5.300	50	24	1586
Gra Loma	Sta Catalina	B	#2ACSR6/1	14.84Y	103.0	0.96	1.97	22.05	12	308	118	93	2.51	0.8	18.500	5.200	4	2	1586
Tawricasa	Gra Loma	B	#2ACSR6/1	14.73Y	102.3	0.76	2.73	21.83	12	302	117	93	1.95	0.6	22.619	4.119	3	1	1559
Punilla	Tawricasa	B	#2ACSR6/1	14.68Y	102.0	0.31	3.04	21.67	12	297	117	93	0.79	0.3	24.330	1.711	6	3	1544
Silvico	Punilla	B	#2ACSR6/1	14.59Y	101.3	0.62	3.66	21.24	12	290	114	93	1.57	0.5	27.816	3.486	1	0	1503
Chataquila	Silvico	B	#2ACSR6/1	14.52Y	100.8	0.50	4.16	21.22	12	288	115	93	1.24	0.4	30.613	2.797	5	2	1498
Chaunaca	Chataquila	B	#2ACSR6/1	14.37Y	99.8	1.06	5.22	20.88	12	281	113	93	2.61	0.9	36.599	5.986	2	1	1497
Caraviri	Chaunaca	B	#2ACSR6/1	14.25Y	98.9	0.85	6.06	20.81	12	277	113	93	2.07	0.7	41.434	4.835	5	2	1487
Colpacucho	Caraviri	B	#2ACSR6/1	14.06Y	97.6	1.29	7.35	20.50	11	270	112	92	3.11	1.2	48.897	7.463	5	2	1457
Potolo	Colpacucho	B	#2ACSR6/1	13.94Y	96.8	0.86	8.22	20.22	11	262	111	92	1.95	0.7	54.294	5.396	37	18	300 1427
Molle Molle SL	Potolo	B	#2 ACSR 6/	13.85Y	96.2	0.61	8.83	17.36	10	223	95	92	1.27	0.6	58.487	4.193	0	0	1127
Molle Molle S	Molle Molle SL	B	Node	13.85Y	96.2	0.00	8.83	17.43	0	221	96	92	0.00	0.0	58.487	4.193	18	9	73 1127
Molle Molle PL	Molle Molle S	B	#2 ACSR 6/	13.82Y	96.0	0.19	9.02	15.98	9	203	88	92	0.37	0.2	59.912	1.425	0	0	1054
Molle Molle P	Molle Molle PL	B	Node	13.82Y	96.0	0.00	9.02	16.01	0	203	88	92	0.00	0.0	59.912	1.425	35	17	183 1054
SorojchiL	Molle Molle P	B	#2 ACSR 6/	13.79Y	95.7	0.24	9.26	13.19	7	168	71	92	0.38	0.2	62.065	2.153	0	0	871
Sorojchi	SorojchiL	B	Node	13.79Y	95.7	0.00	9.26	13.23	0	168	72	92	0.00	0.0	62.065	2.153	27	13	148 871
YorocaL	Sorojchi	B	#2 ACSR 6/	13.76Y	95.6	0.17	9.43	10.12	6	129	54	92	0.20	0.2	64.035	1.970	0	0	654
Yoroca	YorocaL	B	Node	13.76Y	95.6	0.00	9.43	10.15	0	128	55	92	0.00	0.0	64.035	1.970	19	9	86 654
Tomoyo 2	Yoroca	B	#2 ACSR 6/	13.72Y	95.3	0.29	9.72	8.62	5	109	46	92	0.30	0.3	68.035	4.000	0	0	568
TomoyoL	Tomoyo 2	B	#2 ACSR 6/	13.72Y	95.3	0.01	9.72	8.68	5	109	48	92	0.01	0.0	68.122	0.087	0	0	568
Tomoyo	TomoyoL	B	Node	13.72Y	95.3	0.00	9.72	8.68	0	109	48	92	0.00	0.0	68.122	0.087	31	15	129 568
JorojaL	Tomoyo	B	#2 ACSR 6/	13.71Y	95.2	0.06	9.79	4.51	3	57	24	92	0.03	0.1	69.721	1.599	0	0	312
Joroja	JorojaL	B	Node	13.71Y	95.2	0.00	9.79	4.53	0	57	25	92	0.00	0.0	69.721	1.599	17	8	104 312
SorocotoL	Joroja	B	#2 ACSR 6/	13.70Y	95.1	0.09	9.87	3.16	2	40	16	93	0.03	0.1	72.960	3.239	0	0	208
Sorocoto	SorocotoL	B	Node	13.70Y	95.1	0.00	9.87	3.21	0	40	18	91	0.00	0.0	72.960	3.239	29	14	147 208
SoroscopaL	Sorocoto	B	#2 ACSR 6/	13.70Y	95.1	0.02	9.89	0.86	0	11	4	94	0.00	0.0	75.406	2.446	0	0	61
Soroscopa	SoroscopaL	B	Node	13.70Y	95.1	0.00	9.89	0.89	0	11	5	91	0.00	0.0	75.406	2.446	11	5	61 61
LlatapataL	Tomoyo	B	#2 ACSR 6/	13.71Y	95.2	0.04	9.76	1.66	1	21	9	92	0.01	0.0	70.658	2.536	0	0	127
Llatapata	LlatapataL	B	Node	13.71Y	95.2	0.00	9.76	1.70	0	21	10	90	0.00	0.0	70.658	2.536	21	10	127 127
IslucoL	Sorojchi	B	#2 ACSR 6/	13.78Y	95.7	0.02	9.28	0.93	1	12	5	92	0.00	0.0	64.210	2.145	0	0	69
Isluco	IslucoL	B	Node	13.78Y	95.7	0.00	9.28	0.97	0	12	6	89	0.00	0.0	64.210	2.145	12	6	69 69

KEY-> L = Low Voltage H = High Voltage C = Capacity Over Limit (%capacity or load amps) G = Generator Out of kvar Limits P = Power Factor Low

