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INSTITUTIONAL ISSUES ASSOCIATED WITH THE FINANCING OF SMALL-SCALE POWER PROJECTS: LESSONS FROM THE DEVELOPING WORLD AND IMPLICATIONS FOR NEPAL

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Executive Summary

Introduction

The U S Agency for International Development's Mission to Nepal (USAID/Nepal) commissioned this study to assist in directing the efforts of the Ministry of Water Resources' Electricity Development Center (EDC) to identify sustainable project structures for the development of small-scale hydropower projects which could be financed by indigenous approaches such as that envisaged by Nepal Power Development Fund's (PDF) "second window " Under the second window, the PDF would enter into co-financing relationships with qualifying Nepalese financial institutions in order to address local financing barriers to private power development Such an approach will provide incremental financial support as needed to induce participation of local financial institutions to on-lend to private entities promoting projects involving grid connected generating stations of ten (10) megawatts (MW) and below or isolated rural power systems licensed by the EDC The objective of sustainability implies that projects must ultimately generate resources internally for continued activities, and even expansion, without continued support from government, multilateral or even non-governmental organizations (NGO) This is a challenge, because availability and access to adequate financing are a key problem facing rural communities that currently lack electricity This issue is also problematic for the businesses in the renewable energy sector that wish to expand their markets to include such communities

The investment costs for grid-expansion, mini-grid and stand-alone systems are significant for such communities, which are often poor and economically marginalized due to geographic, institutional, or other factors For rural villages, the acquisition of even the most basic stand-alone system is an investment of significant proportion While financial institutions have evolved in industrial nations to finance such investments, a financial network to support investment in affordable electricity generation and transmission systems in Nepal's rural areas where electricity is lacking, or extremely costly, such as that proposed under the PDF second window, has yet to become operational in Nepal

This lack of financing, or in some cases, access to financing, is symptomatic of several other barriers, which go beyond rural electric services Financing challenges are often combined with a lack of familiarity with financial instruments, and, in some instances, the inherent market distortions created when public services are "given" away and viewed as an obligation by the authorities, such as grid extension to non-paying rural end-users Finally, financing issues are often coupled with typical business issues, such as distribution strategies and procurement logistics

Parameters Relevant to the Successful Development of Small-Scale Projects

Several issues relevant to the consideration of smaller scale power projects should be reviewed at the beginning of this monograph in order to classify "models" for financing such projects These parameters include the following

(a) **Grid Extension**
Whether the project involves extending the national grid to a previously unconnected community

(b) **Technology**
Choice of technology and configuration

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(c) **Financing**
Sources of financing and its terms and conditions

(d) **Subsidy**
The extent to which that financing is concessional, i e , has a grant component, soft loans, or benefits from other incentives

(e) **Organization**
Organizational structure for implementing and maintaining the project

Perhaps the most traditional organizational structure used in rural programs is that of the utility grid-extension program, where a utility finances and executes the implementation of a project to extend electric services to a rural community This is usually done in coordination with the local community, and the community may even provide certain important elements of the operational phase of the project, such as bill collection In some cases, on the other hand, the utility may have an exclusive responsibility to provide electric service by law, thereby precluding community participation beyond the initial project phase

However, some projects might be undertaken jointly by the regional utility, be it public or private, with a community organization There are reasons why this structure might be more attractive For example, the financial return on a rural project might be quite limited and often negative, especially if end user fees have to be reduced via a subsidy There are also substantial advantages to ensuring community participation, especially because communities respond better to projects in which they have a stake

The key issue that needs to be highlighted in this context is that in a rapidly evolving market, many of the investment decisions that affect the rural electric market were made in a vastly different policy context This is evident in the tariff policies, for example, where rural tariffs were set equal to urban tariffs thus treating all end users equally, not based on costs to deliver services

In off-grid projects and stand-alone systems, the choice of technology and configuration is critical to successful implementation, as developers must weigh the cost of the investment against the performance of the equipment used Performance is crucial since community satisfaction with the project, and hence their support for it

There is substantial evidence that rural communities are willing to pay for electricity supplied by the grid, a mini-grid, or standalone household system since the improvements in their lifestyles, in terms of quality of lighting, convenience and reduced costs, are significant

Determinants of Success for Rural Electrification Projects

Among the features of a given project, the "determinants of project success" are essential with regards to the ability of the project to deliver services, which meet the community's expectations and needs These determinants, in general order of importance, include

1 Financial and economic feasibility
2 Technical feasibility
3 Community engagement
4 Political/regulatory environment

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The fundamental issue to be addressed is that of ownership and responsibility for the success of the project A clearly delineated sense of ownership and responsibility can be decisive for various reasons The community's material support for the project, either in terms of up-front payments or in-kind investments, may be important to financial feasibility In the longer term, participation in bill collection, maintenance and repair, and other operational support may also be a decisive factor Lastly, community participation can reduce the potential for theft and fraud that could hinder the sustainability of a given project

The regulatory environment also may play a key role in determining which projects are undertaken and financed Regulatory issues and subsidies for electricity or other sources of energy may distort markets significantly, or contribute to a lack of service to marginalized communities

Models for Financing Rural Electrification Projects

Based on the discussion of project parameters and determinants of success, it is possible to identify several ' models" for financing small-scale power projects Each has been applied or is being developed in a variety of countries in the developing world with minor variations to suit local circumstances However, each of the models presented here is not necessarily suited to the range of circumstances that may characterize rural communities across countries or indeed, within any one country such as Nepal Clearly, some mechanisms will be better suited to less-developed communities where knowledge of electricity is limited and where even limited capital resources are scarce, others will be better suited to more developed and sophisticated communities with greater financial resources It is important to note that most models presented here have not yet borne the test of time and are still in their experimental phase of deployment

The models may be expressed generically as follows

(a) **Model 1 Cash**
This involves a straight cash transaction, potentially with a cost-share component This model is most likely to involve stand-alone household or farm systems It has often been implemented with a subsidy from sources such as the host country government, bilateral donors or multilateral lending agencies to offset the substantial initial cost incurred

(b) **Model 2 Project Finance**
This model features a structure closer to that of any project finance arrangement, and as such is likely to apply to investments at the village scale or larger Here, equity investment in the project may be provided by the community, a cooperative, a consortium composed of community and other entities (which may or may not be the regional utility, a private sector company with a concession or other authorization to provide service, etc) The equity investment is leveraged by debt secured from local or international financial institutions (at market or concessional rates), with repayment of debt coming from the cash flow generated by the project through energy sales to the community Grid-extension projects can be considered a special case of projects undertaken using this model, with important variations as to financing, determination of tariffs, etc

(c) **Model 3 Credit**
This model is in many respects close to Model 1, except that the arrangements call for the use of credit to enable the end user to overcome the initial cost hurdle The loan is made by a local bank or other entity specializing in origination of small-scale loans for renewable energy systems at the village level The transaction between the end user and the manufacturer/distributor is commercial, and does not require that

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the vendor supply credit to the end user The customer takes ownership of the equipment and assumes responsibility for maintenance and replacement parts, and services the loan, which may be at market rates or contain some concessional element

(d) **Model 4 Lease**
This financial model is in effect the inverse of Model 3, with the technical partner acting as intermediary in the project as well as distributor/manufacturer of the energy systems The commercial transaction with the end user is based on the assumption that the current energy needs of the end user are currently being met at a higher monthly cost than the lease offered In addition, the arrangement may offer substantial benefits to the end user in that the lessor retains ownership of the equipment and hence responsibility for maintenance and any equipment replacements Indeed, some sources argue that this arrangement offers the lowest costs to the end user, compared to leasing from an intermediary or other arrangements

(e) **Model 5 Concession**
In this model, there are similarities to Model 2 Project Finance and Model 4 Lease, however, there is one important distinction, that a private corporation receive a concession in order to electrify a region and later introduce competition, which reflects the current policy environment vis-a-vis rural energy in newly privatized or quasi privatized markets The government or a larger regional utility can grant the concession The grid can be a virtual grid or physical infrastructure in a distributed generation mode

Several cases taken from recent publications suggest that there is typically at least some degree of concessionality, although in certain instances this may not be required To illustrate this notion in the case of the solar pump program run by the *Fideicomiso para Riesgo Compartido* (FIRCO) in Mexico, a preliminary analysis suggests that some individual projects are attractive enough investments for the perceived market The managers of the program determine the level of support accorded to each project, some may reach 50 percent of total project cost, while others may be substantially less There is also in-kind support from a national laboratory of the U S Department of Energy This project is an example of Model 1

In the case of the Chalan village mini-hydro project in Peru, the project's economics depend on a certain degree of concessionality in the form of below-market financing from a revolving fund established by the Inter-American Development Bank (IDB) and an international NGO A Peruvian NGO also provided a grant that, in effect, represented an equity contribution This project is an example of a Model 2 project finance structure, including a community electric enterprise Similarly, in the case of the Andhi Khola hydropower project in Nepal, concessional resources again played a role in the project's success with a Norwegian grant serving as the project's equity contribution, which then leveraged loans from financial institutions

Model 3 is illustrated by Enersol Associates' SO-BASEC scheme in the Dominican Republic In this case, Enersol serves as the technical partner, training local solar energy entrepreneurs to provide installation, maintenance and related services to end users At the same time, Enersol and the local business community create a solar NGO to manage a revolving fund capitalized with outside resources This fund provides credit to end users who purchase units and repay their loans over periods of between two and five years Loan payments include repayment of principal (the total cost of installation and equipment) as well as a market rate of interest Because the end users own the units, they are responsible for maintenance and replacement parts

Similarly, Model 4 is illustrated by another Enersol project, two companies, *Soluz* and *Industrias Electricas de Bella Vista* (IEBV), are creating a solar energy leasing company with a capitalization of US $700,000 provided by various equity investors, and US $1 3 million in debt, to develop an initial base of 5,000 lease-paying

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customers Customers pay US $10/month per unit, generating cash flow for the energy leasing company to cover debt service as well as provide a reasonable return on equity to investors Unlike in Model 3, the customers do not take ownership of the units, and hence the obligation of maintenance and replacement of used parts is the leasing company's

Argentina has implemented a rural electrification program based on a public bidding mechanism that provides an example of Model 5 The Argentine model encompasses mini-grid systems as well as off-grid projects, depending on the characteristics and requirements of the region offered for bid

1 Introduction

The USAID/Nepal Private Electricity Support Project commissioned this study to assist in directing the Electricity Development Center's efforts to identify sustainable models for investment in small-scale project that could contribute to Nepal's rural electrification deficit Acres International Corporation performed a review of the recent literature on the subject of rural electrification to gather information on current and future programs and projects

One of the key problems facing rural communities lacking electricity and the businesses that wish to expand their markets to include such communities is accessing adequate financing The investment costs for mini-grid and stand-alone village systems are significant for such communities For a rural village, the acquisition of a stand-alone system is an investment of significant proportion While financial institutions have evolved in industrial nations to finance such investments, a financial network to support investment in affordable electricity generation and transmission systems in Nepal's rural areas where electricity is lacking has yet to become operational despite the World Bank's proposal to capitalize a Power Development Fund which would partially finance small-scale projects through its "second window" Therefore, the objective of creating sustainable rural electrification based on renewable sources of energy – that is, projects and markets that will survive without continued support from government, multilateral or even private entities over the long term – poses a challenge

In the analysis of lessons learned from the developing world contained below, a conceptual framework is provided for analyzing the financing and institutional arrangements used in promoting and executing rural electrification projects The paper begins with a review of the key aspects of such projects, referred to here as the "parameters relevant to rural electrification projects" (Section 2) and also considers the key factors in successful implementation, the "determinants for success" (Section 3)

The paper then presents a series of models that have emerged in various recent projects in emerging markets in Section 4 (off-grid projects) and Section 5 (grid extension projects) These models capture the salient features of a wide range of projects, albeit with some case-specific variations Section 6 of the paper presents various issues associated with financing small-scale projects in Nepal Section 7 presents recommendations recently formulated by the Federation of Nepalese Chambers of Commerce for overcoming many of these issues Finally, Section 8 presents the paper's conclusions regarding how Nepal might go about embarking upon a small-scale renewable energy electrification program based on small-scale hydroelectric schemes Appendix A presents a summary classification of a number of small-scale power project in various emerging markets The Bibliography provides a relatively extensive listing of relevant documents available to the reader regarding a multitude of issues raised by this paper

2 Parameters Relevant to Rural Electrification Projects

Several issues are relevant to rural projects and they should be reviewed at the beginning of this analysis to classify models In many cases, the parameter identified encompasses several related issues Examples of specific cases are given where relevant While the discussion of the models in Section 4 will consider off-grid projects only, for the sake of completeness both grid-extension as well as off-grid projects are considered in the discussion here

2 1 Grid Extensions Versus Off-Grid Projects

The first consideration is whether a given project extends the grid to a community that did not have access to the system previously Such projects may be undertaken by a regional utility, or projects may be undertaken by a private or public-private entity that has a concession to provide electricity in a certain region

In the case of a utility electrification program, it is possible for that entity to use a cross-subsidy to reduce the cost of service to the rural community However, utilities are slow to extend their systems into a large number of rural communities due to lack of resources This is because the load served in such areas is relatively small, providing little revenue to offset the upfront costs of installation of extending the grid to rural users For this reason, such entities may be willing to permit private and local enterprises to service this demand, although regulatory and legal factors may prevent this At the same time, the imperative of reducing the costs of electrification has given rise to a number of techniques, including alternative billing mechanisms, the use of standardized home-wiring packages (referred to as harnesses) and other devices, all of which are covered in the literature [1]

Alternatively, the project could involve the establishment of an isolated system to serve a remote community with generation, transmission and distribution services A public utility, a private, or a non-profit entity might undertake such projects In the former case, such activity potentially precedes actual grid connection, with the latter step occurring once demand growth has increased sufficiently for the connection to break-even

A smaller-scale subset of this type of project concerns distributed household systems, which are cost-effective solutions to the problem of electrifying low-density areas These two cases are the subject of this document, as opposed to the electrification via grid connection

2 2 Technology Choice and Configuration

The selection of generation technology is an especially important issue for off-grid projects, although it is a potentially relevant consideration to grid-extension projects as well, especially in cases where system stability and other technical considerations require that generation capacity be established closer to the source of the new load (as in distributed generation applications) This is because rural end users have relatively low requirements as compared with urban end users In general, the technology options for generation include small-scale hydro, diesel fuel oil or biomass-fired combustion (including gasification), wind, and solar, or a combination of two or three of the above in ' hybrid" systems

[1] See for example Nigel Smith ' Affordable Electricity Installation in Developing Countries,' Intermediate Technology Consultants June 1995

Technology selection also involves providing metered or non-metered (load limited) energy supplies to a given community Typically, load limited supply is considered a means to reduce the connection costs, as this reduces the investment required to monitor power flows, as well as to provide peak power loads, to newly grid-connected communities [2]

Typically, however, the decision to select a generation technology arises in the case of off-grid projects, and it depends on a wide range of factors, including the nature of the resource (with seasonal or diurnal variations, etc), storage capabilities, the energy requirements of the users (in terms of quality and reliability), the remoteness of the site from fuel supplies, etc The incorporation of features such as load limiters in off-grid systems would provide greater security or supply in such instances, as they would prevent exceeding the generation limits of the isolated system The use of such features would also add to the investment cost of the project

Another issue related to the reliability of the system is the choice of back-up power, if any The back-up generator in a mini-grid system will add important investment and operational costs, while the choice of back-up batteries for household solar energy systems can vary significantly in terms of cost and performance At the level of the individual household or farm/ranch, the technology choice is certainly going to be driven by installation cost, and to some extent performance requirements

In all cases, the type of appliances and equipment that make up the load is also important For the purposes of this study it is assumed that rural users already have some electric appliances that are powered by batteries, small generators or other high-cost sources of power Once a community has a regular and less costly source of power, however, the demand for power quickly increases This tendency underscores the need for the technical approach used to be expandable and presents the typical problem of adding discrete blocks or "lumps" to the supply-side of the energy equation, without sufficient demand to justify the investment

2 2 1 Small-Scale Hydropower Technology

Of particular concern to this study are small-scale hydroelectric schemes Small-scale schemes will be taken here to have an installed capacity of 10 MW or less Systems of a few tens or hundreds of kilowatts are often referred to as micro- or mini-hydro but since the principles of operation remain the same for both mini- small- and large-scale hydropower schemes, no differentiation will be made here