	Load	Adjustment	Capacitance	Charging	Gen&Motors	Loops&Metas	Losses	No Load Losses	Total
KW	3938	0	0	0	0	0	35	0.00	3973
KVAR	1907	0	0	-72	0	0	39		1874

Lowest Voltage = 95.11 on Element SoroscopaL

Max Accm VoltD = 9.89 on Element SoroscopaL

Max Elem VoltD = 1.29 on Element Colpacucho

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GLOSSARY

NESC	National Electrical Safety Code (Código Nacional de Seguridad de Líneas Eléctricas)
NRECA	National Rural Electric Cooperative Association (Asociación Nacional de Cooperativas Eléctricas Rurales)
REA	Rural Electrification Administration and agency of the Department of Agriculture of the United States, now know as RUS.
RUS	Rural Utilities Services (Servicios a Empresas Eléctricas), an agency of the Department of Agriculture of the United States, previously known as REA.
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

ATTACHMENT 3

WORKSHOP AGENDA

Partnership for Rural Electrification

Workshop Sponsored by Power Finance Corporation (PFC)
with International Finance Corporation
and National Rural Electric Cooperative Association (NRECA)

May 29- 30, 2006
Taj Mahal Hotel
New Delhi

Day 1 : (May 29,2006)

9:00 - 9:30 am	Registration & tea
	Introduction by Ms. Anita George, IFC
9:30 - 11:30 am	First Session: *International Experience Panel in Rural Electricity* (USA, Philippines or Bangladesh) Speakers: Mr. Paul Clark, NRECA Mr. James Ford, NRECA Ms. Denise Leonard, IFC
11:30 - 11:45 am	Tea Break
11:45 - 12:15 am	Second Session: *Indian Rural Electrification Challenge and Programs Statement by* Ministry of Power, Mr. Arvind Jadhav
12:15 - 2:00 pm	Lunch
2:00 - 3:30 pm	Third Session: *On the Ground Reality in Rural Electricity Distribution in India* Speakers: Orissa: Mr. D. Biswal, CESCO Punjab: Mr. M. S. Walia, PSEB Madhya Pradesh: Mr. B. K. Singh, PKVVCL Moderator: Mr. Rajeev Sharma, Ministry of Power
3:30 – 4:00 pm	Tea Break

4: 00 – 5:30 pm	Fourth Session: *Technical Parameters for Rural Distribution* – NRECA and state representative Moderator: Mr. R. C. Dhup, NTPC Speakers: Mr. Meena, Jaipur, VVNL, Rajasthan Mr. James VanCoevering, NRECA

Day 2 : (May 30, 2006)

9:30 – 11:00 am	Fifth Session: *Social, Institutional, Regulatory, Legal Structures – International and Indian Experience* Moderator: Paul Clark, NRECA Speakers: Ms. Akanksha Chaurey, TERI Mr. Alok Kumar, Ministry of Power Mr. Girish Sant, Prayas Mr. V. V. Sadamate, Ministry of Agriculture
11:00 - 11:15 am	Tea Break
11:15 - 12:45 pm	Sixth Session: Generation - *Grid extension, mini-grid, Alternative/Conventional Energy- Indian and International Case Studies* Moderator: Mr. Arvind Jadhav, Ministry of Power Speakers: Mr. Faizi Moshini, GE Mr. Datta Roy, DSCL Energy Services Mr. J. D. Wright, World Bank Mr. S. Tandon, IFC
12:45 – 1:00 pm	*Closing remarks by Dr. V. K. Garg, Chairman & MD, PFC*
1:00 – 2:00 pm	Lunch

Day 2 Afternoon

One-on-one meetings with utilities

ATTACHMENT 4

NRECA International Ltd.

Your Touchstone Energy® Partner

National Rural Electrification Strategy for Yemen: Dissemination Workshop Report

NRECA International

June 2006

TABLE OF CONTENTS

Background 1

Seminar Purpose & Organization 2

Review of Presentations & Discussion 3

Participant Findings 4

Observations & Conclusions 8

Annex 1: Workshop Agenda 1

Annex 2: Participant List 4

Annex 3: Summary of Group Feedback from Dissemination Workshop 7

List of Acronyms

DLDSP	Decentralization and Local Development Support Project (UNDP)
ESMAP	Energy Sector Management Assistance Program (World Bank-UNDP)
GIS	Geographic Information System
GOY	Government of Yemen
LC	Local Council
MOE	Ministry of Electricity
MOLA	Ministry of Local Administration
NRECA	National Rural Electric Cooperative Association
PEC	Public Electricity Corporation
PMU	Program Management Unit
UNDP	United Nations Development Program

National Rural Electrification Strategy for Yemen: Dissemination Workshop

Background

Yemen suffers from a very low level of access to electric services in rural areas. Less than 25% of rural households current enjoy electric service. Electricity is one of the primary public services required to increase economic productivity, to improve the quality of life, to generate employment and income earning opportunities for families and businesses residing in rural areas.

To address these needs, the Ministry of Electricity and the World Bank are sponsoring the development of a National Rural Electrification Strategy. The Strategy will incorporate the means by which electrification coverage can not only be expanded, but can be sustained over time via a suitably-designed government agency overseeing technically and commercially viable rural electric service providers.

The terms of reference of the National Rural Electrification Strategy Project required organization of a workshop during which the findings of the various studies undertaken by the project would be presented to rural electrification stakeholders. Upon reviewing the scope of the various studies, NRECA International, the contractor selected by the Ministry of Electricity to carry out the project, proposed to hold a series of one day seminars to address findings of technical studies. NRECA further proposed that a two day event be sponsored to address the rural electrification institutional framework and strategy, a topic of greater importance and one that would require more in-depth discussion and participation of various stakeholders. This recommendation was accepted, and as a result, the Dissemination Workshop was held on June 6-7, 2006.

In preparation for the workshop, the project team developed and circulated to the MOE and PEC a document to highlight issues related to program design and management as a means of stimulating discussion among the various stakeholders in the future program. The document, entitled, "Institutional Options for Rural Electrification Management" was then revised and circulated to various stakeholders through the Project Management Unit (PMU) to initiate the process of exchanging ideas and information. The report reviewed the electric sector environment in Yemen, as well as reviewed historic experiences with rural electrification in Yemen. It further presented a review of successful experiences with rural electrification program models in a variety of political and cultural settings, as well as findings from a World Bank-sponsored study to determine the key elements required to assure program success. The report finally proposed an institutional framework upon which the rural electrification should be structured in the future.

The present report provides a description of the process and findings of the Dissemination Workshop held at the Moevenpick Hotel on June 6-7. A participant list and agenda are included in Annexes 1 and 2 of this document.

Seminar Purpose & Organization

The purpose of the Dissemination Seminar was to convene government, non-government, and private sector stakeholders in present and future rural electrification programs to discuss the design of and issues related to the future rural electrification program in Yemen. The seminar was designed to:

- provide an overview of the history of the rural electrification program in Yemen, as well as successful programs in other countries;
- review strengths and weaknesses of present program implementation; and
- stimulate discussion of the issues and obstacles related to development and support of a sustainable rural electrification program in Yemen.

To this end, the workshop was designed with two primary components: (1) a series of plenary presentations covering various aspects of Yemen's rural electrification program and recommended modifications; and (2) discussion group break-out sessions to allow the workshop participants to engage in specific debate on various key elements of the findings and recommendations.

Annex 1 presents the Agenda of the seminar. During Day One, Ministry of Electricity, NRECA, PEC, and invited speakers from the Ministry of Water and Environment, as well as the Decentralization & Local Development Support Project to make a series of presentations. The purpose of the presentations was to assure that participants benefited from perspectives and issues deemed critical to allow meaningful reform in Yemen's rural electrification sector so as to facilitate an in-depth discussion and debate of the components of the future rural electrification program.

Day Two of the workshop was dedicated to a structured discussion of the issues presented during Day One. This segment opened with a 45 minute question and answer period due to allow time for questions and answers on the presentations made during Day One. Participants were encouraged to not only ask questions, but to also offer comments and perspectives regarding the presentations made by Ministry, NRECA, and invited speakers, as well as the Institutional Options paper that was distributed prior to the Workshop. Participants were then split into four groups, each group composed of up to ten members. Each group selected a group coordinator and a rapporteur. Each group was assigned an identical set of themes in a written matrix that is presented at Annex 3-2. The groups were given two and one-half hours to discuss the assigned topics, after which group coordinators presented the results of the discussions as recorded by the rapporteurs of their respective group. A limited time was allowed for questions and clarifications of the findings presented by each group.

This was followed by a general discussion period. Participants were again encouraged to ask questions and make general or specific comments regarding their perspectives as stakeholders in the future electrification program.

Review of Presentations & Discussion

Presentations were organized to provide an overview of the key issues addressed in the document circulated entitled, "National Rural Electrification Strategy for Yemen: Institutional Options for RE Management", together with other material deemed necessary for a more complete understanding of seminar material. After opening addresses by Deputy Minister of Electricity Ahmed Al-Aini, Wolfgang Schuett of GTZ made a brief presentation to describe the Yemen Rural Energy Access Program in which the Ministry of Electricity, the World Bank, GTZ, and other stakeholders have all contributed to program design and implementation. This presentation provided a context for participants to understand the timeline for program implementation, and the place of the National Rural Electrification Strategy within the broader framework of the Rural Energy Access Program.

After a brief description of the organization of the seminar, Dr. Daniel Waddle made a presentation to provide an historic context of the characteristics and components of successful rural electrification programs that have been implemented in other countries. The presentation also addressed the enabling environment required to support a sustainable and effective rural electrification program, as well as a description of the key qualities and components required to support the future RE program in Yemen. This presentation closed with a summary of the degree to which the program managed in Yemen has satisfied those components required for program success.

Engineer Ali Khamis, the General Director of the PEC Planning Department, then discussed the Government of Yemen electric sector policy and provided an overview of the PEC expansion plan required to support economic development in Yemen. This presentation discussed both expected demand expansion and the means by which PEC will address increasing demand with generation, transmission, and distribution expansion.

After this presentation, two presentations followed to summarize the electrification program managed by the PEC Rural Electrification Sector, and to comment on the process of rural electrification planning. Faud Al-Maktari presented the RES program design and accomplishments, highlighting program goals, objectives, and accomplishments. This was followed by a presentation by Dr. Waddle that discussed a rational planning approach whose goal it is to systematically address electrification coverage so as to attain full access to electrification over a pre-determined period of time.

This presentation was immediately followed by presentations by Daniel Waddle on the recommended sector management framework and by Paul Clark on the topic of rural electric service providers. These two presentations were designed to present the key themes of the seminar. Dr. Waddle's presentation discussed the recommended program management framework required to assure that program management and financing functions of future rural electrification investments would be based on appropriate planning, design, implementation and oversight. The program management agency as described in the presentation stressed strong and professional leadership, independence

from political influence in project design and selection, assignment of capital subsidies and tariff design on a rational basis, and transparency and clarity in operating procedures and methodologies. A key finding discussed in Dr. Waddle's presentation was that the existing rural electrification program suffers from the uncoordinated functionality of various entities and units across the Ministry of Electricity, PEC, and local authorities. Moreover, it was noted that in the future, staff must be highly trained, motivated, and selected on the basis of experience and competency in rural electrification engineering, economics, and planning principles.

Mr. Clark's presentation focused on service provider options from worldwide experience including systems from Yemen's current and past rural electrification experience. This presentation proposed that a rural electric cooperative model be adopted, and described in greater detail the characteristics of successful rural electric cooperatives, the capacities that cooperatives will need to embody, and the support and oversight required to assure that cooperatives have the greatest opportunity to succeed. The presentation described in some depth the practical challenges of cooperatives, as well as composition and characteristics of cooperative governance and management.