A "hydroelectric scheme" consists of the following elements

- A suitable site, consisting of two natural features a rainfall catchment area and a hydraulic head The head is the difference in height between the surfaces of two bodies of water, for example, the level behind a dam and in front of it
- Civil works, consisting of a water intake placed above a weir or behind a dam, the dam itself, a method of transporting the water from the intake to a turbine such as a penstock or leat and an outflow where the exhaust water returns to the main flow
- A flow control system
- Plant and associated equipment consisting of turbine, generator, buildings and grid connection

Small-scale schemes are usually "run-of-river", meaning that they do not rely on a large water reservoir providing daily or seasonal storage Some small-scale hydro schemes do have a reservoir and, rarely, are

[2] Ibid p 16-17

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configured for pumped storage Good practice requires that run of river schemes be designed to take only a small proportion of the water in the river to protect the downstream environment The unused water, called the compensation flow, may be required to be as high as 95 percent of the average flow This means that a run of river scheme may have periods when no water is available for generation thus highlighting the benefits of storage

The power available from a given hydropower site is directly proportional to the product of the hydraulic head and the water flow Different designs of turbines are required for the range of flow and head conditions that are to be found in Nepal Generally, impulse turbines are high head, low flow machines such as the Pelton or Turgo design Reaction machines operate at high flow rates and low heads characterized by the Kaplan and bulb turbine Between these two extremes are the generic crossflow and Francis machines Turbines are available for power ranges upwards of a few hundred watts, heads of 1 5 meters or more and water flow rates exceeding 0 01 cubic meters per second Machines can be expected to have an availability of 95 percent or over and will operate at capacity factors of between 20 and 80 percent depending on the availability of water Machine type selection is a straightforward decision based on the site conditions

It is unlikely that there will be significant changes to equipment design since the existing product range covers the needs of most potential small-scale sites There may be small improvements to machine efficiencies and some reduction in equipment cost The main cost reductions are likely to come from more effective procurement strategies, by using common designs across many schemes, for example

2 3 Financing Sources

For project-finance structures, potential sources might include resources provided by a multilateral lending agency, a regional utility, leveraged with national or international credit, other public or private agencies, and even NGOs In the case of larger projects, including mini-grids, the mix of resources may be complemented by in-kind or cash resources from the local community

In the case of household or village-level projects, the vendor or other financing provider offers micro lines of credit These entities must have sufficient distribution presence in rural communities to facilitate transactions As will be described in Section 4 on financing models and case studies, multiple sources of financing may be required to provide the right mix of equity and debt financing for project finance structures

2 4 Degree of Concessionality in Financing

The degree of concessionality[3] is discussed in the project case studies in Section 4 This reflects the literature on rural models where, in all the models there is an element of concessionality The concessionality of a given financial structure may be evaluated by considering the following continuum of financing types, as shown in

[3]"Concessionality is used here in the sense of an objective measurement of the degree to which the terms of a given transaction differ from those that would apply in an undistorted market environment Another expression is 'grant element but this is not used as it suggests only the presence of grant payments or subsidies Concessionality is intended to encompass both the role of grants or one-time subsidy payments as well as the use of below-market interest rates and generous repayment schedules or grace periods

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Table 2 1 It should be noted that the spectrum does not consider the *magnitude* of the subsidy, rather it denotes the *type or modality*

Table 2 1
Spectrum of Concessionality

Some Concessionality ◄═══ ═══► No Concessionality

Grants	Grants and Concessional Loans	Concessional Loans	Fiscal Incentives	Market-Based Loans and/or Self-Financing

The level of concessionality of a particular financing structure is difficult to assess, given a wide variety of schemes and instruments The issue with regards to rural electrification is rather what mix of incentives (tax benefits, utility concessions, market price signals, etc) is required to attract private or NGO service providers or suppliers For example, certain fiscal incentives, such as performance credits or rebates, or depreciation benefits, introduce a concessional element into the financing package, but do not require an actual budgetary expenditure

2 5 Organizational Structure

The organizational structure is another important parameter to consider in an evaluation of models Perhaps the most traditional organizational structure, is that of the utility grid-extension program In this case, a utility finances and executes the implementation of a project to extend electricity services This may be done in coordination with the local community, and the community may even provide certain important elements of the operational phase of the project, such as bill collection In some cases, on the other hand, the utility may have an exclusive responsibility to provide electric service by law, thereby precluding community participation beyond the initial project phase [4]

As suggested, however, some projects might be undertaken jointly by the regional utility and a community organization There are reasons why this structure might be more advantageous First of all, the utility may wish to share the cost of a rural project, whose returns might be negative Furthermore, the literature on rural electrification describes in ample detail the advantages of community participation Without such involvement, for example, the incidence of fraud and theft of energy is likely to be higher Communities respond better to projects in which they have a stake

Accordingly, community electric cooperatives provide a successful organizational model adopted in several developing nations as well as the United States and other industrialized nations The largely positive experience of Costa Rica's cooperatives, for example, demonstrates the value of creating electrification institutions, managed by local communities Indeed, the move toward "cooperativism" in Costa Rica stemmed from dissatisfaction

[4]For example in Mexico the state-owned *Comision Federal de Electricidad* (CFE) along with its smaller sister company *Luz y Fuerza del Centro* is the only entity that is allowed by law to distribute electricity to end users Typically, all grid extension projects must be reviewed by CFE for technical compatibility with the national system, and the CFE must assume management of the program This does not apply to off-grid and small projects which can be undertaken by others

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among the more isolated rural communities in the country at the level of service — or lack thereof — provided by state-owned entities [5]

The organizational structures described above are likely to emerge only in the case of larger-scale undertakings, whether they are grid-extension or mini-grid projects In the case of household- or farm-level systems, these might be referred to as having independent organizational structures [6]

Also of importance in the consideration of organizational structures in rural electrification is the significant role of NGOs in many projects The National Rural Electric Cooperative Association (NRECA) in the United States played an important role in the establishment of the cooperatives in Costa Rica in the 1960s In the 1980s and 1990s, Enersol Associates, a Massachusetts-based NGO, played an important role in disseminating technical expertise in solar electrification in the Dominican Republic and later, Honduras, this effort has facilitated the emergence of a solar energy sector in both countries, making it possible to promote the sale of vendor-financed household solar units Enersol founder Richard Hansen argues that NGOs occupy an important niche in the creation of markets for renewable energy technologies in areas unserved by for-profit or state-run utilities He suggests that once those markets have been started by NGO activity, often supported by subsidies and charitable donations, private companies may step in and generate far more substantial resources by offering a reasonable mix of risk and return for investment in the sector [7]

In all cases, the salient issue is the attractiveness of the underlying market, be it delivery of services to heretofore pent-up demand or created via a mix of policy incentives (i e, a rural concession) and market drivers (i e , cost effective technology innovation or attractive credit terms)

Since the cooperation of the local community is important, it is likely that the community will be involved in some way in the process, either at the planning stage, or through execution to operation and maintenance [8] Indeed, many rural electrification projects come about because the community has lobbied for it

A related issue is that of ownership Along with ownership, the question of responsibility for maintenance and repairs is also addressed This is especially relevant in the case of household systems where financed by the vendor or a separate financial intermediary Ownership must be established to prevent dissatisfaction among the end users when units fail or need to be replaced

2 6 Summary

Table 2 2 provides a summary of the elements presented in the foregoing discussion In addition, it includes several examples of projects or programs, some of which are reviewed in greater detail in Section 4

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[5]See Gerald Foley "Rural Electrification in Costa Rica A Case Study " ESMAP, November 1996 mimeo

[6]For the purposes of this study such systems will be referred to as standalone systems

[7]Richard D Hansen NGO and ESCO models paper presented at the Roundtable on Rural Energy and Development World Bank Washington DC April 1997

[8]In Mexico grid-extension projects begin with consultations between the CFE and the community committee that handles electrification and community members may be involved in execution but operation and maintenance are handled by the CFE alone

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Table 2 2
Parameters Relevant to Rural Electrification Projects

Parameter	Description	Example(s)
Grid extension vs off-grid projects	Projects may involve linking communities to the national grid or regional system or may involve an off-grid mini-system, or at the smallest possible scale, standalone installations	Grid extensions Costa Rica cooperatives Off-grid mini-system APS-CFE proposals for BCS and Sonora Off-grid standalone installations FIRCO solar program
Technology choice and configuration	In addition to the choice of solar, wind, mini-hydro, geothermal or conventional thermal generation, technology choice issues include decisions related to how payment for service is made, whether by meter by fixed amount (load-limited), or based on the capacity of the unit installed (in the case of standalone systems)	Grid extension, metered Grid extension load limited Nepal, Zimbabwe (Smith) Grid extension, other *kutir jyothi* program India (Smith) Off-grid metered Total (time on) Off-grid load-limited Unit-limited FIRCO solar program any standalone system program
Financing sources	The sources of financing may include single sources or multiple sources, and may involve a constellation of organizations from the public private and NGO sectors	Mixed public/private financing Mexico, Costa Rica Peru, Bolivia Brazil Private financing Enersol in the DR
Degree of concessionality in financing	The type of concessionality in financing ranges from 100% subsidy to 100% self-financing Intermediate types include provision of concessional credit or market-based credit Mixed financing (grants and self-financing various types of credit) also is common	Mixed financing FIRCO solar program Concessional credit Enersol PV financing in the Dominican Republic*, micro-hydro credit program in Peru (Barnes et al) Market-based credit New World Power do Brasil Self financing Community Power Corporation Indonesia
Organizational structure	The organizational structure is likely to be influenced by project type For example, for grid extension projects, a utility possibly in conjunction with a community-based organization (cooperative, *patronato*, or other) is almost a certainty, for off-grid mini-systems, the same is true, with greater likelihood of a community based organization, for standalone systems little organizational infrastructure is required	Utility/community-based CFE grid extensions Community based Costa Rican cooperatives for grid-extension projects Household systems FIRCO solar program

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3 Determinants of Success for Rural Electrification Projects

The presence of certain determinants of success is key for the project to provide electric services adequately While other factors, outside of the project design, may be very important to successful implementation, these are not considered here

The determinants are presented in their general order of importance Financial feasibility of the project is generally considered of greatest importance, as it is a necessary condition for successful implementation, whereas the other determinants may be present but still not guarantee success The other determinants are technical feasibility, community engagement, and political/regulatory environment

3 1 Financial and Economic Feasibility

3 1 1 Financial Feasibility

In most cases analyzed, financial feasibility was attained in part through the provision of a sufficient amount of concessional support Hence, the mix of grants or concessional loans along with end-user contributions, equity financing, and market-based loans, reflect the extent to which economic, institutional, or project risk issues were perceived to limit the project's viability

If they are necessary, the subsidies required will reflect the community's willingness to pay for electricity or, alternatively, its willingness to borrow The literature on rural electrification suggests that the willingness to pay is high among rural communities that depend on high-cost sources of electricity, such as batteries or diesel generators For example, a survey of the Asunta Valley in Bolivia reported that rural households were spending a significant percentage of their income on fuels for lighting that are inferior to electricity, in terms of lighting efficiency [1]

Rural inhabitants have demonstrated a readiness to enter into financial obligations, either in the form of leases or loans, when it suits their interests The experience of Enersol Associates in the Dominican Republic suggests that villagers are not only willing to borrow but willing to pay their loans back as well, according to Enersol, the default rate for its Solar-Based Rural Electrification Concept (SO-BASEC) is less than 1 percent, although late payments are not uncommon [2]

In the case of community systems and grid-extension projects, experience in numerous countries emphasizes the need to ensure full cost recovery and financial sustainability as a crucial ingredient to the long-term viability of projects In Costa Rica, the experience of the cooperatives demonstrates the importance of pricing electricity to reflect all operational and long-term costs, thereby ensuring that the entities have sufficient resources to invest in extensions, upgrades and new sources of power As Foley notes, full-cost recovery helped assure the cooperative's sufficient resources to invest in new generation capacity, which could generate power at lower costs than electricity supplied by the national utility, ICE,

[1] See D Barnes W Floor J Mullaney and P Wolman, "Energy Strategies for Rural and Poor People in Latin America Industry & Energy Department World Bank January, 1997, mimeo p 6

[2] See D Barnes et al , op cit, p 17

thereby enabling them to pass along cost savings to their consumers The cooperatives have been able to provide electricity at tariffs below those of ICE, in part due to such investments, but also partly due to the fact that ICE's larger system has higher operating costs [3]

3 1 2 Economics of Small-Scale Hydropower

The economics of a small-scale hydropower scheme are characterized by a large initial investment that is recovered over a long time horizon Well-designed and managed schemes demonstrate high reliability and availability coupled with low operation and maintenance (O&M) costs Well-constructed civil works can last as long as 100 years and plant and equipment up to 50, although refurbishment may be required during that time period Schemes are designed for given flow and head conditions and run at their optimum efficiency at or near the design condition This can have serious consequences on the economics of the scheme where flows fall below those anticipated Thus, flow efficiencies are a particularly important design parameter for run-of-river schemes

Costs vary substantially depending on the scheme rendering individual investigation and tailored design essential Some sites are naturally better adapted to small-scale hydropower schemes and thus require little work whilst others, particularly those with low heads or where a reservoir is required, may require weirs, extensive sluice gates and penstocks, all of which can increase costs substantially Generally, cost per kilowatt (kW) is reduced as head increases and as installed capacity increases as well Typical costs for a small hydro station are presented in the table below

Item/Proportion of Total Cost	Head 5 – 225 m, Power 5 – 1 300 kW	
	Minimum Cost US $/kW	Maximum Cost US $/kW
Plant ex Factory 33%	330	1 520
Commissioning and Installation 9%	90	410
Civil Engineering 36%	360	1 650
Electrical Engineering 6%	60	280
Design and Management 7%	70	320
Contingency @ 10% of above	90	420
TOTAL	1,000	4,600

Typical annual O&M costs are in the range of 2 to 3 percent of capital costs broken down as follows

Item	Annual Cost US $/kW
Insurance	11 0
Annual Surveys	5 6
Maintenance	14 0
Land Use	8 4
Administration	2 8
TOTAL	41 8

A 500 kW small hydroelectric scheme with a capacity factor of 50 percent and an annual cost of capital of 12 percent would produce electricity costing between US $0 037 and US $0 136 per kilowatt hour, depending on where in the range of US $1,000 to US $4,600 the capital cost of the scheme fell

[3] Foley op cit pp 46-47

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3 1 3 Risks Associated with Small-Scale Hydropower Schemes

Small-scale hydro schemes share risks in common with all power projects such as development and construction risk, including cost overruns, completion delays, failures of plant to meet performance specifications, physical, and government risks Equally, the risks common to all plant in the operating phase, relating, for example, to political, legal, financial and revenue issues have to be dealt with The environment in which such schemes are built, particularly by the private sector, is a function of the host country and its laws and regulations Hence, there is a systematic and country risk associated with all private power development from which small hydro schemes would not be exempt The paragraphs below highlight some of the risks specific to small-scale hydropower development

Operational risks include, *inter alia*

- Technical non-performance of the scheme based on inadequate or inaccurate site data predicting head and flow rates
- Hydrological variation either from short-term fluctuations in water availability, due, for example, to unseasonably high or low rainfall or snowmelt upstream, can have a serious impact on run of river schemes
- Variations of a long-term nature, upstream offtake, for example, can affect all types of schemes
- Where the unit is connected to the grid and is fitted with an asynchronous generator, there is a danger of forced outage due to grid failure

3 2 Technical Feasibility

Technical feasibility relates on two issues the first of which deals with the adequacy of the technology choice and configuration, while the other has to do with the availability of technical support If technical support is not readily available in the community, then the technology chosen must be sufficiently robust to provide a low failure rate This latter issue impinges on issues related to community support, as well, in two ways First, support will tend to be greater as local members are seen to be participating in the on-going maintenance of the project Second, a reduced failure rate will keep end users satisfied with the service

A project employing a technology that cannot deliver electricity in accordance with community needs and desires will lose the support of that community over the longer term Foley argues that the cooperative movement in Costa Rica, as well as the case of the municipal utility JASEC in Cartago, developed in part because of dissatisfaction with service provided by the state-owned utility [4]

Another case is that of the *X Calak* project in Quintana Roo, Mexico Here, a limited back-up power system meant that a seasonal dip in wind generation due to variability in the wind resource could not be compensated The limitations on the system's ability to provide enough power throughout the year to meet community demands created discontent and also the high costs of maintenance made it difficult to operate

More generally, electrification projects must be designed for expansion, since a community, once electrified, will tend to increase Demand growth will eventually cause the system to bump up against the system's capacity,

[4] Ibid pp 25-26

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requiring rapid attention to the system's limitations [5] In this regard, it is often important that the end users not perceive off-grid projects as being an alternative to connection to the grid This is the case in Sri Lanka, where villages are often not very far from the grid, and where the penetration of the grid in rural areas is still relatively low