Day One was concluded with two presentations describing successful experience with user associations in the water development and services, and the role of local administrative bodies in the planning and execution of rural infrastructure programs, including rural electrification. The presentation by Mohammed Abdullah Abdul Razzak from the Ministry of Water & Environment focused on practical experience with formation and management of community water associations, a program that has attracted a great deal of attention due to the degree to which it has generated community participation and gained widespread acceptance.

The presentation by Aladeen Shawa of the UNDP Decentralization and Local Development Support Project described how this project unit has incorporated local authorities in planning, decision making, and implementation of all development activities in rural communities. Mr. Shawa went further to propose how the planning and decision making framework that has been developed by UNDP could be applied to the future rural electrification program in Yemen.

Participant Findings

As discussed above, the Day Two of the workshop was dedicated to discussion of the key issues that will affect the design and implementation of the rural electrification program strategy. The discussion was structured to address four primary findings from the NRECA institutional study, requesting feedback on two to five issues associated with each finding. Each group organized itself to address and evaluate the findings and the related issues in the manner decided among group participants. Some groups elected to use free-flowing discussion, while others allowed each group member to provide comments for each issue before discussing final conclusions.

Notes were taken during the discussion period; the group coordinator was responsible for summarizing the notes onto an output matrix that assembled all of the groups'

conclusions and presented in a plenary session of all the workshop participants. The notes were later summarized on a single output matrix, a copy of which is shown in Annex 3-2.

The first finding listed in the discussion matrix given to the groups concerned the rural electrification program management network. The output matrix required participants to consider several key issues:

- what criteria affect program management agency effectiveness;
- how the agency should be formed to assure it has adequate decision making authority;
- whether the Rural Electrification Sector of the PEC should be reformed, or whether to start a new agency; and
- NRECA's recommended modifications to the current scheme.

Group A suggested that the new program management agency should embody technical competency, autonomy, have clearly defined goals, and should be accountable for its actions. Group B suggested that the agency should have access to adequate financing, while Group C suggested that the agency should have qualified staff, act in a fully transparent modality, exercise adequate planning, and should play a firm oversight role to maximize outputs, while operating in a truly independent manner. Group D suggested that strong leadership would be key, while emphasizing transparency and administrative competency.

With regard to the issue of authority, the groups provided a number of perspectives. Two groups emphasized the need for a legal framework to provide the required authority, suggesting that this authority can only be adequately established by legislating the program authority under a new comprehensive enabling law. The groups also emphasized the need for a clear regulatory environment under which the agency would operate.

With regard to the issue of whether to establish a new agency, or reform the PEC/Rural Electrification Sector, there was much spirited discussion. Many participants felt that RES should be retained, but that all rural electrification planning, financing, and project implementation should be consolidated under a single unit (RES). Others felt that a completely new mechanism is needed to implement the rural electrification program. Participants in Groups B and D felt that the financing mechanism (a new rural electrification trust fund recommended by NRECA) should be separate and independent from the rural electrification apex agency, even if the management of the program were retained as it currently is under PEC.

With respect to the last issue regarding whether the participants would propose any changes to the recommended structure, there was a relatively high degree of consensus among the discussion groups. One recommendation was that the financing function should be separated, as in an independent trust fund. Another key recommendation was that the new rural electrification scheme should include coordination with Local Authorities. It was also suggested that the management agency should be a separate governmental authority, not a corporate entity.

The second NRECA finding suggested that rural electrification investments as presented implemented do not focus on operational sustainability. The issues with regard to this finding included which criteria should be used to assure sustainability; how to assure proper project selection; and whether service territories should include existing PEC consumers. A fundamental point raised in Mr. Clark's presentation on service provider options was that rural electrification investments should be identified, planned and financed as a function of the basic institutional planning and management of service providers, as contrasted to the prevailing system of disjointed, individual project developments. This approach would tend to ensure that projects are directly related to local economic and demographic planning across multiple sector needs: agriculture, social services, industrial development, etc. This approach also lends greater strength to the operational imperatives of successful rural electrification investments – financial planning and cost recovery including appropriate tariff setting, staffing requirements, post-construction system maintenance and record-keeping, etc.

Few participants responded to the issue of the criteria that should be applied to assure system sustainability, reflecting the relative lack of importance that is currently attached to post-construction system operations, however those participants that did comment suggested that studies should be performed to quantify economic and social benefits; that projects should be selected on the basis for leveraging industrial, tourism, and agricultural activities; and that community participation should be a requirement. Regarding the issue addressing proper project selection, participants simply stated that proper application of sustainability criteria would assure selection of the most appropriate projects. Finally, with regard to whether projects should include existing PEC consumers, the participants answered in the affirmative, i.e., under integrated service territories consisting of all users in those defined areas including both new and existing customers.

The third finding given in the discussion matrix stated that control of project financing determines whether investment decisions are appropriate. This means that the entity that has control of the purse strings has the most leverage over future service providers, specifically in terms of monitoring their performance and assuring compliance with program objectives. The issues presented for discussion included whether the trust fund should be independent of the rural electrification program management agency; and, how this fund should be capitalized to assure sufficient capital resources for both initial investment and also for service provider expansion and upkeep/replacement needs.

Responses to this finding and the two implicit issues were direct and relatively uniform. The participants stated that a separate financing mechanism is indeed necessary; they felt that the program would benefit most greatly from a separation of the program management and financing functions. In response to how the fund should be financed, the answers were again uniform and definite. The respondents stated that the program should be financed from a combination of resources to include Government of Yemen resources (annual budget allocations); donor financing; local contributions from consumers and local governments; and, intra-sector capital flows, such as a tax on urban consumers.

The fourth finding stated that user participation must be effectively incorporated into service provider schemes to improve operational governance and performance. The issues included whether, in the opinion of the participants, cooperatives are likely to be the best option. A specific question raised in the matrix was whether within Yemen diverse geographic and demographic makeup, where cooperatives may work better in some areas than others. Finally, the matrix required the groups to consider the role local administrative units should play.

Participants responded with uniformity to the first issue. That is, it was stated clearly that the participants feel that cooperatives are a realistic option that should be used for future rural electrification. In response to the second issue, the groups had differing conclusions. One group suggested that cooperatives would work best where the investment environment is sound in economic terms, including the Tihama, Hadramout, Saddah, Sana'a, Ta'iz, Ibb, Amran, and Dhamar, i.e. the areas with greater population densities.

To the last issue, there were more clear responses. One group suggested several functions for local authorities. These included identification of priority areas for rural electrification expansion; integration of rural electrification projects into overall development plans; community organization and facilitation of participation in RE schemes; and participation in productive use programs. Some of the groups suggested that the local authorities should provide service provider support, as well as assisting with program monitoring and setting priorities for expansion planning.

The fifth finding addressed the issue of subsidies that should be required to assure that services can be provided at an acceptable cost. Issues included how to assure rural consumers can enjoy parity with urban consumers; should operating subsidies be required, how should they be formulated; and, how subsidies should be devised to assure balance between grid and off grid services.

On the first issue of parity between urban and rural consumers, the participants stated that they felt rural consumers should enjoy similar levels of service quality to those that urban consumers enjoy, and that tariffs should be set under a rational system that assures cost recovery but under a social policy recognizing that some service territories would have greater incidence of poor households. On the issue of how to allocate subsidies, one group stated that they should be allocated on the basis of economic impact – that is, on the basis of the capacity to increase income and create jobs. Another group felt that subsidies should be geared to lower tariffs to the communities' composite ability to pay for service.

On the issue of operating subsidies for service providers, participants views differed somewhat. One group stated that operating subsidies should not be applied in any case. This same group further stated that fuel subsidies employed by PEC should be gradually reduced to the point that operating subsidies were removed altogether. Another group

felt that subsidies should be employed for off-grid systems to reach tariff parity with on-grid systems.

Annex 3-2 provides a summary of the comments of the four groups to each of the four findings and to the issues that were assigned for discussion. The presentation in Annex 3, as well as the discussion above, represents only what was reported in the output matrix. There were many other comments that were not recorded in the output matrix. However, in large part, the output matrix summarizes the key points that were made by each group.

Observations & Conclusions

The seminar provided a highly useful forum for raising key issues and for engaging the stakeholders in an interactive discussion with Ministry of Electricity, PEC, and NRECA team members on these issues.

Perhaps the single most important point of consensus that emerged from the discussion groups was to employ electric cooperatives as the primary (albeit perhaps not the only) service provider mechanism. There was no voiced opposition to this proposal, and many comments supporting the formation and development of cooperative societies were made. This theme will be further elaborated in the Phase I final report.

There was one key point of discussion wherein consensus was not reached. That is, there were two divergent views regarding whether the future home of the program management unit should be under the PEC/Rural Electrification Sector, or whether a new agency should be formed. In general, PEC personnel supported reform of PEC rural electrification programs, while non-PEC personnel believed that program management should be separated from PEC and a new administrative unit should be formed.

As reflected in NRECA's Institutional Options paper, there are very clear reasons why PEC should not continue to involve itself in rural electrification expansion. First and foremost, PEC has not been successful in establishing a financially viable electric distribution model, even taking into account that PEC serves the most financially attractive markets with the highest load density. From the history of PEC operating capability, it would seem that PEC does not have the capacity to establish and support new, independent service providers if it has not been able to achieve financial viability for the distribution service territories it serves as part of its integrated system. Moreover, given the need for PEC to focus on improving its financial performance, it would seem that serving less profitable areas would compromise its primary focus..

Perhaps more importantly, there is an obvious conflict of interest that will emerge in program management should PEC remain responsible for implementation of the revised electrification program. The recommended program scheme calls for establishment of new, independent rural electric utilities. These utilities will border PEC service territory. PEC will, over time, compete with these service providers for consumers. It is clear that PEC will not be able to serve its own best interests and those of the rural electric utilities, due to the unavoidable existence of a competitive environment between distribution utilities.

For these reasons, NRECA's recommendation is to establish a new rural electrification agency, and to staff it with the most highly qualified managers, administrators, engineers, economists, and other professionals possible. Moreover, NRECA believes the program management unit should be relatively small in size, setting salaries at more competitive levels to be able to attract and retain highly qualified and experienced professionals.

A third issue that is of utmost importance for which there was general consensus was the proposal to separate program management and project financing duties between the program management unit and establishment of a rural electrification trust fund, or similar capital allocation mechanism. Several stakeholders strongly stated their support for the proposal to separate program management from financing duties to assure that allocation of funds as well as the process of project selection is clear, transparent, and free of political influence.

As suggested by several of the participants, consideration should be given to developing a comprehensive new legal code covering the organization, financing, operation, and regulation of new rural electric service providers. Under the prevailing cooperative law, it is the responsibility of the Ministry of Electricity to establish such a code. This legal measure could also establish the structure and function of a new oversight authority and its functions, i.e., the recommended apex agency, as well as the recommended financing mechanism.

Without question, the participants in the seminar took the subject matter quite seriously and provided thoughtful and considered feedback to the consultants and Ministry staff who organized the seminar. Without doubt, additional time for internal discussion will be required, but there appears to be support for the rural electrification program strategy to enable the Ministry of Electricity to proceed to the final steps of program design and implementation.