3 3 Community Engagement

Most projects to date have found that community support is critical The fundamental issue is that of ownership and responsibility for the success of the project, whether it is a mini-grid system, a grid-extension project, or a series of stand-alone units A clearly delineated sense of ownership and responsibility can be decisive for various reasons

- The financial viability of the project may depend on community participation that reduces implementation costs For example, villagers may choose to "invest" in a project to provide power in their community by providing labor for plant and line construction. Although the financial importance of such contributions may not be decisive in some cases, such community participation is probably an important mechanism for villagers to develop a psychological stake in the project [6] Local knowledge is also important for project identification and construction, where rights of way and other local permits will be required

- The development of a community engagement in the project is likely to reduce the threat of thefts, unauthorized connections, delinquency in payments, etc Foley argues that the cooperative program in Costa Rica benefited in a decisive way from community participation [7] Community pressure can provide a discipline that an outside entity cannot reasonably expect to impose, or even afford

- A training program for members to become proficient in basic maintenance and repair will create a sense of involvement and long-term benefit that enhances community support and the sustainability of a project The presence of trained personnel near the project site or close to households or farms where equipment is installed may also facilitate project design and, in the case of programs to develop markets for renewable technologies, may help propagate demand for those technologies, as in the Enersol case (see Sections 4 3 and 4 4)

- Lastly, community participation is one strategy for clearly establishing ownership of a project or of equipment This is essential to ensure that responsibilities for providing maintenance, upkeep, and replacement of old parts are understood and that the system's requirements are addressed This is especially important where financing terms assign equipment ownership, and hence maintenance responsibilities, to the end user or to the vendor

In many communities, these resources may not be available, and even if present, there may be political divisions at the community level that could create administrative problems if carried inside the enterprise or cooperative

[5] Several studies have attempted to measure the impact of electrification on rural economic development The results appear to be inconclusive, despite the fact that in certain cases electrification preceded growth in commerce in a particular rural area because of the numerous other factors that also play a role See Foley op cit , pp 51-58

[6] CFE

[7] Foley op cit pp 45-46

Again, the Costa Rican experience suggests the need for awareness of such problems, as in the case of the cooperative in Guanacaste province, COOPEGUANACASTE [8]

In the case of the *X'Calak* hybrid system, another source of community dissatisfaction appears to be poor management of the rate-setting function and bill collection functions Although the state government requested that meters be installed in the village, end users are assessed a flat rate Obviously, this has created resentment among those who feel that they do not consume as much as other villagers [9]

3 4 Political/Regulatory Environment

In most countries, political and regulatory considerations may shape how rural electrification projects are undertaken, and may also influence the financial feasibility of projects in the longer term Typical political problems may involve restricting energy service providers

For example in Mexico, all grid-extension projects must be reviewed and approved by the national utility, the CFE, and operational control is required by the Law on the Public Service of Electricity However, off-grid projects need not be approved or run by CFE, although it is likely that CFE will get involved since it is the main public entity in the country dealing with electricity Also important is the fact that project-permitting procedures may differ depending on the size of the generating facility contemplated Again in Mexico, off-grid projects of less than 1 MW face far fewer permitting requirements than projects larger than 1 MW [10]

The regulatory and legal environment may not be suited to certain types of projects in other ways Foley describes how certain aspects of the tariff structures set by the national energy regulatory body, the *Servicio Nacional de Electricidad* (SNE) created significant problems for the cooperatives early in their development To begin with, ICE did not have a tariff category specific to bulk power sales to the rural cooperatives, with the closest substitute being the tariff accorded large industrial consumers, which was substantially higher than the tariff applying to residential consumers As a result, early on, the cooperatives were forced to charge their residential customers higher tariffs than those offered to residential users in other parts of the country In addition, the cooperatives' tariffs were designed with steep price escalation, even at low levels of use As a result, consumers often limited their usage to the lowest consumption block, depressing revenues to the cooperatives The cooperatives lobbied forcefully for SNE to modify the structure [11]

Lastly, national policies may also limit the resources available to support rural electrification projects, thereby limiting the number of viable projects in cases where such activities require subsidies or the provision of credit at concessional rates

[8] Ibid , pp 39-40

[9] CFE

[10] Renewable Energy Program National Commission for Energy Conservation (CONAE)

[11] Foley op cit pp 42

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3 4 1 Legal and Regulatory Risks Associated with Small-Scale Hydropower Schemes

Legal and regulatory risks associated with small-scale hydropower developments include, *inter alia*

- Consequential damage resulting from catastrophic failure, especially of dams,
- Regulations concerning the use of water for irrigation Many dams in arid areas are built primarily for irrigation and there may be restrictions on drawing down water for power use either on a daily or seasonal basis, and
- Changes to the regulatory and inspection requirements following dam failures elsewhere

Although considered to be environmentally benign, small-scale hydroelectric schemes do have some environmental risk Schemes are often required to conform to some environmental regulation, if there is none in place then there is a risk that it will be imposed retrospectively

3 5 Summary

Table 3 1 provides a summary of the elements presented in the foregoing discussion In addition, it includes several examples of projects or programs, some of which are reviewed in greater detail in Section 4

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Table 3 1
Determinants of Success for Rural Electrification Projects

Determinant	Description	Example
Financial feasibility	This is the crux of the issue for any technically feasible project that is not financially feasible will not succeed The key issues are whether the project can obtain the necessary mix of credit and subsidies to balance the community contributions which are in turn dependent on the willingness to pay of the community or the individual In general the rural population favors electricity because it reduces overall energy costs in the short term as incomes rise however electricity consumption tends to increase as a share of total outlays In the end programs/ enterprises must be sustainable financially implying that the full costs of projects must be recoverable	The FIRCO solar program in Mexico has been successful because it provides a subsidy to give ranchers/ farmers an incentive to go with solar powered pumps for remote wells thereby opening up otherwise unused ranch lands for use
Technical feasibility	Equally important and related to financial feasibility this is perhaps the most important consideration Technical issues include both the robustness of the technical solution to meet community requirements as well as the technical support necessary to ensure that the project succeeds after initial installation	An example of where the technical solution to a rural energy project fell short of community needs is the *X Calak* project in Quintana Roo Mexico Here variations in wind generation (Bergey Windpower) and limited back up appear to have limited the system s ability to provide enough power throughout the year to meet community demands (NRECA)
Community engagement	This is related to the previous item in the sense that local support is likely to be greater if there is local technical support and participation in the project Beyond that community engagement is crucial to the success and financial sustainability of grid-extension projects	The Costa Rican cooperatives and municipal utilities were successful to a large extent because of the support of local inhabitants who saw them as the only way to bring electric service to remote areas (Foley)
Political/regulatory environment	Limitations on private participation in generation transmission and sale of electricity will necessarily limit feasibility of grid extension projects and possibly even off grid projects However it seems less likely that political and regulatory issues should play a major role in off-grid projects	In Mexico CFE must support project design and must operate and manage grid extension projects due to legal restrictions on private participation in the power sector In Costa Rica legal issues and basic tariff design flaws created problems for the cooperatives in their earliest phase of development (Foley)

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4 Financing Models for Rural Electrification – Off-Grid Projects

Based on the foregoing discussion, it is possible to identify several models for rural electrification Each of the models presented here is not necessarily suited to the range of circumstances that may characterize rural communities across countries or indeed, within one country Some mechanisms will be better suited to less-developed communities where knowledge of electricity is limited and where even limited capital resources are scarce, others will be better suited to more developed and sophisticated communities with greater financial resources

One of the key features of the application of a given model is the extent of the subsidy introduced to ensure a project' s successful implementation. In most cases reviewed, some concessional element was required to reduce risk, overcome technical, economic or institutional barriers, or simply to secure community support However, these cases are insufficient to determine that, depending on the specific situation, it may be possible to eliminate the use of subsidies or to design projects without this element Technical and economic issues affecting project viability are changing constantly, creating circumstances more (or less) favorable to projects in addition to political and regulatory changes Clearly, the use of subsidies creates a constituency that may resist efforts to eliminate them, so, a strategy starting with subsidies is inconsistent with the notion of sustainability (i e markets, customers, etc)

This section provides a review of models for financing rural electrification projects, and then provides an example of each drawn from the recent literature Figures provided at the end of this section illustrate these models, and are identified by the same numbers as models

4 1 Model 1 Cash

Model 1 is a straight cash transaction, potentially with a cost-share component, as noted in Figure 1a These are most likely to be household systems, in which the end user acquires the system in a market-based transaction, and possibly receives a subsidy to offset the substantial initial cost incurred The subsidy may take the form of a financial and/or in-kind benefit that reduces the net cost of the purchase, and/or diminishes some of the risk associated with acquisition of the equipment This may take the form of a one-time cash transfer to offset up-front investment costs [1] There are some recent examples of business models where no subsidy is present, such as Community Power Corporation' s project in Indonesia, and these are promising new efforts, which have yet to prove themselves

The example of the model presented in Figure 1b is drawn from the program run by the Trust Fund for Risk Sharing (*Fideicomiso para Riesgo Compartido*, or FIRCO) in Mexico, in conjunction with other government agencies and the Sandia National Laboratory of the U S Department of Energy, since early 1995 Under the FIRCO program, ranchers and farmers in several states have received subsidies of up to 50 percent of the installation and equipment cost of solar-driven pumps placed on ranch lands to increase the amount of irrigated land available for grazing The units also displace the cost of pumping water using diesel generators and the labor required to operate and maintain those units As a result the program allows participating ranchers to realize a double benefit the expansion of the productive area of their land enables them to increase the number of head

[1] This is the case in Chile, where private or NGO entities pursuing rural electrification projects receive a one-time cash transfer from the government

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raised for sale or slaughter, and the solar pumps displace labor and fuel costs An analysis of three representative projects is presented in the next section

Program funds are disbursed on a case-by-case basis Interested ranchers and farmers present proposals to the FIRCO field offices, and these are reviewed by FIRCO staff, who prepare a brief financial, environmental and social analysis and determine the amount of subsidy based on the project analysis Once approved, the participating rancher pays the quoted investment costs, and is eligible to receive payment from FIRCO of the stipulated amount The participant assumes ownership of the equipment, and is responsible for maintenance and replacement costs [2] There is no data available as to the program's rate of implementation (i e level of acceptance), however, the interesting aspect of the program is that it demonstrate the incipient willingness to pay, which has been leveraged with the FIRCO funds in this case, but could also be leveraged with market-based mechanisms, i e loans

A summary of the program's first two years of operation is presented in Table 4 1 Total investments under the program have reached about 4 million pesos, equivalent to about US $504,000 at current exchange rates End users have contributed roughly 51 percent, FIRCO contributed another 26 percent, and Sandia's contribution makes up the remainder While the majority of the projects undertaken fall under the FIRCO-Sandia program, several others have been undertaken in conjunction with other state and federal programs in Mexico

Table 4 1
Summary of FIRCO Rural Solar Program

		Funding by Source (thousands of pesos)				Beneficiaries		
Program	**No Proj**	**FIRCO**	**Sandia**	**End User**	**Total**	**Users**	**Area***	**Head**
FIRCO-Sandia	13	1 015 75	903 21	1 499 70	3 418 66	276	25 23	3,558
Sequia	4	N/A	0 00	518 39	518 39	33	22 30	980
Alianza	2	20 95	0 00	25 51	46 46	6	5 30	289
Total		1,036 70	903 21	2,043 60	3 983 51	315	52 83	4 827

*Thousands of hectares Source preliminary data from FIRCO

4 1 1 Discussion of FIRCO Solar Program

The FIRCO solar program's use of subsidies suggests that some of these projects would not be financially feasible on their own A discounted cash flow pro-forma analysis was carried out using FIRCO data for three projects A detailed methodology is presented in the appendix The results suggest that some of the projects would be feasible without the subsidy even at high (risk adjusted) discount rates The three individual projects analyzed present widely different Internal Rates of Return (IRRs) While the FIRCO data available does not include the amount of the subsidy payment made for each individual project, it seems likely that the more attractive projects received smaller payments, while the less attractive ones received comparatively larger ones, thereby ensuring that the IRRs with subsidies would be roughly equivalent

Without subsidies, the least attractive of the projects had an IRR of 19 percent and it also had a negative NPV at the discount rate of 25 percent applied in the Tables With a 50 percent subsidy, the same

[2] FIRCO

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project offered an IRR or 51 percent (and a sizable NPV when evaluated at a discount rate of 25 percent)

A reasonable project discount rate might be 15 percent, with a risk premium for Mexico of 5 percent, and another 5 percent risk premium for an "unconventional" technology This would suggest a discount rate of roughly 25 percent, in excess of the 19-percent IRR estimated for Project 2 Hence, some projects would require a subsidy, however, Project 3, with a pay back of less than a year and an attractive IRR, is a good example of a sustainable project that does not need one In the longer term, assuming that current economic trends in Mexico continue to improve, it would be possible to reduce subsidies significantly

4 2 Model 2 Project Finance

Model 2 features a structure most resembling a typical project finance, and as such is likely to apply to investments at the village scale or larger Here, equity investment in the project may be provided by one or more entities The equity investment is leveraged by debt secured from financial institutions, with repayment of debt coming from the cash flow generated by the project through sales revenues In the case of community-based projects, ownership is by the community enterprise or cooperative, and management is provided by representatives from the community, while the project and operational risk is assumed by the project enterprise along with the equity participants

There is a distinction between projects financed by a regional utility and those financed as off-grid or separate grid-extension entities, in that a utility might be in a position to cross subsidize, whereas an off-grid project, or a grid-extension project financed by a separate entity could not Model 2 best encompasses the latter type of project

An example can be found in Chalan village, Peru, where the villagers provided part of the equity through an in-kind contribution of labor, and an outside investor (a Peruvian NGO) provided the balance in cash (see the example given in Figure 2b) Debt for the project was provided by a special-purpose financial entity (the "revolving fund") created by the IDB in conjunction with an international NGO, Intermediate Technology Development Group (ITDG) In 1993, the Intermediate Technology Development Group (ITDG) and the IDB established a rotating fund in Peru to make loans of up to US $30,000 available to rural communities and rural enterprises for micro-hydro schemes The interest rate is 8 percent per year, and the amortization period is five years

The first scheme to be installed under the program supplies electricity to the village of Chalan, fifty miles from the national grid Chalan has a population of 540 people in 120 families In addition, nineteen other small settlements or hamlets in the area use Chalan as their main center for services

The initiative for the micro-hydro scheme came from the village council and a local NGO that was working with local farmers The funding for the scheme came from four sources a loan from the credit program, a grant from the local NGO, the resources of the village council, and the labor of every family in Chalan, who agreed to contribute a set amount of time to construct the channel, install the pipe, and build the powerhouse (the community provided a total of 4,318 person-days of labor) The ITDG supervised construction and provided technical and management training

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The capacity of the Chalan micro-hydro scheme is 25 kW and the capital cost was US $82,700, therefore yielding a unit cost of US $3,308/installed kW, which is in general terms consistent with hydroelectric capital costs Direct connections have been provided to eighty families to date, with most remaining households expected to connect in the future A further 617 families from surrounding communities are indirect beneficiaries of the scheme as they now have access to improved health and education facilities, battery charging, agro-processing, and workshop and communication services and also benefit from public lighting in the village

An elected committee that is independent of the village council manages the project and is responsible for overseeing operation and maintenance, collecting tariffs, promoting safe and efficient use of the energy, and managing the introduction of new end uses, such as workshop equipment At present, the power from the plant is priced at US $ 09/kWh, although this will increase to cover the costs of generation and to provide a reserve fund for repairs and replacements Conversely, as demand increases, the marginal costs of generation will fall, providing the opportunity to reduce tariffs

The credit program aims to install around twelve schemes The program has already attracted considerable interest among communities and enterprises, government bodies, and international agencies [3]

Of interest in the case of the Chalan micro-hydro project is the fact that the financing shows how concessionality can provide an important missing link to secure project finance In brief

- The local NGO that participated in the project acted, in effect, as an equity partner in the deal, providing up to 64 percent of the total cost of the project, depending on the valuation of the villagers' "sweat equity" component [4] However, the NGO treated the contribution as a grant, and hence will not require repayment of dividends
- The terms of the loan secured from the revolving fund are arguably below-market, given the nature of the project, its location, partners, and size Under commercial market conditions, lenders would require a much higher risk premium on such a loan, not to mention the premium for handling such a small transaction It is worth mentioning that this type of loan would likely not be available from commercial banking institutions, given the project's risk profile

A rough calculation suggests that a tariff designed to recover all costs from the Chalan project would be about US $0 13/kWh, implying a subsidy of 30 percent compared to the actual sale price of US $0 09/kWh [5]

[3] Stephen Fisher, ITDG 1996 Quoted in Energy Strategies for Rural and Poor People in Latin America

[4] It is not clear from the information available on the project whether the value of the in-kind contribution made by the villagers is included in the US $82,700 given as the cost of the project

[5] The tariff estimate is based on the standard calculation of the tariff required to repay a given investment in power generation equipment The total investment cost is divided by the total capacity, yielding a cost per unit of capacity This ratio is then multiplied by the cost recovery factor (CRF) which is 0 25 given the terms of the loan in the project (five years at 8 percent, see Grant E L and Ireson, W G , *Principles of Engineering Economy* fifth ed (Ronald Press Co New York), for a table of compound interest factors) This yields the revenue required per unit of capacity, per year This ratio is then divided by the plant availability, which expressed as the number of hours per year that the plant is expected to operate This is assumed to be 70 percent The formula may be summarized as follows Tariff = ([I/C] * CRF) / A, where I = investment cost, in dollars C = capacity in kW CRF = Capital Recovery Factor and A = availability in hours

4 3 Model 3· Credit

Model 3 is similar to Model 1, except that the arrangements call for the use of credit to enable the end user to overcome the initial cost hurdle A local bank or other entity specializing in origination of small-scale loans for solar or other renewable energy systems, either at the household or village scale makes the loan The transaction between the end user and the solar energy manufacturer/distributor is commercial, and does not require that the vendor supply credit to the end user The customer takes ownership of the equipment and assumes responsibility for maintenance and replacement parts, and services the loan

A variation on this model involves the provision of lease terms to the customer, with the lessor retaining ownership of the equipment, at least until the end of the lease, if it is a lease-to-own arrangement

Enersol Associates' SO-BASEC scheme in the Dominican Republic and Honduras provide a good example of Model 3 In this case, Enersol serves as the technical partner, training local solar energy entrepreneurs to provide installation, maintenance and related services to end users At the same time, Enersol and the local business community create a solar NGO to manage a revolving fund capitalized with outside resources This fund provides credit to end users who purchase units and repay their loans over periods of between two and five years Loan payments include repayment of principal (the total cost of installation and equipment) as well as a market rate of interest

This model is quasi commercial in that the households are forced to pay market rates for the financing This enables them to take on the initial cost hurdle Indeed, there is some credit support that is provided to the end users in terms of the financing extended to the local NGO fund, which may not be strictly at market rates Furthermore, the NGO probably does not require the same return on its loans, as would a bank The risk of default on the credit is borne by the NGO fund and not by the end users Finally, the technical partner at no cost provides the maintenance training and support

This model is particularly interesting because it blends a financial incentive, the NGO fund's credit, with technical assistance and also mitigates the financial risk to the end user, by having the creditor bank use the NGO as a guarantee mechanism

4 4 Model 4 Lease

This financial model is in effect the inverse of Model 3, with the technical partner assuming the role as financial intermediary in the project as well as the role as distributor/manufacturer of the energy systems The commercial transaction is based on the assumption that the current energy needs of the end user are currently being met at a higher monthly cost than the lease offered In addition, the arrangement may offer substantial benefits in that the lessor retains ownership of the equipment and hence responsibility for maintenance and equipment replacements Indeed, some sources argue that this offers the lowest costs to the end user, compared to leasing from an intermediary or other arrangements

In the case of a pilot project being undertaken by *Soluz* and *Industrias Electricas de Bella Vista* (IEBV), a solar energy leasing company has been created with capitalization of US $700,000 provided by various equity investors, and leveraged with US $1 3 million in debt to develop an initial base of 5,000 customers Customers pay US $10/month per unit under long-term lease agreements, generating cash flow for the energy leasing company to cover debt service as well as provide a reasonable return on equity to investors

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With the exception of a limited number of enterprises that are already in operation (such as Soluz), this model is attractive due to the strict financial covenants governing the transaction (i e the lease) Some proponents of the model argue that new risk-capital resources are still lacking for this type of ventures In this case, the fresh capital needs to be provided either by private investors, investment banks, venture capitalists or multilateral institutions, once such new resources can be channeled to qualified enterprises in key developing markets, proponents argue, the powerful cost advantages to end users of energy services leasing will propel growth in the industry [6]

It is unclear at this point whether subsidies will be necessary for the formation of a more mature energy leasing market. While this may not be necessary at the level of the leases contracted with end users, it may be required at the level of the financing provided to the energy services company In the joint "concept paper" for the Solar Development Corporation (SDC), E&Co and the World Bank write, "SDC would provide financing to PV businesses for equity investments, working capital and, indirectly, for end-user credits This finance is seen as pre-commercial and parallel to commercial financing Financing will not be on a grant basis but will be tailored as close to commercial terms as possible "[7] This would suggest that a concessional element will be necessary to get such financial and energy services companies started, however, this particular model may prosper without this support

4 4 1 Solar Rural Electrification in Indonesia

The Solar Home Systems (SHS) Project in Indonesia provides another example of a Model 4, vendor lease program, with one variation in that a Global Environment Facility (GEF) grant helps buy down the cost of financing for the end users This ambitious project intends to provide solar power to roughly 1 million end users in three un-electrified markets in Indonesia (Lampung, West Java, and South Sulawesi), with 200,000 50 Wp SHS units, totaling 10 MWp at a cost of roughly US $118 1 million, equivalent to US $11 8/Wp [8]

The model is based upon a direct sale of SHS to end users by dealers, who will provide credit to the end users and sign lease-to-own contracts, referred to as "hire-purchase-contracts" (HPCs) The SHS dealers will extend leasing of up to 4 years to the end user households, with the term depending on the dealers' credit analysis

Typically a SHS system will cost approximately US $500 per household The components of the SHS are relatively straightforward, including a photovoltaic (PV) module, balance of system (BOS) components, including battery to store energy, battery-to-charge controller, lamps, wiring and switches, and mounting hardware

Financing is envisioned as a combination of a US $90 down payment by the user (18 percent of the total investment cost), a GEF grant for US $125, or 25 percent, and US $285 in financing over the term of the loan (57 percent of the total investment cost) Hence, each investment is composed 57 percent debt and 43 percent equity, including the GEF grant Thus, if the end user is to finance US $285 over a four

[6]See for example E&Co and the World Bank "Solar Development Corporation Concept Paper " mimeo

[7]Ibid p 5

[8]It should be noted that Wp (Watt peak) costs are not comparable to typical generation costs used in industry as benchmarks (i e US $/W installed)

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year period, he or she will be paying roughly US $0 20 per day in debt service on the system, in addition to the down payment, which in nominal terms is about US $0 06 per day The total cost to the user is therefore approximately US $0 26 per day In this analysis, no implicit discount on the payments is assumed, however, in a more accurate financial analysis the nominal cost to the user would have to be escalated at the rate of inflation or some other suitable discount factor

Rural market research by the World Bank has shown a high willingness to pay for solar electricity The studies suggested that the top quartile by income in the Lampung province spends US $6 67 - US $15 per month, or US $0 22 - 0 50 per day, for energy Spending by another 40 percent of the same sample is in the range of US $3 33 - US $6 66 per month, or US $0 11 - US $0 22 per day Grid-connected rural households, by comparison, have monthly electric bills in the order of US $1 or US $0 03 per day These end users will typically have lighting requirements, a radio and a TV

It is difficult to estimate *a priori* the cost of energy in terms of US $/kWh However, estimates of grid extension costs are in the range of US $0 118 - 0 15 per kWh By comparison, it is likely that at approximately 15 each household per month or 0 5 kWh per day will consume kWh of solar-generated electricity This yields a cost of US $0 52/kWh or about three times the cost to extend the grid

This simple analysis suggests that the GEF grant subsidy is filling an important gap in this financial structure While the willingness-to-pay surveys indicate a much higher threshold than the *nominal* US $0 25/day calculated here, therefore implying that there is demand at that price, the grid-extension scenario, or "hidden" threat, has an implied cost of US $0 03/day In practical terms, this scenario is not really an option as the grid is unlikely to reach these users in the near term Therefore, the grant assists a venture which would otherwise cost the end user approximately 25 percent more, and commensurately less attractive than the grid

More importantly, without the GEF grant component, the SHS financing would have to be extended to a maturity of up to eight years, and these terms are simply unavailable to the SHS dealers through the PBs in-country Hence, the GEF grant allows the amortization period to be shortened and therefore be consistent with current financing conditions

Furthermore, this model is interesting because of the risk allocation implicit in its design For example, the end user does not assume any financial risk, rather it is the SHS dealer that assumes most of the risk by borrowing from the Participating Banks (PBs) and assuming the liability of repayment It is assumed that the credit analysis by the PB will ensure adequate business plans and sufficient demand to make individual schemes sustainable, however, ultimately it is the SHS dealer who assumes the risk of non-payment by the end-user Given typical energy expenditures already incurred by the rural households, this would seem to be a small risk Likewise, any major *force majeure* event (i e flood) that would seriously impair any end user's ability to pay, poses a risk that is passed on to the dealer

To mitigate the risk of non-payment, the SHS dealer must target the highest quartile market and undertake the distribution of SHSs accordingly It seems unlikely that this model will reach all end users in the market survey, but given the household energy expenditures, it is likely that the SHS dealer will be able to capture roughly 50 percent of the potential market, as long as there is a sufficiently "high volume, low margin" business

4 5 Model 5· Concession

The final model presented here is introduced mainly to highlight a particular scheme, which has similarities to Model 2 (Project Finance) and also Model 4 (Lease) The model is simply a utility mini grid concept with the key participation of the private sector The model is best illustrated through an example

Argentina has implemented a rural electrification program based on a public bidding mechanism that provides a variation on Model 4 The Argentine model[1] encompasses mini-grid systems as well as off-grid projects, depending on the characteristics and requirements of the region offered for bid (see Figure 5) However, it does not appear that the mini-grid projects would necessarily involve establishment of a new system, instead, the bidders would be competing to operate, maintain and expand already-established systems Concessions are awarded based on the best technical offer and the least amount of subsidy required per rural consumer served, and would include a guarantee of territorial exclusivity Proposed tariffs are approved by the Secretariat for five years, at which time they could be renegotiated

In this case, the Energy and Transportation Secretariat's "Electricity Supply Program for Small Rural Markets" issues a call for proposals by private entities to provide electric services to specified areas under a concession regulated by the Secretariat The concession lasts 45 years, with the possibility of renewal after 15 years The concession applies to provision of basic electricity service to consumers of up to 90 kWh/month for mini-grids with service 24 hours a day, or up to 60 kWh/month for users with reduced service (five hours daily), or household or other off-grid services Consumers of more than 90 kWh/month could not be served under a concession with territorial exclusivity or access to a subsidy More than one company may be awarded a concession for one or two of these service "types," for example, in Jujuy province, one company has been awarded the "dispersed" market while another has been awarded the concession for operation of the existing rural systems

The subsidy will be paid out of the Tariff Compensation Fund (*Fondo de Compensacion Tarifaria*), and will be keyed to the density of users in a given concession area While concessionaires will be responsible for investments made to provide service to new users, they will be eligible to receive connection fees from the Secretariat, although these will be paid out according to a sliding scale, with payments declining with each year of the concession The scale consists of a multiple of monthly tariff payments to which the concessionaire would be entitled for each new user served In the first year, the multiple is set at 40, then 30 for the second year and finally 20 in the third year and thereafter

The issue of financing for the concessionaire is not a direct concern to the Secretariat, since it evaluates proposals that presumably include a financing plan based on the capabilities of the bidders For the purposes of the model, it is assumed that banks and/or other sources of financing will work with the concessionaire according to the relevant, privately negotiated agreements

To date, concessions have been awarded to provide service in the provinces of Jujuy and Salta, and similar bid packages are being prepared for the provinces of Rio Negro, Santa Fe, and La Rioja