Annex 1: Workshop Agenda

National Rural Electric Cooperative Association

Yemen National Rural Electrification Strategy Project
Dissemination Workshop
June 6 and 7, 2006

Day 1: June 6, 2006 Presentations

Arrival and registration of participants Coffee and tea		8:30
Opening Ceremony		
Inauguration	Deputy Minister of Electricity Ahmed H. Al-Aini	9:00
Presentation of Workshop Objectives	Eng. Wolgang Schuett, GTZ Project Manager	9:15
Organization of workshop	Aziz Said Workshop Moderator National Rural Electrification Strategy	9:25
Presentations		
Characteristics of Successful Rural Electrification Programs	Dan Waddle Vice President, NRECA	9:35
Government of Yemen Energy Sector Policy	Ali Khamis Hamdan General Director, Planning Department	10:15
The Rural Electrification Program in Yemen		10:25
PEC RE Sector Program Description	Fuad Al-Maktari	
NRECA comments on RE program in Yemen	Dan Waddle	
Break for coffee and tea		10:45
Program Management Agency Options	Dan Waddle	11:00
Service Provider Options: Cooperatives and User-owned Utilities Structure Major functions Support and Oversight Requirements	Paul Clark	11:30

Continued on next page

Yemen National Rural Electrification Strategy
Dissemination Workshop Day 1 (continued)

Service Provider Options: *Lessons from Water User Associations*	Mohammed Abdullah AbdulRazzak Technical Secretariat Water Supply Sector Reform Ministry of Water & Environment	12:30
Service Provider Options: *Local Authorities*	Aladeen Shawa Chief Technical Advisor UNDP Decentralization & Local Development Support Project	12:45
Group Discussion	Moderator	1:00
Discussion of Day 2 Assignments	Moderator	1:30
Lunch		1:45

National Rural Electric Cooperative Association

Yemen National Rural Electrification Strategy Project
Dissemination Workshop
June 6 and 7, 2006

Day 2: June 7, 2006 Group Sessions and Plenary Session

Group Sessions: each group to discuss one topic each **8:30-11:00**

Topics

1. **Program Management Options.** *There are three options for a program management agency to implement a national rural electrification program in Yemen.*

What is the potential for program management options to result in a successful national rural electrification program? What type of rural electrification program management agency will be most effective and appropriate in Yemen? What is the appropriate role of government in rural electrification?

2. **Service Provider Options.** *The Yemeni Government's electricity sector policy and experience in other countries point to the potential benefits of non government providers of electricity options: local administration, user groups, cooperatives, the private sector?. The factors to consider include:*

- *a. How important is local and community participation?*
- *b. Social and cultural feasibility*
- *c. Organizational and management capacity*
- *d. Technical support requirements*
- *e. Operational issues:*
  - *i. Cost recovery and tariffs*
  - *ii. Reliability of service*
  - *iii. Responsiveness of provider to local needs*
- *f. Expansion of rural electrification to new areas*

What is the potential in Yemen for successful local or community management of rural electric systems by cooperatives, local authorities and other entities? What are the advantages and disadvantages for management of rural electrification service by cooperatives, user groups, local councils or the private sector?

Break for coffee and tea		10:30
Presentation of individual group recommendations in Plenary Session		11:00
Group Discussion – participants make individual comments & ask questions		12:30
Closing comments	Minister. Ali Mugawar	1:00
Lunch		1:30

Annex 2: Participant List

List of Participants for the Rural Electrification Dissemination Workshop on June 06-07, 2006

No.	Name	Organization / Title	Institution
		Ministry of Electricity	
1	Dr. Ali Mugawar	Minister	Ministry of Electricity
2	Ahmed H. Al-Aini	Deputy Minister	Ministry of Electricity
3	Adel Damran	Assistant Deputy Minister	Ministry of Electricity
4	Abdul Karim Abbas	General Manager Planning	Ministry of Electricity
5	Mohamed Hameed Al-Sha'abi	Director Renewable Energy Department	Ministry of Electricity
6	Asaad Al-Ashwal	Director Project Management Unit	Ministry of Electricity
7	Mohamed Al-Jarbani	Engineer Project Management Unit	Ministry of Electricity
8	Rami Al-Shaibani	Engineer Renewable Energy	Ministry of Electricity
9	Dr. Andreas Zoellner	CIM Advisor at the Ministry	
10	Wolfgang Schuett	GTZ, Project Manager	
		PEC	
11	Abdul Moati Al-Jonaid	General Manager	PEC
12	Fuad Al-Qawsi	Deputy General Manager	PEC
13	Ahmed Qaid Al-Sabri	Deputy General Manager, Rural Electrification Sector	PEC/RES
14	Fuad Al-Maktari	Deputy General Manager of Rural Electrification Sector	PEC/RES
15	Fuad Al-Kowsi	Deputy General Manager, Distribution	PEC
16	Ali Khamis Hamdan	General Manager, Planning Department	PEC
17	Ismaeel Abu Dunya	General Manager, Project Execution Unit	PEC
18	Fadl Al-Iriyani	General Manager, Secondary Town Department	PEC

19	Abdullah Al-Iriani	Manager, Technical Inspection	PEC /RES
20	Waheeb Abdul Kader	Director, Renewable Energy Department, Rural Electrification Sector (RES)	PEC /RES
21	Abdul Salam Mansour Al-Janad	Renewable Energy Department	PEC /RES
22	AbdulSatar Al-Sharjabi	Project Department	PEC
23	AbdelAziz Sultan Al-Mansub	Consultant	PEC
24	Safwan Salam	Consultant	PEC
		Other Organizations	
25	Capt Said Abdulla Al-Yafai	Local Council Committee	Decentralization
26	Awad Al-Soqotri	Head, Service Council	Parliament
27	Mohamed Najib	Parliament	Parliament
28	Abid Al-Hamr	Representative, Ministry of Finance	Planning
29	Amin Mohamed Al-Maqtari	Assistant Representative, Local Councils	Decentralization
30	Mohamed Hamood Al-Hamdani	Off Mgr for Minister, Ministry of Local Councils	Decentralization
31	Aladeen Rashad Al-Shawa	Project Manager, UNDP	Decentralization
32	Mohamed Ibrahim Al-Hamdi	Representative, Ministry of Water & Environment	Water Sector
33	AbdulQadr Hanish	Assistant Representative, Ministry of Water & Environment	Water Sector
34	Anwer Sahooly	Technical Secretariat (MoWE)	Water Sector
35	Ali Suraimi	Chairman	Rural Water Project Authority
36	Mohamed Abdulla AbdulRazaq	Director	Rural Water Project Authority
37	Mohamed Saad	Program Manager	CARE
38	Salah Ahmad Al-Dhayf	General Manager Local Cooperatives	MoSA&L
39	AbdulAlam AbdulJabar	Head Power Department	Ministry of Planning & International Coop
40	Sulaiman Al-Qatabari	General Manager, Planning	Ministry of Planning & International Coop
41	Towfiq Sufyan	Professor of Electrical Engineering	University of Sana'a
42	Ali Mohamed Al-	Professor of Electrical Engineering	University of

	Ashwal		Sana'a
43	Nuria Al-Badah	General Manager, Women's Development	Ministry of Agriculture
44	Abdu Al-Qubati	Planning Directorate	SFD
45	Ali Khamis	World Bank	
		End Users / Private Sector (10)	
46	Abdul Karim Al-Ashwal	Private Sector Representative	Private Sector
47	Ali Awad Bahamish	Cooperative Union	Agriculture
	AbdulHadi Al-Najjar	Cooperative Union	
48	Mujahid Ahmad Qa'ban	Manager, Electric Project, Sa'da	Electricity Sector
49	Abdulla Ahmad Sayf	Manager, Electric Project, Ibb	Electricity Sector
50	Abdulla AbdulMalik	Director	Rural Water Corporation
51	Yassin Al-Ariqi	Hodeida Director	Rural Water Corporation
52	Shihab Nasr	Abyan Director	Rural Water Corporation
53	Najib Damaj	Ibb Director	Rural Water Corporation
54	Ahmad Shabin	Local Council member, Hodeida	Decentralization
55	Karama Al-Qarzi,	Local Council Head, Hadramawt	Decentralization
		Consultants	Potential Facilitators of Group discussions
56	Paul Clark	NRECA	
57	Dan Waddle	NRECA	
58	Jahid Faruque	NRECA	
59	Alan Pashkevich	NRECA	
60	Romeo Pacudan	Lahmeyer	
61	Rolf Oldach	IT Power	

Annex 3: Summary of Group Feedback from Dissemination Workshop

Table 3.1: Group members.

Group A	Agency
Rami Ali Al-Shaibani	MoE
Mazen Gazadeen	MoLA
Mohamed AbdulRahman	MoLA
Tawfiq Sufian	U of Sana'a
AbdulSalam Monsour Al-Janad	PEC
Safwan Mohamed Al-Salam	PEC
Wahib AbdulQadir	PEC – RE Admin
Audrey Necioux	RES
Ali Al-Amery	Ag Coop Union

Group B	Agency
AbdulAziz Sultan	Consultant
Fuad Mohamed Al-Maqtari	RES
Ahmad Mohamed Shabiin	LC, Hodeidah
Jamal Al-Yemani	LC, Abyan
Romeo Pamdan	Lahmeyer
Mohamed Najib	Parliament
Adib Hussain Al-Wahbishi	MoE
Ahmad Hassan Al-Aini	MoE, Dep Min
Mohamed Al-Jarbani	PMU

Group C	Agency
Amin Ali Al-Harazi	NRECA
Amin Mohamed Al-Maqtari	MoLA
Asa'ad Al-Ashwal	PMU
Mohamed Hamid Al-Shaabi	MoE, RE
Awad Saad Al-Soqotri	Parliament
Ahmad Qaid Al-Sabri	RES
Ali Al-Ashwal	U of Sana'a
Abdulla Ahmad Sayf	Elec Proj, Ibb
AbdulAlam AbdulJabbar	MoPIC
Karama Hassan Al-Qarzi	LC, Hadramawt

Group D	Agency
Mujahid Ahmad Dahban	Elec Proj, Sa'da
AbdulRahman Al-Masni	RES
Aladeen Al-Shawa	UNDP
Wafa' Hassan AbdulWahad Nashir	Min of Ag, Women
Abdullah Al-Iriani	PEC
Rolf Oldach	IT Power
AbdulAziz Sa'ed	
Adil Dhamran	MoE, Asst Dep
AbdulKarim Abbas	MoE, Planning
Suleman Al-Qatabari	MoPIC

Table 3-2: Summary of findings, recommendations and issues.

KEY FINDINGS	RECOMMENDATION	ISSUES TO BE ADDRESSED
1 RE development & management framework currently is fractured, uncoordinated and subject to political decision-making.	Establish all planning, standardization, financing, technical assistance and monitoring under a single-purpose RE agency with independent authority.	* *What are priority criteria to assure agency effectiveness?* * *How to assure that the agency has adequate authority?* * *Reform existing RES or start anew?* * *What changes in the recommended scheme are needed?*
2 RE investments are not currently designed to assure operational sustainability.	Base RE investments on a rural utility service provider format scaled under defined service territories and formulated to operate as sustainable businesses.	* *What criteria to use in determining sustainability?* * *How to assure proper project selection?* * *Should service territories include exisiting PEC users?*
3 Control of project financing determines whether investment decisions are decisions are appropriate.	Establish an RE trust fund as the vehicle for mobilizing and disbursing RE capital resources.	* *Should the trust fund be independent from the RE management agency?* * *How should it be funded to assure adequate resources?*
4 User participation must be effectively incorporated into the service provider scheme to improve operational governance and performance.	Establish a standardized service provider format that gives the beneficiaries a direct voice in their governance and management.	* *Are user-owned entities likely to be the best option?* * *Where might cooperatives work, and where not?* * *What role should local administrative units play?* * *Are multiple service provider formats preferable to a single format?* * *Should contract operators be used to manage isolated grid systems that require high opreating subsidies?*
5 Some form of subsidy will be required to allow services to be provided at acceptable cost. The subsidy mechanism should be equitable, transparent and efficient.	Subsidies should be provided so as to assure that the initial capital investment is feasible, and also to assure that the service providers have time to achieve commercial viability.	* *How to assure that rural users enjoy parity with urban?* * *If operating subsidies are deemed necessary, how should they be formulated?* * *How should subsidies be designed to achieve balance between grid service and off-grid services?*

Table 3-3: Summary of workshop finding.