Figure 1a
Model 1 Cash transactions with / without cost sharing

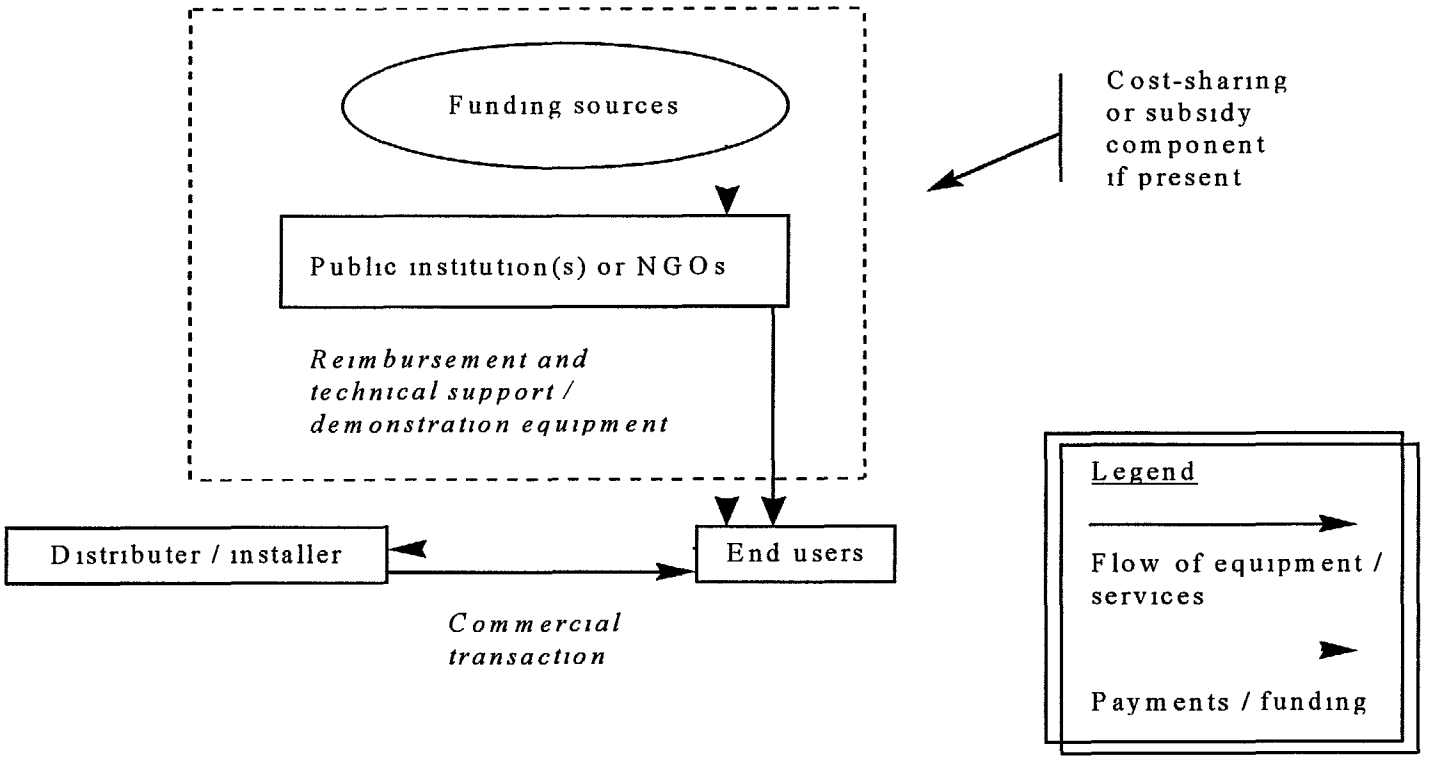

Figure 1b

Model 1 Subsidized project cost-share, no credit Case(s) FIRCO

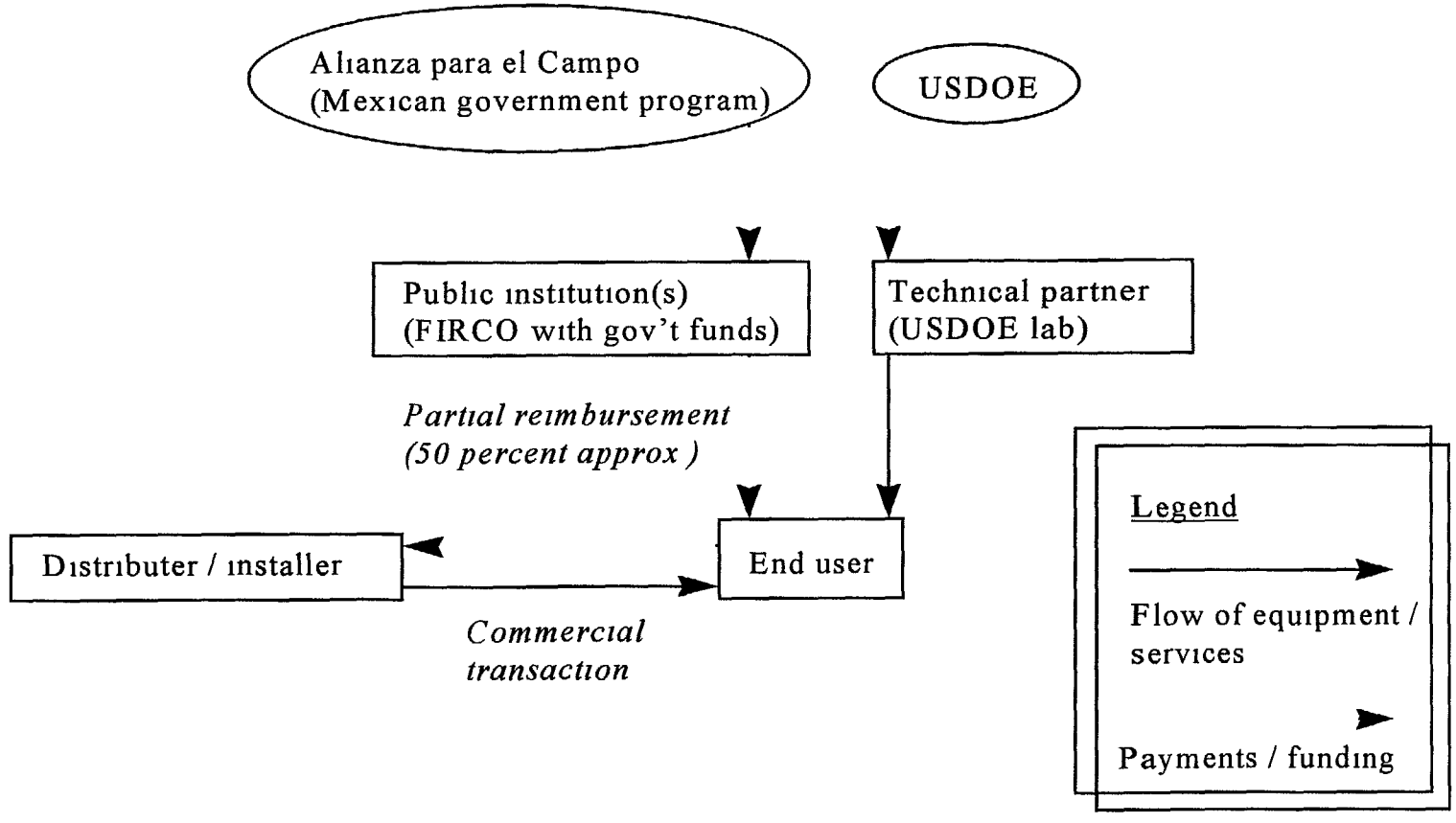

Figure 2a

Model 2 Project finance structure, community cooperative / enterprise or other entity

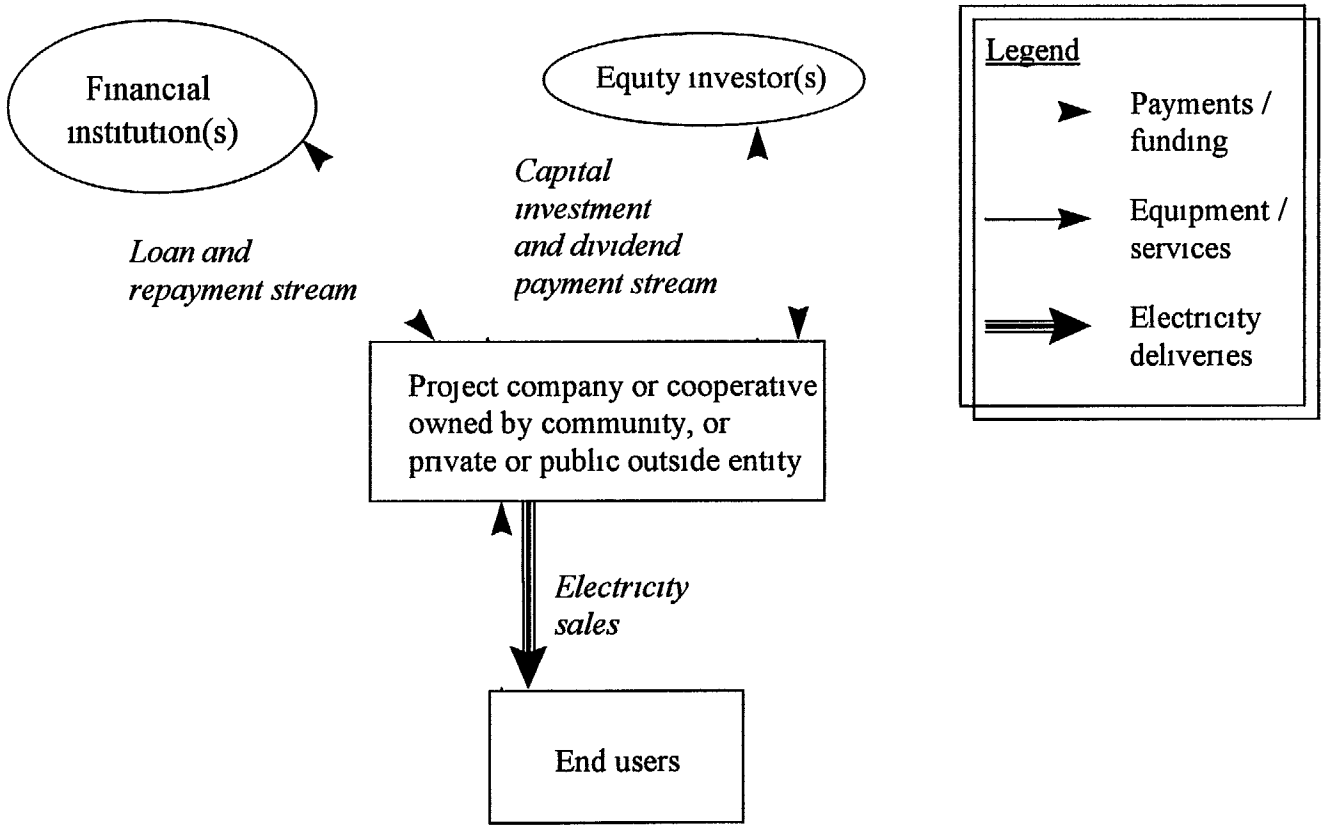

Figure 2b

Model 2 Subsidized credit, project finance structure community cooperative

Case(s) Peru micro-hydro Chalán village, Peru

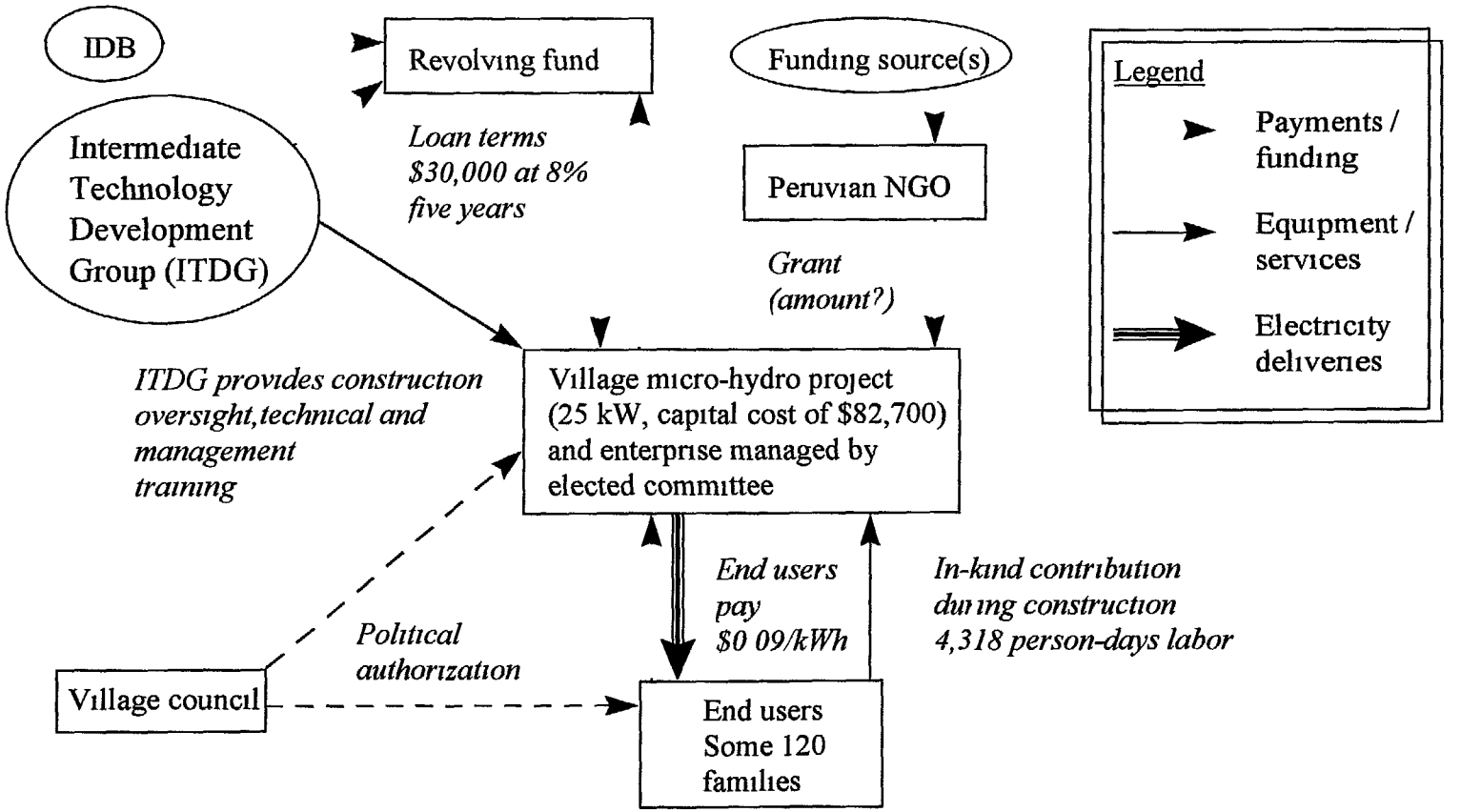

Figure 2c

Model 2 Subsidized credit, project finance structure community co-operative

Case: Andhi Khola Small Hydropower Project, Nepal

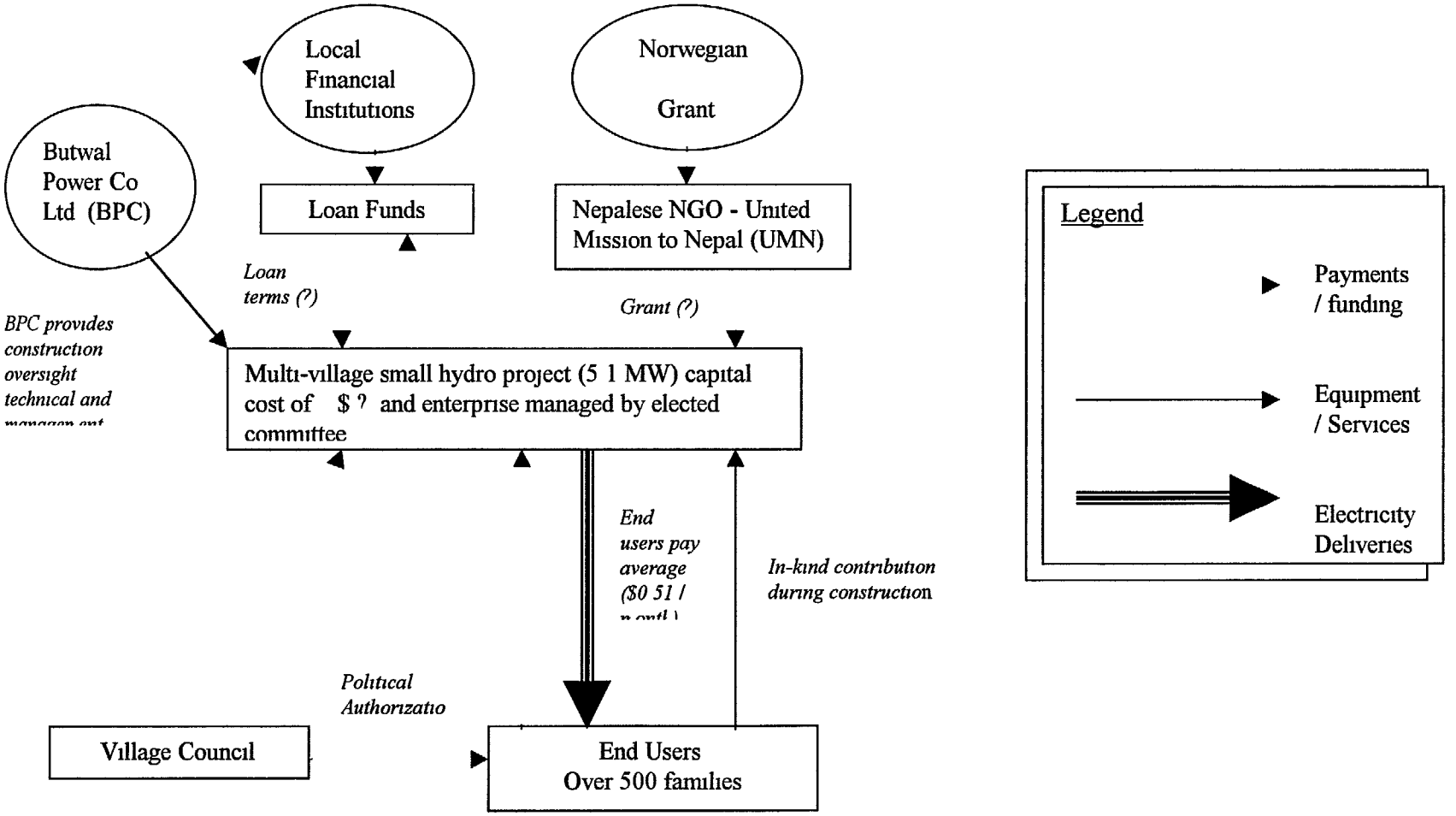

Figure 3a

Model 3 Customer financing by loan or lease

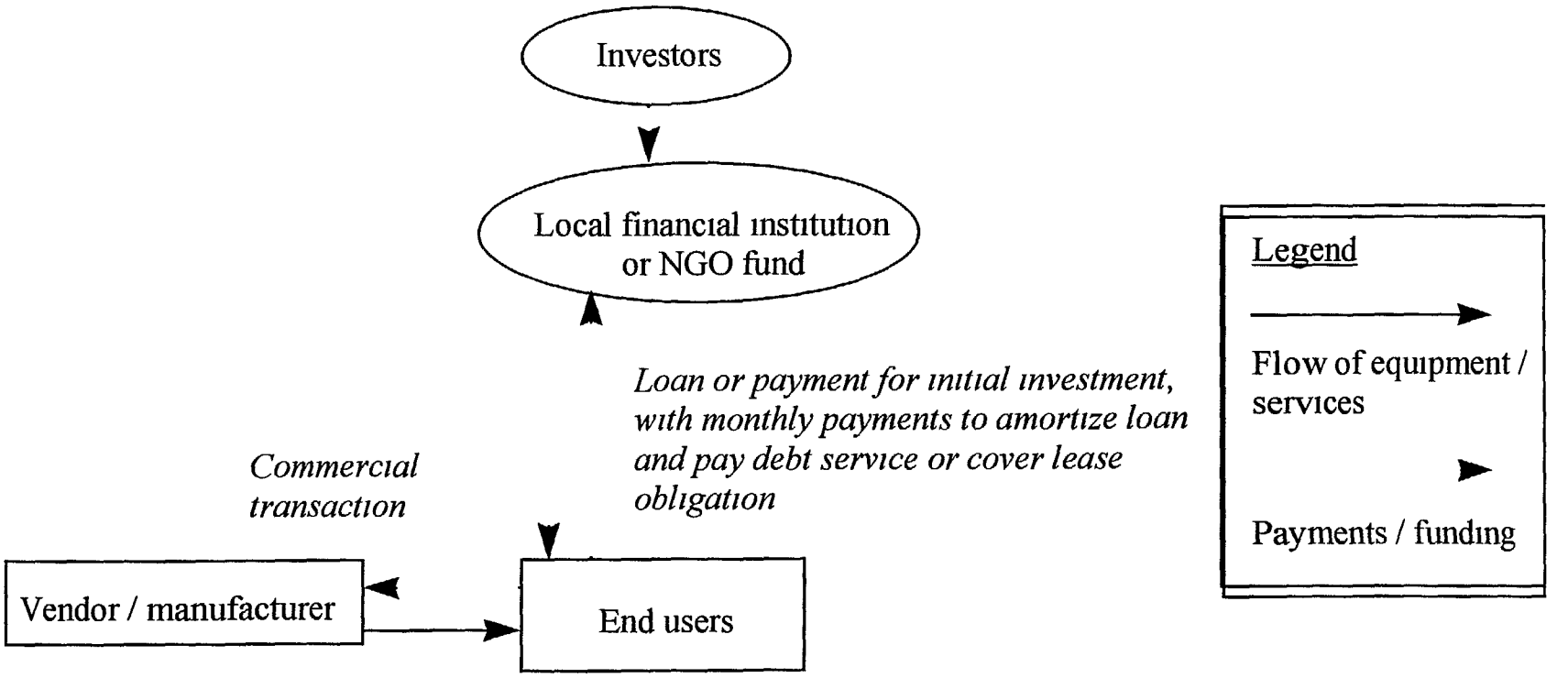

Figure 3b

Model 3 Unsubsidized household installation through lease-to-own financing

Case(s): Enersol Dominican Republic

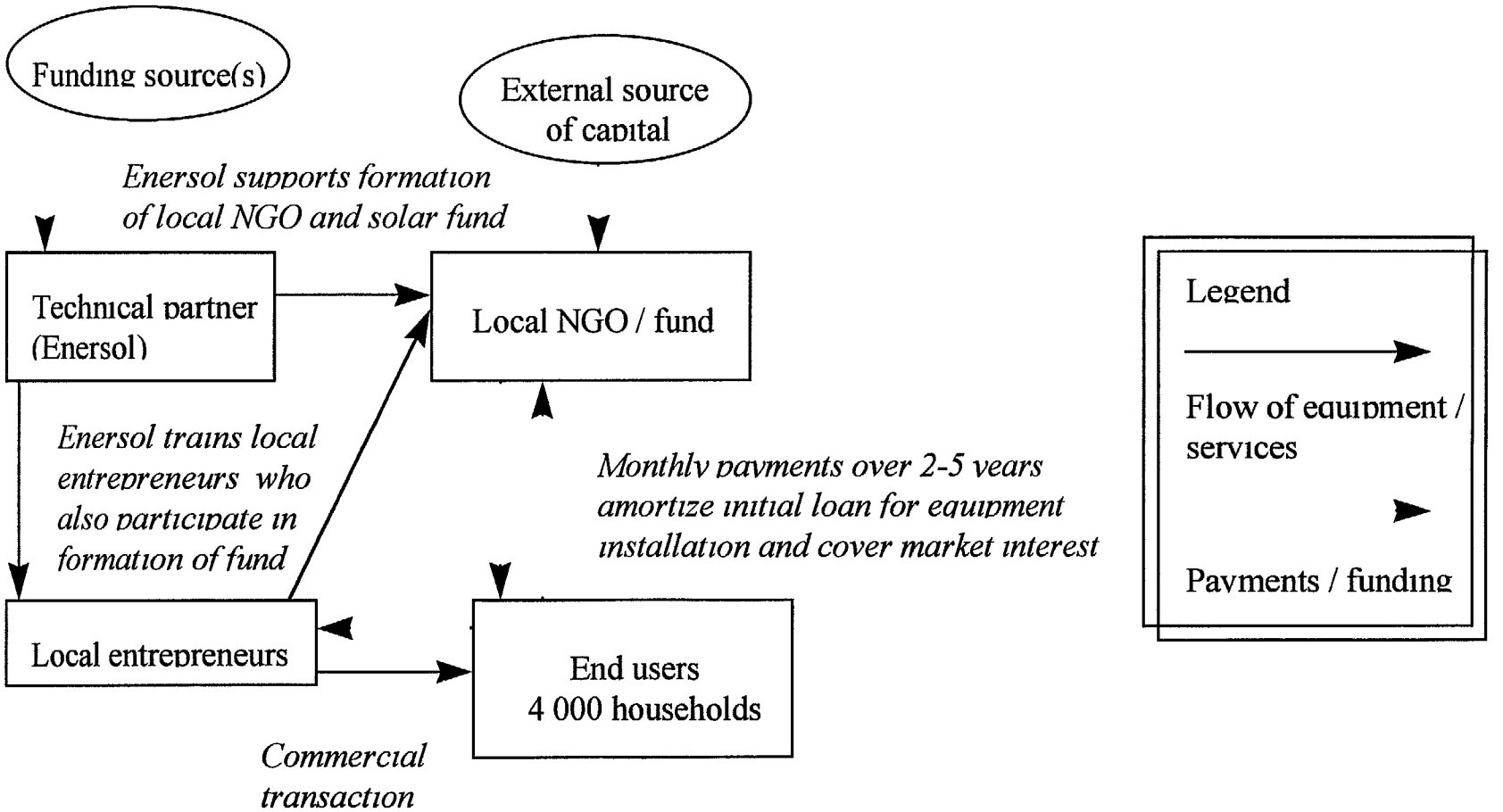

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Figure 4a

Model 4 Vendor financing under lease and service contracts

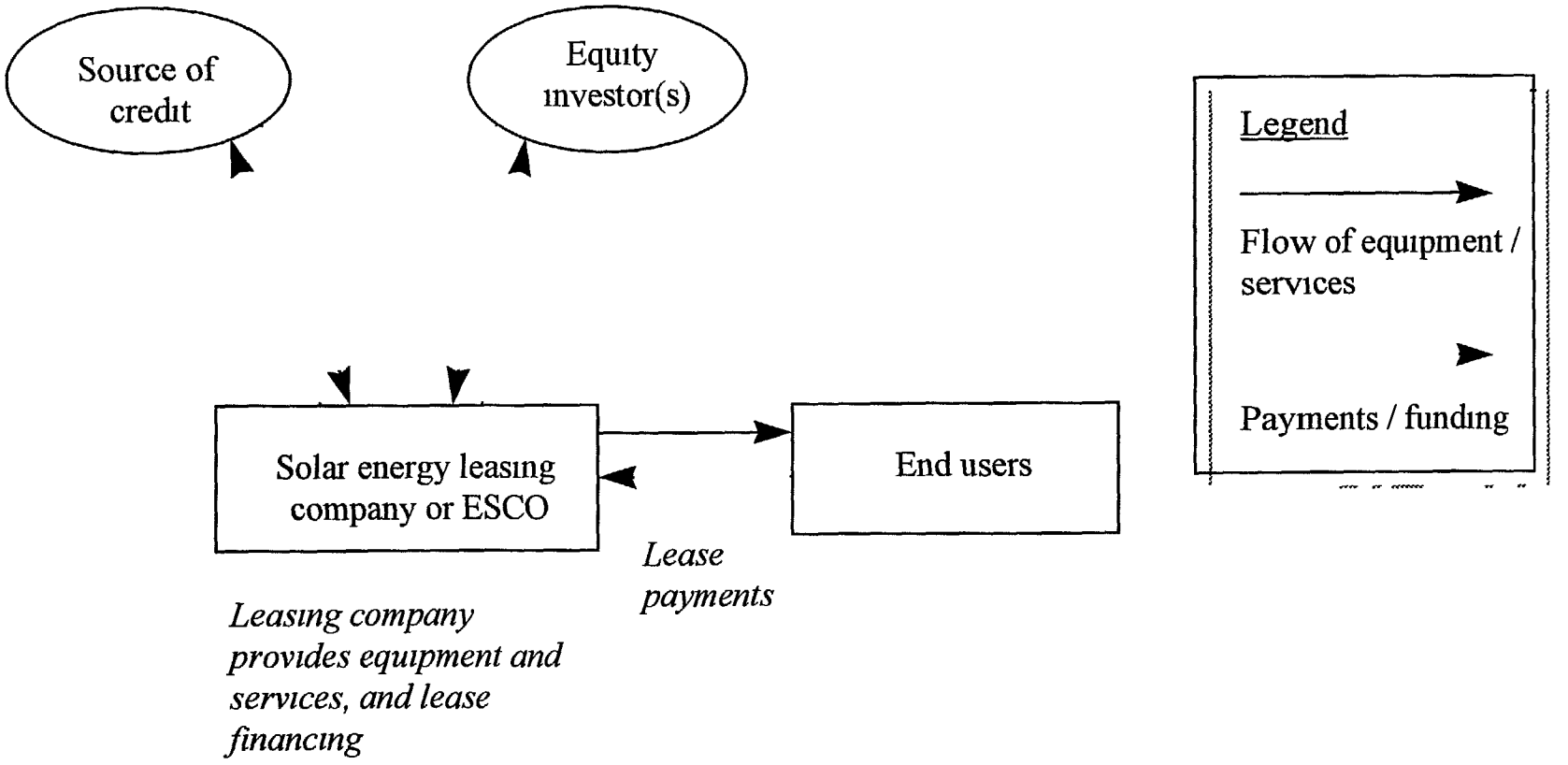


Figure 4b

Model 4 For-profit household and village system installation under lease and service contracts

Case(s) Soluz / IEBV Dominican Republic (Experimental stage)

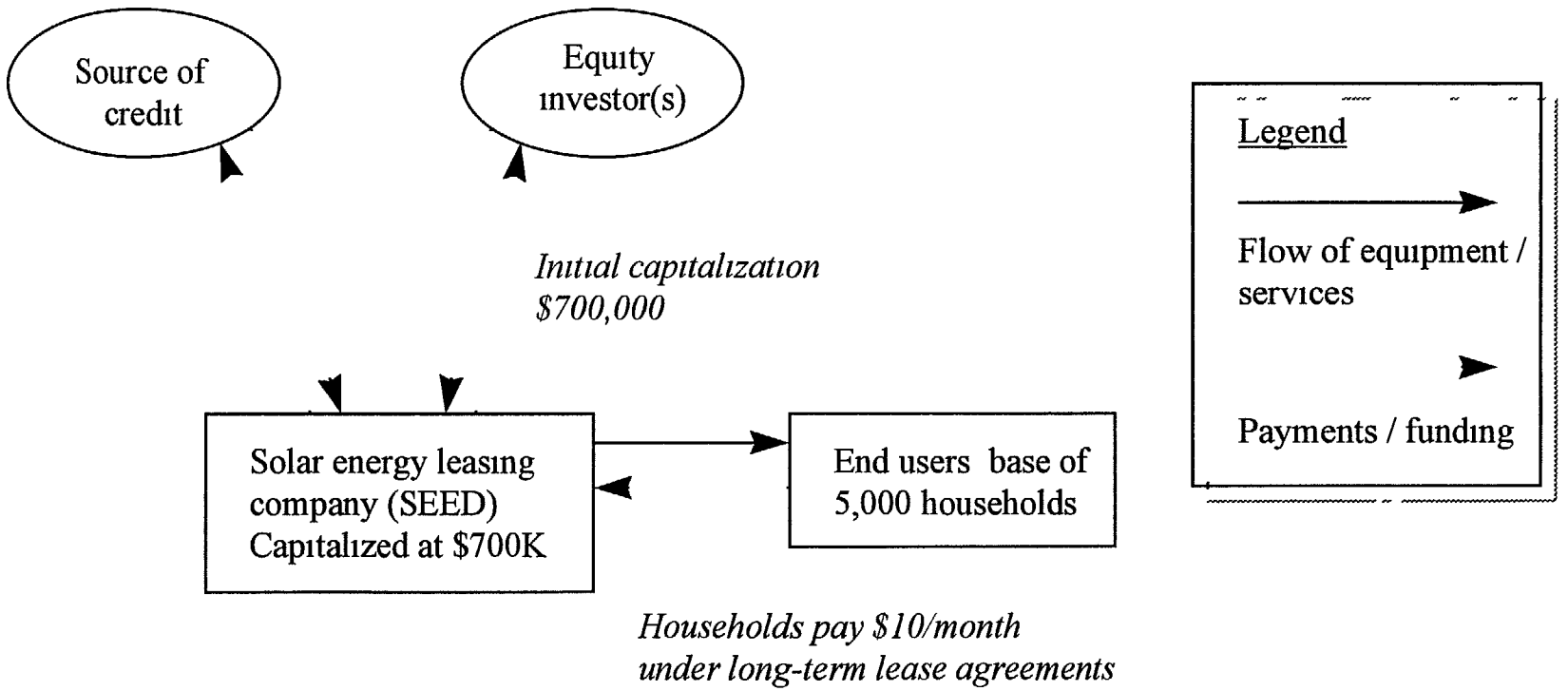


Figure 4c

Model 4 Vendor financing of household units under lease-to-own contracts, with subsidy

Case Solar Home Systems Project, Indonesia

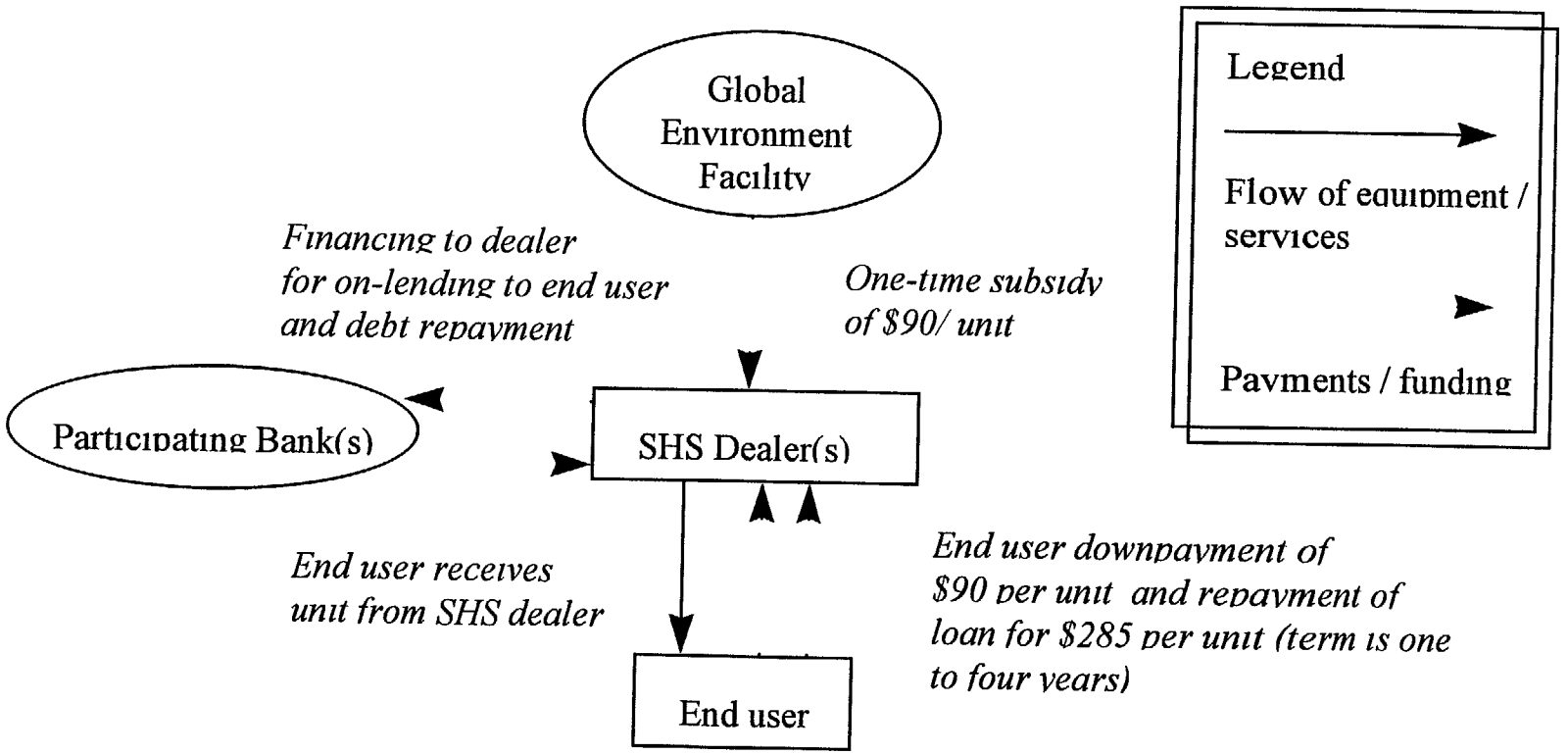
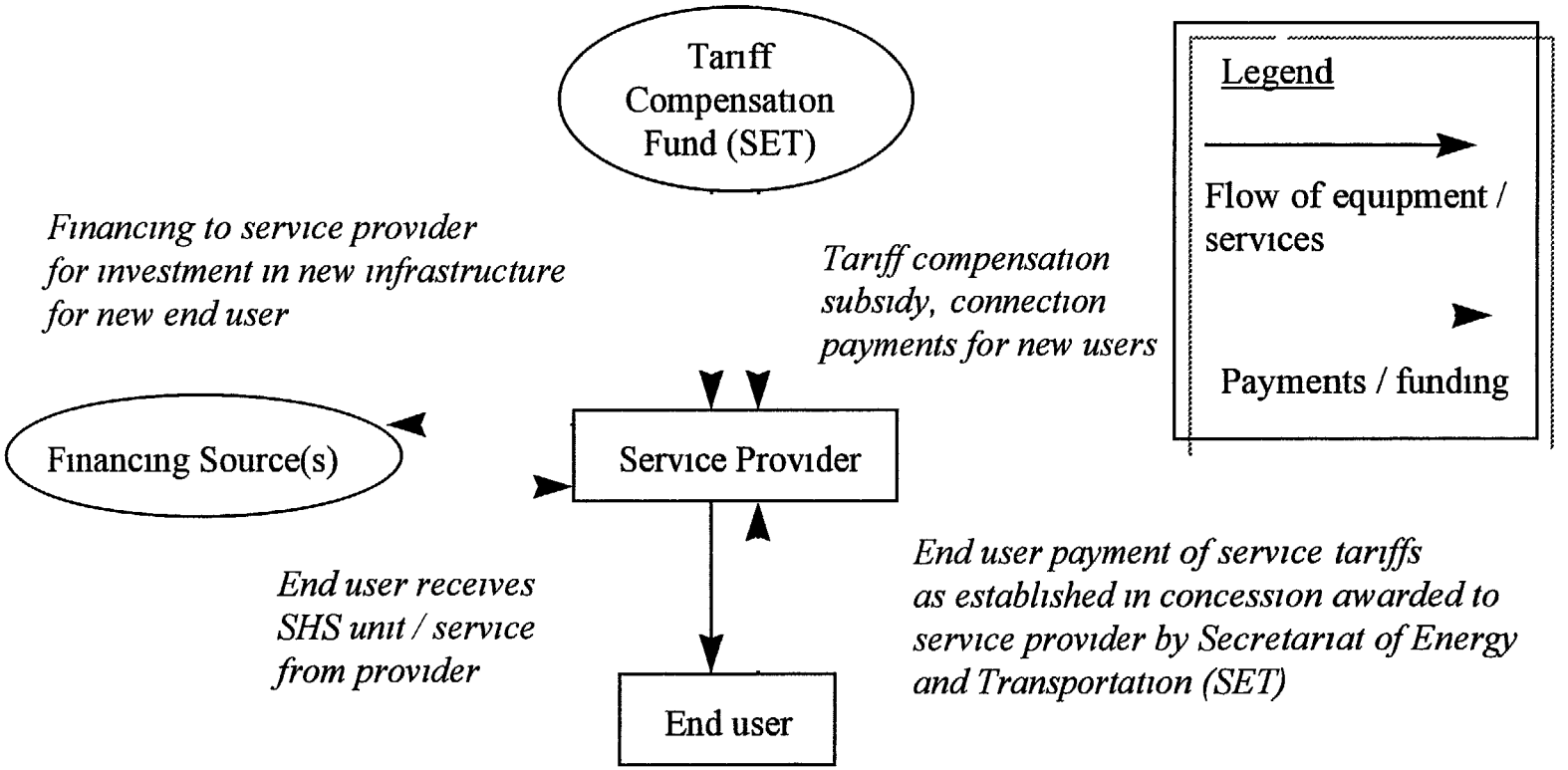


Figure 5

Model 5 Concession of electricity services to private providers, with subsidy

Case Electricity Service Program for Rural Communities, Argentina



5 Financing Models for Rural Electrification – Grid Extension Projects

5 1 Model 2. Project Finance – Nepal

A project executed in Nepal by the United Mission to Nepal (UMN), an NGO, provides an interesting case of grid-extension coupled with use of local hydroelectric capacity to provide electricity to a series of remote villages The financing structure of the Andhi Khola hydroelectric project is similar to that depicted in Figure 2b above where subsidized credit in the form of a Norwegian grant was used to leverage debt from financial institutions and the cash flow generated by the project's sale of electricity serving as the source of debt repayment The Andhi Khola project received all "equity" financing through a subsidiary of the UMN, the Butwal Power Company (BPC), which, in turn, received external grant funding for the project BPC is a public utility operating and managing hydroelectric power projects and associated distribution systems

UMN built a 5 1 MW run-of-river hydro station and extended a transmission line to a nearby village that lacked electricity The project is experiencing good financial performance (in terms of covering its operation and maintenance costs but without the need to amortize its capital costs) and customer satisfaction

The customers served include 500 households in six villages, located at a distance of up to 5 kilometers from the national grid Annual incomes are less than US $500, with many end users able to purchase only enough electricity for basic needs, amounting to about US $1/month

BPC provided grid extension at a cost of roughly US $200 per consumer using light weight tapered galvanized poles, which could be manufactured locally in sections, to support a 1 kV transmission line, which is higher than the typical 400 or 230 V system The line cost approximately US $4,000 per km, much lower than the normal costs of over US $10,000 per km and total connect costs of over US $600 per customer

The installation does not use meters to monitor consumption, rather, BPC charges a flat fee of US $0 80 per month for a base demand of 50 W A user group provides local organizational and institutional support, arranging for bill collection and depositing the proceeds into BPC's bank account, and handling maintenance and services to the system under direction from BPC

In addition, BPC's tariff scheme establishes an interesting incentive to reduce the villagers' use of fuel wood for cooking BPC offers an electric cooking option for US $2 20 per month, obviating the need to gather fuel wood, an activity that has been a major contributor to deforestation in Nepal

The Andhi Khola project has employed major technical and organizational innovations in the following areas intermediate 1 kilovolt distribution voltage, transmission and distribution line poles, low-wattage cookers, power-based tariff and metering, wiring harnesses, users's organizations and motivators

5 1 1 Intermediate 1 Kilovolt Distribution Voltage

To reduce distribution costs, a study undertaken by the BPC concluded that an intermediate distribution of 1 kilovolt (kV) would be the least-cost approach for supplying the project's service area The rationale was the by using this higher voltage rather than the standard 0 4 kV, line loading (as measured

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in kilowatts per kilometer) could be increased by a factor of nearly six In other words, six times more load could be imposed on the same line without increasing the percentage voltage drop Furthermore, this voltage permits the use of insulated conductor and components commonly used for low voltage (400/230 volts) applications at its maximum voltage rating, thereby exploiting the advantages of higher voltage without the need for additional costlier insulation

5 1 2 Transmission and Distribution Line Poles

The project designed tubular steel poles, used predominately to support primary and secondary distribution lines, and steel lattice towers used as transmission structures Both are fabricated and galvanized locally These can be carried by porters to the site and then assembled with simple tools To reduce the costs of distribution within a rural area even further, maximum use is made of wooden poles contributed by the villagers and existing trees and buildings

5 1 3 Low-Wattage Cookers

To reduce peak electricity demand attributable to cooking and to make use of the underutilized capacity commonly found in rural systems (manifest ultimately as a low load factor), the project has researched several designs of cooking appliance It has developed and is promoting a low-wattage cooker for heating water, cooking rice, and preparing stews

5 1 4 Power-Based Tariff and Metering

The availability of hydropower-based electricity at a low marginal cost and the desire to use energy for low-wattage cooking prompted the project designers to implement a power-based (kilowatt) tariff to avoid the equipment and operations costs associated with an energy-based (kilowatt hour) tariff Any of several types of current limiting devices can be used to limit the maximum consumption at each home These include older electro-mechanical devices, thermistors, miniature circuit breakers, and electronic current cutouts These are less costly than meters Furthermore, because the tariff is based on the installed capacity of these devices, periodic meter readings are not required Bill collection and accounting are thereby simplified

5 1 5 Wiring Harness

A wiring harness for housewiring has been developed which can be prefabricated in a controlled setting where it is easier to ensure higher quality workmanship The harness can be installed with minimum training and at minimum cost It also results in a product less likely to pose a fire or safety hazard Several standard configurations are available

5 1 6 Users' Organization

While wishing to provide electricity to outlying areas, the BPC did not wish to significantly increase the burden it would place on itself, nor was it willing to compromise on enforcement of its regulations The project therefore gave BPC an opportunity to test the effectiveness of relying on electricity user's organizations to assist it in its task of rural electrification The users' organizations would maximize local manpower and material inputs in the construction, maintenance, and management of village-wide

systems They would further stimulate self-reliance and local initiative and ensure villager commitment to the project They would also reduce the cost of implementation and operation for small village systems and place responsibility for the financial success of the project on the villagers (by having them reduce operational costs, follow up with delinquent consumers, and ensure that theft of energy was minimized) Such an approach allows BPC to focus on the generation and transmission of electricity – more centralized functions which it is better qualified to undertake

5 1 7 Motivators

In an attempt to ensure that most households in its service area have access to electricity in their homes and safely use it to their benefit, BPC has hired and trained a team of "extension agents" commonly referred to as "motivators" Through drama presentations, committee meetings, and household visits, motivators carry out the following activities

- Increase awareness among villagers who will have access to electricity of potential uses to which this resource can be put
- Assist in deciding to what level of consumption consumers should subscribe
- Share ideas about how best to electrify their homes
- Respond to other questions potential consumers may have concerning this new commodity

5 2 Model 2 Project Finance – Brazil

Recently, Idaho Power Resources Corporation (IPRC), an investor-owned electric utility with generation, transmission, and distribution services in the northwest United States, made a decision to expand its business interests to non-U S markets IPRC was considering many types of investments, from traditional rural electrification investments through participation in privatization offerings to hydroelectric power development projects After surveying many possibilities in Asia and South America, IPRC decided to develop a business plan for Brazil and other South American countries IPRC's strategy, however, was not focused on renewable energy rural electrification only It's strategy has evolved into an integrated plan that would include the following elements

- Establish a presence through participation in buying a distribution utility, most likely in collaboration with other partners
- Develop name recognition thorough the Brazil-based utility business
- Pursue private power hydroelectric opportunities, to both rehabilitate abandoned hydroelectric facilities and/or to build new generation stations
- Expand rural electric service via grid extension in the concession area of the distribution business and via renewable energy systems in other non-concession areas, as the law and opportunity provides

The IPRC strategy, then, is not directed specifically at rural electrification programs using renewable energy technology as its principal source of business IPRC is gaining market share in one segment of the market through a subsidiary vender system packager, Applied Power Corporation (APC) APC has successfully bid on a number of small and large equipment solicitations, and is building name recognition for itself and its parent, IPRC

The model that IPRC is developing is completely consistent with their history as an electric utility corporation IPRC intends to establish a place in the electric energy market for itself that crosses some boundaries, but in such a way that they can establish benchmarks for rate of return on a sufficient volume of business to justify the

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venture The model they are using will likely have a high degree of impact, but only after they have gone through the paces of establishing their electric distribution utility business

6 Issues Associated with Financing of Small-Scale Hydropower Projects in Nepal

6 1 Willingness to Pay, Full Cost Recovery and Efficiency Issues

As briefly discussed in Section 3 1, willingness to pay is a key element for the success of small-scale power projects Several of the case studies cited have demonstrated that rural inhabitants are willing to enter into financial obligations when it suits their interests In the case of community systems and grid-extension projects, experience in numerous countries emphasize the need to ensure full cost recovery and financial sustainability as a crucial ingredient to the long-term viability of projects

Focusing on demand represents a radical departure from the traditional preoccupation on the supply of services with little attention paid to the user The lack of a demand orientation results in dissatisfied consumers and leads to wasted investments, lost economic production, and low willingness to pay for services Essential actions for achieving such a demand orientation include, *inter alia*

- Electricity must be provided by demand driven institutions Demand orientation means that all processes within an organization are responsive to consumers This responsiveness must drive decisions such as what to deliver, what technologies to employ, and how prices should be set
- Service demands differ widely across cities, regions and industries along the dimensions of accessibility, capacity, diversity, quality, time, condition, and price The traditional focus has been on capacity, but demands are increasingly shifting to other service dimensions Delivery plans must be in place to meet demands that differ along each of these dimensions both within and across cities
- Power sector investments should be made in cases where a known demand for services exists
- Demand should be managed through properly set prices
- Services are best provided to low income users by determining specific services that are in demand and identifying cost effective measures for meeting these demand
- Better infrastructure is associated with better economic growth but infrastructure is best used to accommodate economic activity

Power sector improvements are unlikely to stimulate more rapid growth, except for unusual circumstances where all elements of growth are in place except for adequate infrastructure Nevertheless, appropriate infrastructure is imperative to a strong economy Infrastructure investments will have the greatest effect on economic growth when a minimum complement of services is available, including transportation, water, electricity, telecommunications, and other services Higher quality and more diverse services should be targeted to specific areas with more sophisticated users

6 1 1 Improved Infrastructure Must Come from Increased Efficiency in the Production of Services

The goal here is to deliver services at the lowest possible life cycle costs for society In the past, however chosen technologies often have failed to offer the lowest cost and highest output, in part because the best long-run decisions have not always been made Existing deficiencies may result either from some aspect of physical delivery (for example, poor technology or inadequate operation and maintenance) or from the institutional structure (poor financing or inability to delineate demand, for example) In many cases, overcoming these deficiencies offers the greatest potential for better services

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For example, improved capacity can come from strengthened maintenance practices that reduce water and electricity losses The life cycle costs of an under maintained system often are several time greater than those of a properly maintained system Actions that can make infrastructure service delivery more efficient include, *inter alia*

- Service delivery technologies should be selected with the goal of meeting specific demands of users and facilitating maintenance Other factors in the choice of technology include the existing technology and configuration of the urban network, costs, and service delivery conditions
- A maintenance program must be developed that results in the maximum benefits from the infrastructure system, while delivering services at the least cost Technologies and service delivery institutions must have the ability to carry out maintenance Service delivery institutions must be given proper incentives to perform maintenance rather than rebuild systems Resources must be set aside to finance adequate maintenance Self help can be an important means of maintenance, particularly in low income areas, but will only occur if proper incentives exist
- An inventory of existing infrastructure services should be maintained for evaluating current service delivery and for planning purposes The inventory also is important because the existing physical and organizational structure will heavily influence how expansions of urban services can be undertaken
- Service delivery organizations must be held accountable Examples include creating competitive pressures and making agencies responsive to users

6 1 2 Adequate Service Delivery Cannot Occur Without a Proper Financing System and a Satisfactory System Will Require that Services are Properly Priced

Properly set prices will generate sufficient resources to deliver services (in most cases), will ration consumption to the appropriate levels, and will serve as an indicator of demand Elements of a proper financing system include, *inter alia*

- User fees should be set at marginal cost Connection fees should be imposed as well in the cases of electricity, telephones, and water Most services can be fully financed with user fees, though some services such as urban mass transit and sewerage probably require some subsidy
- Newly imposed user fees or significant increases in fees should be accompanied by improvements in service delivery
- User fees should be earmarked for service delivery
- Equity should be integrated into the user fee system through special programs for those least able to pay Lifeline rates and rising block pricing structures are examples of ways to assist lower income consumers
- Private financing schemes such as concessions, and to a more limited extent build-operate-transfer concessions, can be used to obtain private financing and the benefits of privatization However, in most cases, governments will be expected to continue to bear some of the risks of service delivery

6 1 3 Costs Can Be Lowered and Demands More Effectively Met by Integrating Competition into Service Delivery

Private sector production and delivery of services through devolved governments appear to be the best means for interjecting competition Some aspects of nearly every service can benefit from competition, though variation exists across services and cities Increased use of competitive forces shifts the Central

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government's role to an emphasis on regulation to ensure that producers deliver reliable services, quality outputs, and competitive prices Some specific actions to encourage competition include, *inter alia*

- Central government must create an environment where competitive pressures can be brought to bear Private sector production of services should be actively encouraged Privatization can be most effective for electricity distribution Free entry and exit of firms into other infrastructure markets should also be encouraged In many cases where privatization is inappropriate, creativity is necessary to encourage private participation
- Regulatory agencies must be enhanced in order to maintain quality and reliability, prevent payoffs and collusion, and control prices Skilled staffs with sufficient regulatory authority must be developed Regulations that inhibit effective business practices should be discarded Where possible, regulations that limit competitive pressures, such as those preventing competition with public service providers, should be eliminated
- The choice of whether to use public or private sector producers should be made after consideration of the effects on quality and reliability of services, potential for corruption, and an analysis of costs that include contracting, regulating, and monitoring private firms

6 2 Access to Resources to Employ the Unsubsidized Project Finance Model

To provide additional capacity in Nepal's power sector to meet domestic demand for electricity, hundreds of millions of dollars are required in the medium term[1] for small-, medium- and large-scale projects However, the magnitude of the resources is unlikely to come from multilateral lending agencies, bilateral donors or other public agencies Making these projects attractive to private capital is the only means of raising this magnitude of money But at present, non-recourse or limited recourse financing for private sector energy projects in Nepal is lacking and the country's weak and inefficient capital and stock exchange markets constrain the availability of adequate financial resources particularly for medium-term project financing

One potential source of funds for the project finance model as depicted in Figure 2a is the World Bank's proposed Power Development Fund (PDF) The PDF has been designed to supplement private and other public financing available for the development of Nepal's private sector It will provide long-term debt financing for power projects in order to overcome i) the lack of sufficient debt financing for power projects, ii) the inadequate maturity of available debt financing, and iii) the need to provide comfort to private investors wishing to become involved in "first time" projects Given the thinness of Nepal's commercial debt market which impedes the development of private projects financed on a limited recourse basis, the PDF would allow potential investors to access long-term financing thereby offering the private sector the opportunity to invest in and own, operate and maintain new power facilities Only projects that have fulfilled the necessary licensing requirements of the EDC and which have received clearances from the Ministry of Population and Environment would be allowed to solicit financing from the PDF

The PDF would initially be a pooled fund contributed to by the International Development Association (IDA) with the ability to solicit official financing sources, together with reflows of debt service payments made by borrowers The PDF would not be a major provider of funds for any one project, rather it will co-finance projects

[1]According to the December 1997 Load Forecast Report prepared for the Nepal Electricity Authority by Norconsult the FY 1997 actual peak load for the domestic market was 293 MW on average The energy required by FY 2012 is projected at 960 MW of peak demand rising to 1 654 MW of peak demand by FY2020

with international and domestic lenders, including commercial banks, investment funds, export credit agencies the International Finance Corporation, and other multilateral institutions The aim of the PDF will be to act as a catalyst to maximize the inflow of private capital

6 2 1 The Power Development Fund "Second Window"

Of particular relevance to the financing of small-scale projects is the PDF's "second window" The "first window" would be for projects that involve generating facilities greater than ten (10) MW Under the "second window", the PDF would provide direct funding to eligible project sponsors and/or enter into co-financing relationships with qualifying Nepalese financial institutions (styled as "Participating Credit Institutions") in order to address local financing barriers to private power development Such an approach would provide incremental financial support as needed to create partnerships with Participating Credit Institutions (PCI) to enable them to provide pooled financing comprising both PDF and PCI resources to private companies promoting projects involving grid connected generating stations of ten (10) megawatts (MW) and below or isolated rural power systems licensed by EDC Loans to project companies for these smaller projects would be in either local or foreign currency at maturities justified by the economic life of the project However, it is unlikely that maturities of more than fifteen (15) years could be justified by smaller projects Twenty (20) percent of the total amount of IDA's contribution to the PDF will be earmarked for the second window

During the first two years of operation, it is envisaged that the PDF would offer long-term subordinated loans However, consideration will be given to providing take-out financing, stand-by financing, and other financial products and services on a case by case basis for projects sponsored by qualified project companies and for PCI participation A review of the PDF's operation after year two would determine whether demand warrants expansion of the PDF's financial products and services

By making medium- and long-term resources available to PCI' s for onlending to private sponsors of small projects as defined above, the PDF can also play a significant role in mobilizing local resources from these institutions to provide additional financing for eligible projects ***The objective of involving PCIs is to leverage PDF resources*** By requiring loan funding in a ratio of 1 2, for example (US$1 lent by the PDF for every US$2 rupee equivalent that the PCI places in the project from its internal funds), PDF resources would be leveraged with capital from PCIs, thus opening the way for these pooled resources to be used for small hydropower project financing on a fully sustainable, commercial basis over the medium- to long-term

The PDF/PCI partnership would contribute to the creation of a sustainable commercial marketplace for small hydropower project development and financing However, some changes in the Nepal Rastra Bank's monetary policy, particularly with regard to "deprived sector" lending and/or tax concessions for participation in power sector lending, may be required to induce PCI participation For example, if PCI participation in small hydropower project financing were excluded from the base of outstanding credit against which commercial banks are statutorily required to invest designated proportions in the and deprived sectors, entry of PCIs into the power project financing market would probably be more assured This, in turn, would generate expertise in project finance The experience gained and the increase in local financial institution participation in the power sector would reduce transaction costs for and encourage development of subsequent projects Entry of additional financing sources into the power sector would encourage competition, lower rates and promote greater marketing efforts and market penetration

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6 3 Constraints to Implementation of the Power Development Fund

6 3 1 Effective Demand for Power Development Fund Resources

Despite apparent acceptance of the PDF's Borrower's Implementation Plan earlier this year by both HMGN and the World Bank, no concrete steps have been taken toward PDF implementation This is particularly true with regard to movement toward finalization of the PDF Administration Agreement between HMGN and the World Bank Furthermore, no one within either EDC or the Ministry of Water Resources (MOWR) has stepped forward to "champion" the cause of the PDF to ensure its implementation This ambivalence toward the PDF can be attributed to a variety of factors However, the demand for PDF resources is highly correlated with the country load forecast The release of the preliminary "Power System Master Plan for Nepal Load Forecast Final Report" elaborated by Norconsult[1]

One potential source of funds for the project finance model as depicted in Figure 2a is the World Bank' s proposed Power Development Fund (PDF) The PDF has been designed to supplement private and other public financing available for the development of Nepal's private sector It will provide long-term debt financing for power projects in order to overcome i) the lack of sufficient debt financing for power projects, ii) the inadequate maturity of available debt financing, and iii) the need to provide comfort to private investors wishing to become involved in"first time" projects Given the thinness of Nepal's commercial debt market which impedes the development of private projects financed on a limited recourse basis, the PDF would allow potential investors to access long-term financing thereby offering the private sector the opportunity to invest in and own, operate and maintain new power facilities Only projects that have fulfilled the necessary licensing requirements of the EDC and which have received clearances from the Ministry of Population and Environment would be allowed to solicit financing from the PDF

The PDF would initially be a pooled fund contributed to by the International Development Association (IDA) with the ability to solicit official financing sources, together with reflows of debt service payments made by borrowers The PDF would not be a major provider of funds for any one project, rather it will co-finance projects with international and domestic lenders, including commercial banks, investment funds, export credit agencies, the International Finance Corporation, and other multilateral institutions The aim of the PDF will be to act as a catalyst to maximize the inflow of private capital

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[2]Norconsult International A S , Power System Master Plan for Nepal Load Forecast Final Report, Report Funded by Asian Development Bank for the Nepal Electricity Authority December 1997

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significantly overstated projected average annual growth rates in electricity demand This, accordingly, downplays the need for domestic energy generation expansion requirements in the medium-term and thus lessens the urgency to borrow IDA resources to capitalize the PDF

The previous forecasts conducted by Electricite de France in 1991, the Japan International Cooperation Agency also in 1991, and the World Bank and the Nepal Electricity Authority (NEA), both in 1993, all "overshot" the actual projected energy requirements and peak demand for fiscal year 1997 For the 1998-2011 period, these three forecasts together with that of Norconsult all project an increase of about 8 5 percent in average annual growth In terms of peak demand, the differences between the forecasts are quite small By 2020, however, there are wide differences between the World Bank, NEA and Norconsult forecasts, with energy projections by the World Bank and NEA being more than double those of the Norconsult forecast For peak demand the differences are smaller, largely due to much lower load factor assumptions in the Norconsult forecast For the entire forecast period, peak demand requirements will increase by 10 5 to 11 percent annually according to the World Bank and NEA, whereas Norconsult projects these requirements to grow an at an annual rate of only 8 percent

Following the abandonment of the 201 MW Arun III project in 1995, NEA revised its generation expansion plan which called for adding an additional 1810 MW developed and owned by either independent power producers or NEA subsidiary companies through 2015 With a revised growth projection of 8 percent per annum through 2020, NEA's expansion plan will obviously have to be scaled back unless export outlets to India are established Barring the development of export potential to India in the near term given the current political economy, demand for the first tranche of PDF resources – an initial US $100 million from IDA potentially cofinancing US $400 million worth of projects[3] – may stretch into the next millenium

[3]The PDF may finance individual investments not exceeding 25 percent of total project cost

7 Institutional and Regulatory Reforms to Encourage Small-Scale Hydropower Development

The report prepared for the Federation of Nepalese Chambers of Commerce and Industry[1] made a number of cogent recommendations regarding institutional and regulatory changes to promote hydropower development in general The intent here is to not repeat or to comment on the findings of that report – the reader is encouraged to review the report and draw his/her own conclusions – but simply to summarize the most salient points addressed by the document which could affect the financing of small-scale hydropower projects These include

- A new Section 15A to the Electricity Act 2049 permitting the mortgaging of immovable properties and the pledging of shares of the licensee in electricity generation, transmission or distribution to foreign lenders investing in the project
- A new subsection of Section 12 to the Electricity Act prohibiting fees of any kind on the above mortgaging of immovable properties and the pledging shares to foreign lenders
- A new Section 15B to the Electricity Act which waives the requirement for work permits for foreigners employed by a contractor with a valid license for electricity generation, transmission or distribution
- Rewording of subsection 7 of Section 12 of the Electricity Act stipulating that only one percent customs duties and no value added or other tax shall be levied on the importation of plant, machinery, equipment and spare parts, construction equipment and spare parts and construction materials
- Exemption of hydropower projects from value added tax
- A new subsection 8 of Section 12 of the Electricity Act which waives the imposition of income tax on dividends resulting from investments in hydropower generation, transmission or distribution
- A new subsection 9 of Section 12 of the Electricity Act which waives the imposition of local taxes of any kind on an individual or corporate entity involved in hydropower generation, transmission or distribution
- Rewording of subsection 10 of Section 12 of the Electricity Act stipulating that no additional or new tax, fees, charges or any form of revenue for the government whatsoever called shall be levied by any agency of HMGN on a licensee other than those prevailing under existing laws on the date of issuance of the license
- A new subsection 3 of Section 11 of the Electricity Act which stipulates that the licensee shall pay twenty-six percent of the royalty amount payable by the licensee to HMGN directly to the District Development Committee where structures and facilities for electricity generation are located for local development in the district
- The Electricity Development Center should be designated as the final authority to exercise the power of the "prescribed authority" under the Electricity Act Furthermore, the Electricity Development Center shall be the responsible hydroelectricity development unit of HMGN to develop or cause to develop hydroelectricity and to encourage private sector entrepreneurs for the development of hydroelectricity and to follow up the works relating to hydroelectricity development

[1]Nepcon Private Limited Proposed Changes in Hydropower Legislation and Institutional Framework discussion paper prepared for Federation of Nepalese Chambers of Commerce and Industry July 1998

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8 Conclusions

The lessons that have been learned in conventional electrification program design and implementation can and should be applied to any plan devised by HMGN to embark upon a small-scale renewable energy electrification program based upon small-scale hydroelectric schemes, if this program is going to reach a level of self-sufficiency necessary for its entrance into the commercial marketplace Small-scale hydroelectric schemes need to be market-based, by avoiding ongoing subsidies, by setting cost recovery goals and minimum quality of service standards to insure user satisfaction Moreover, if these conditions are going to be met, and the job of creating a sufficiently strong demand for the services is to be reached, reforms such as those proposed by the Federation of Nepalese Chambers of Commerce will need to be implemented and some form of oversight will be needed from an agency such as EDC whose role is tightly defined so as not to encourage unneeded government involvement

The financing models that are mentioned above are by no means the result of an exhaustive body of work The models that have been presented have not been operational for an extended period of time The PDF second window, for example, has yet to become operational Most have enjoyed some level of public sector subsidy and none have matured to the point that they can be said to be truly self-sustaining

How then, does a government decide which model to employ? As evidenced above, each model that has been adapted has been selected with a specific set of public policy goals in mind Each has been adopted to fit into a particular set of circumstances Some of the models are being used as part of a greater strategy to provide basic infrastructure to rural areas while others are being implemented specifically as part of larger rural electrification efforts

Some of the experiences mentioned in this monograph have shown that sustainable projects with a high degree of cost recovery and a very low percentage of public investment are possible Typically, they have been implemented where there is flexibility on the part of the project owners to provide a menu of services They are more successful when the institutions are not over-burdened with costly administration systems, but where they are well trained and prepared to offer a quality service for a reasonable fee But the caveat must be included that there is a scaling issue involved in the projects that have used the models herein They have been small in size, and the models are by no means mature as of yet

Clearly, the challenge is to increase the scale, to increase the market penetration rate to the point that programs can be established rather than just projects Projects by themselves serve communities, serve beneficiaries, and are important in their own right But a critical mass of the market must be served before a real program exists to the point that the market can sustain itself

The question then becomes how to scale up when in most cases so little infrastructure exists The above discussion would argue that there are many, many options to choose from Utilities can be used as vehicles, around which one may develop a program, but utilities are typically very conservative, and utility engineers are not known for their openness to change NGOs can and have implemented projects successfully, but they often have a very well defined mission statement and a focus to serve that mission statement This should be carefully considered when deciding to work with NGOs Businesses that offer equipment are very seldom interested offering services The risk is much lower if they can sell equipment rather than rent equipment, due to the fact that a critical mass of users has to be reached before they earn a profit, and it is not their business expertise to commercialize energy services

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These are the difficulties one may face when deciding which model to use Many institutions have learned how to overcome the obstacles and are presently in the process of expanding their programs to reach the critical mass necessary to earn a profit on the projects they are undertaking Many of the risks or paths to failure are not yet identified, and it is likely that much more will be documented in the coming years as the base of experience grows

However, there are some uniform rules that can be followed to mitigate risk for new small-scale projects These include the following

- To the extent possible, determine the willingness to pay for the service offered, whether the model employs fee for service or direct sales of equipment
- Establish quality standards that will be provided in terms of equipment to be provided, after sales service, maintenance of equipment, methods for clients to communicate with the service provider
- Be very conservative when estimating administrative costs, including billing, collections, maintenance (if offered), promotion, and other costs
- Always seek to establish the program with groups that have some experience with commercializing a rural public service, if at all possible
- Survey all rural development and rural service institutions to find possible synergy with local groups

Providing rural energy service is not a complicated endeavor, but it is an undertaking that requires considerable experience and can be very capital intensive It is also a process that requires a great deal of trust built through good faith efforts of the groups working with rural people One fact that should not be overlooked is that the success or failure of a program can turn on the trust that is built through the service provider to the communities served This means that the models depend upon institutions more than the institutions depend upon the models The way an institution does business will determine the appropriate model

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Appendices

Appendix A

Classification of Projects by Model

As a follow up to the above discussions of parameters, determinants of success and project and program financing models, it is helpful to consider the range of projects identified in the recent literature on rural electrification and categorize them according to the models presented in Section 4

Table A
Classification of Project by Model – With Descriptions

Project Name / Location	Type	Project Model	Description of Key Variations
FIRCO solar pump program	SS	1	Direct subsidy to end user
PAPP wind pumping program Brazil	SS	1	PAPP is funded by the World Bank Northeast Rural Development Project
Costa Rica rural cooperatives	GE	2	USAID provided concessional loan financing in early phase of development
Arizona Public Service/CFE Hybrid mini grid in San Juanico Baja California	MG	2	The US $650 000 investment in wind and solar generation plus efficiency upgrades in the existing mini-grid will replace diesel systems
Gas fired generation in Santa Cruz Bolivia	MG	2	USAID/NRECA participation suggests donor technical assistance involved
Nepal grid extension	GE	2	Grant sourced equity" component in financing
Indian grid extension (kutir jyothi)	GE	2	State Electricity Boards appear to charge below-cost tariffs for rural users
Mini hydro Chalan Peru	MG	2	NGO financing by IDB supported revolving fund and equity participant
Roatan Electric Company Honduras	MG	2	USAID/NRECA participation suggests some donor technical assistance
Enersol SO BASEC Dominican Republic	SS	3	NGO to provide micro-credit
Argentina	MG	5	Long term service territory concession awarded to low bidder with least amount of subsidy requested
Soluz, Dominican Republic	SS	4	Intent is to create unsubsidized, sustainable ESCO
Chile	SS	4	Government takes bids on concessions to offer lease-financed household systems in specified areas The bidder requesting the least amount of government subsidy wins the concession
SHS Indonesia	SS	4	GEF subsidy buys down financing risk

Legend GE grid extension MG, mini-grid SS, standalone systems
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