Key Findings	Issues	Group Findings
Finding 1: RE development & management: framework currently is fractured, uncoordinated and subject to political decision-making.	1. What are priority criteria to assure agency effectiveness?	Group A: Technical know-how Autonomy Adequate integrating of process Clarity of functions, well-defined Time-bound goals Accountability Group B: Provision of financial potential. Group C: Qualified staff, transparency, adequate planning for execution of the projects Government oversight is essential through one agency with efforts all coordinated and independent budget and decisions. Group D: Clear goals & objectives Solid effective administration Strong personality of leadership Financial viability
	2. How to assure that the agency has adequate authority?	Group A: Ensure an appropriate regulatory framework. Managerial autonomy Collegiate selection process (ed: peer selection?) Well pre-designed technical criteria for selection. Group B: Through implementing the provisions of the law. Group C: New legal framework with clear obligations and responsibilities on the central and local levels. Clear regulatory system with appropriate well-defined responsibilities. Group D: Clear & transparent decision-making. Respective laws and rules. Clear & transparent rules & regulations. Board of directors.

	3. Reform existing RES or start anew?	Group A:	Keep as a sector and stop overlapping the same project from PEC.
		Group B:	Given all potentials and technical and administrative capabilities and a unified framework or sector for all departments now working in the same areas, and with participation of LCs in defining project priorities.
		Group C:	Yes, by bringing all existing departments into one set-up (ed: established?) body. Support the existing Rural Sector with expertise. Well-defined criteria for prioritization of the projects. Coordination with local authorities and other authorities concerned with electricity.
		Group D:	Trust fund should be independent.
	4. What changes in the recommended scheme are needed?	Group A:	Include Local Authorities with clearly defined functions.
		Group B:	Implement recommendations given previously.
		Group C:	The institutional structure should be in the form of an authority rather than as a corporation as it is now. Financing issues should be located with an independent body.
		Group D:	Separate financial institution from the management of RE as shown in the 1 draft (Mar 06).
Finding 2: RE investments are not currently designed to assure operational sustainability.	1. What criteria to use in determining sustainability?	Group A:	
		Group B:	Social and economic studies of project benefits. Industrial and agricultural activities are present. Tourism activities are present; all poverty level and population groups are considered. Participation of community and beneficiaries.
		Group C:	
		Group D:	

	2. How to assure proper project selection?	Group A: Group B: By application of criteria. Group C: Group D:
	3. Should service territories include existing PEC users?	Group A: Group B: Yes, but in framework of sub-districts. Group C: Group D:
Finding 3: Control of project financing determines whether investment decisions are decisions are appropriate.	1. Should the trust fund be independent from the RE management agency?	Group A: Group B: Fund is necessary; must be independent. Group C: Group D: Yes, it is necessary.
	2. How should it be funded to assure adequate resources?	Group A: Group B: Donors, GoY, taxes on (utility) bills. Group C: Group D: GoY, lenders & donors, taxes & local contributions.

Finding 4: User participation must be effectively incorporated into the service provider scheme to improve operational governance and performance.	1. Are cooperatives likely to be the best option?	Group A:	Cooperatives are one of the best options.
		Group B:	No conditions.
		Group C:	
		Group D:	Yes, coops may be successful service provider.
	2. Where might cooperatives work, and where not?	Group A:	They might work in locations that have a good environment for investment: Tihama, Hadramout, Saddah, Sana'a, Amran, Dhamar.
		Group B:	According to geographical area.
		Group C:	
		Group D:	Enabling environment.
	3. What role should local administrative units play?	Group A:	Local authorities can and should perform an important role: ▪ identifying priority needs/priority areas ▪ ensuring that electricity projects are properly integrated in the local development plan ▪ organizing communities/facilitating the establishment of coops ▪ monitoring ▪ productive use programs
		Group B:	Monitoring and setting priorities for implementation of what is in law. (Technical unit under technical center – and this under the LCs.)
		Group C:	
		Group D:	Service provider support.

	4. Are multiple service provider formats preferable to a single format?	Group A: Group B: One format only. Group C: Group D: Yes & according to local circumstances.
	5. Should contract operators be used to manage isolated grid systems that require high operating subsidies?	Group A: Group B: As needed. Group C: Group D: Possible.
Finding 5: Some form of subsidy will be required to allow services to be provided at acceptable cost. The subsidy mechanism should be equitable, transparent and efficient.	1. How to assure that rural users enjoy parity with urban?	Group A: Ensure equal tariffs & service quality. (option 1) Group B: With presence of subsidy, it's necessary to take into consideration conditions of rural areas with parity to cities. Group C: Appropriate control and audit through the tariff mechanism to insure the same quality and continuity of service. Group D:
	2. If operating subsidies are deemed necessary, how should they be formulated?	Group A: Social criteria. Economic criteria (i.e.) employment generation Efficiency criteria A possible source of the subsidies: high urban tariffs (option 2) Tier tariffs (option to consider): industrial use; agricultural use; domestic use Group B: According to individual income and level of salaries in targeted rural areas. Group C: There should be no subsidy for operating costs. However, the project study should highlight these issues and give recommendations considering the peculiarity of Yemeni villages. Group D:

	3. How should subsidies be designed to achieve balance between grid service and off-grid services?	Group A: Tariffs ought to be the same for grid and off-grid services; subsidies should match the difference. Group B: The requested operating amounts (ed: subsidies) should be sufficient for generation, transmission and distribution. Group C: Remove subsidy from all supplied fuel to PEC on gradual basis. Group D: