Regulating Rural Electrification:

Experiences and Lessons Learned

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ACRONYMS

ERB	Energy Regulatory Board
ESCO	Energy Service Company
GRZ	Government of the Republic of Zambia
ICT	Information and Communication Technology
K	Kwatcha
Km	kilometer
Kv	kilovolt
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
m/s	Meters per second
MEWD	Ministry of Energy and Water Development
MOE	Ministry of Education
MOH	Ministry of Health
mW	Megawatt
NGO	Non-governmental organization
PV	Photovoltaic
RE	Renewable Energy
REA	Rural Electrification Authority
REC	Rural Electric Cooperative
RES	Rural Energy Services
SHS	Solar Home System
SWER	Single Wire Earth Return
UNIDO	United Nations Industrial Development Organization
USD	US Dollar
Zamsif	Zambia Social Investment Fund
ZESCO	Zambia Electric Supply Company

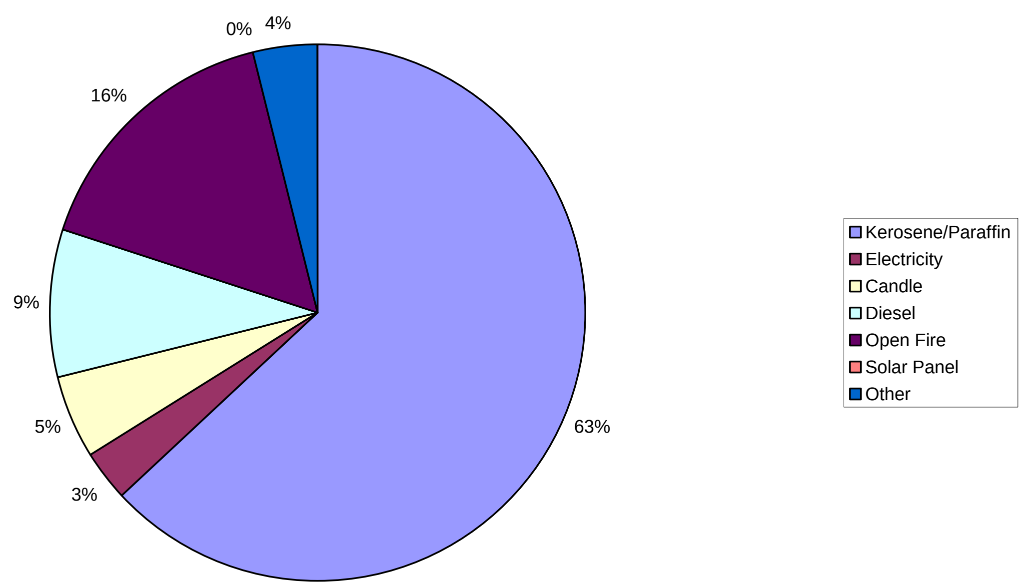
1. Regulation[1] and Rural Electrification

1.1. Introduction

At the time this work began, the rainy season was approaching. Now the rainy season is past and, in a pattern that is often repeated, a drought grips much of Zambia. Hunger remains a constant companion to millions of Zambians and starvation is only a drought away. This cycle takes place in the midst of significantly undeveloped and unexploited water resources. Successful exploitation of these water resources could release Zambians from their dependency upon the seasonal rains, turn subsistence farming into surplus farming, and create the types of viable export industries that could drive Zambia's rural economy into the new millennium.

Rural electrification in Zambia is virtually non-existent. Less than 2 percent of the rural population has access to electricity and they depend mainly on traditional energy sources; firewood, charcoal, paraffin, candles, animal power and human power. Figure 1 below illustrates this lack of electricity by providing the distribution of rural household energy use for lighting.

Distribution of Rural Household Energy Use for Lighting



[1]Regulation is often used in broad terms to mean legislation, policy and implementing rules and regulations for those laws and policies. In this report, a stricter definition is used and considers only the latter or the implementing rules and regulations.

Rural households use an overwhelming amount of paraffin for lighting. Modern energy comprises less than 15% of lighting use. Use of energy for cooking shows similar patterns with 88% of rural households using wood, which they collect, for cooking alone. These patterns have profound implications for rural electrification because people do not simply or easily transition from the use of one fuel to another.

The lack of modern energy services, if not a direct cause of lower economic growth, is certainly a major impediment to confronting drought and raising rural productivity. It is an inescapable fact that modern economies run on modern energy. While this is a cause for concern, it also presents Zambia's Energy Regulatory Board (ERB) with a unique opportunity to play a catalytic role in shaping the sector by using regulation to promote investment and foster markets where electricity markets do not yet exist and to reduce cost and risk through the promulgation of standards and guidelines.

The ERB is charged with this task in coordination with the Rural Electrification Authority (REA) on Tariffs, the Zambia Bureau of Standards for technical standards and the Zambia Competition Commission on competition. Zambia has models to follow and there is ample experience in Africa for innovative rural electrification and in using regulation to create and shape the market. Moreover, the ERB has shown itself to be a progressive, proactive member of the energy community by constantly moving forward to lead the sector.

1.2. Background

In the past, many countries focused their rural electrification programs on the increased welfare that rural residential users would receive from electricity. These benefits included reductions in indoor air pollution, increase in education and health options, decreases in crime and increases in technology transfer. An example from Southern Africa documents these benefits:

"In general, the welfare of poor communities with access to electricity has improved significantly under both off-grid and grid programmes….Electrification of the poor has also resulted in several additional benefits. These include reduction of fires (particularly in low-income urban areas) from the use of paraffin and candles, and reduction of local and indoor air pollution from firewood use, especially in areas that use these fuels extensively for cooking and heating. Electrification of clinics and schools has yielded significant benefits for communities in the form of improved health-care service provision, involvement of schools in evening adult education, and improved efficiency of school operations through use of equipment, such as photocopiers and computers. In certain cases, electric street lighting may have contributed to reduced crime levels."[2]

[2] Electricity Access in South Africa and Zimbabwe, Global Network on Energy for Sustainable Development, page 19.

Lesson[3]: While the above benefits are important, there is little evidence that they translate into increased or sustainable economic activity and income levels. It appears that increased economic activity is unlikely to result from rural electrification unless it specifically targets income and wealth generating activities.

There is a strong documented relationship between electricity access and economic development. Electricity, accessible to less than 2% of Zambia's rural population, is one of the requirements to the development of a modern way of life. The primary obstacle for making electricity accessible to rural Zambia is that, no matter the measure of poverty, whether it be income or another metric such as the Human Development Index, Zambia's rural population is poor. The vast majority of Zambia's rural poor are at or below the subsistence level of $1 a day. In 1991, 69.7% of the population was determined to be unable to sufficiently feed themselves. By 1997 this figure had risen to 73%.[4] In 1998 it was estimated that 83% of Zambia's rural population was in poverty, with 70.9% experiencing extreme poverty. This extreme poverty is compounded by the country-wide lack of population density. With approximately 14 persons per square kilometer, including urban areas, Zambia is challenged by both the poverty as well as by a lack of concentrated population.

In particular, inadequate access to infrastructure and to energy specifically has been a major factor hampering rural economic development. To address this need, the Government of Zambia has embarked on a new way of providing rural electricity by framing the issue as a national imperative.

Lesson: Increased energy access alone will not guarantee a way out of poverty for Zambians unless it is strongly guided towards access that targets promoting more developed economic activity specifically and directly.

In the past, rural electrification was the primary responsibility of the national utility, ZESCO. ZESCO pursued this objective by extending the national grid and using small diesel or hydropower plants in isolated grids for towns. However, extension of the grid for rural electrification has been hampered by a number of factors including: the high unit cost per connection which results from low population density, enormous distances between major towns or load centers, low demand per connection, lack of sufficient government funding, and, finally, the inconsistent performance of ZESCO.

Lesson: In most cases, grid extension is not the most cost effective method of rural electrification[5].

Other programs for rural electrification have centered on solar energy service companies (ESCOs) and a few other isolated attempts. Despite these efforts, penetration in rural areas has remained relatively low. Given these realities and the

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[3] Throughout this paper we use "Lessons" to illustrate the lessons which have been learned across projects throughout the world. Lessons do not represent one time occurrences. They represents patterns which have been empirically verified.
[4] Zambia's Poverty Reduction Strategy Paper, page 22
[5] See, for example, Rural Electrification: Lessons Learned, Findings, No. 177, February 2001, Africa Region, World Bank. (Appendix 1.)

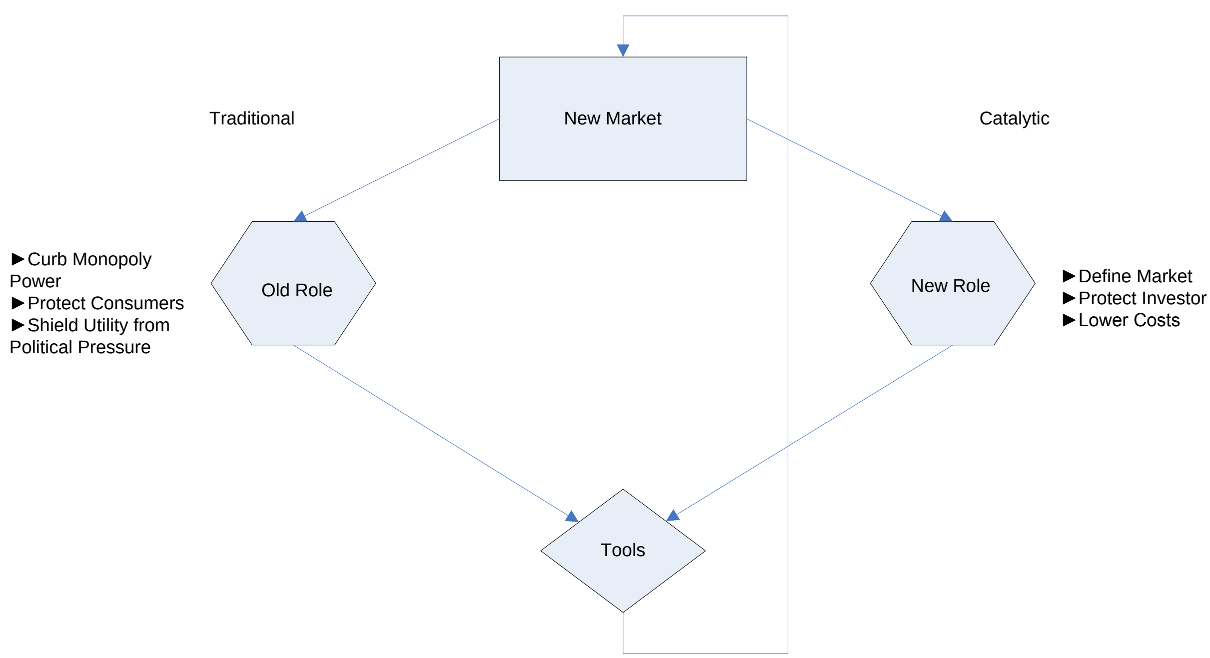
necessity of increasing rural electricity access, the Government opted for the idea of harnessing public-private partnerships in providing rural electricity services and created the Rural Electrification Authority in 2003.

1.3. Purpose

Why is a paper on regulating rural electrification in Zambia needed? After all, Zambia has experience in rural electrification. Zambia's regulator, the ERB, is almost a decade old. ZESCO, the state owned vertically integrated utility, has been in charge of rural electrification. The Rural Electrification Fund has been in operation since the mid 1990's. The ERB and the newly created Rural Electrification Authority have drawn on capable and experienced staff from ZESCO and the Ministry of Energy. Why then, with all this experience, is a new look at regulating rural electrification necessary?

The reason is quite simple: while the principles of regulation remain unchanged, the characteristics of the companies, the consumers and the technologies that will be used in most off-grid rural electrification are significantly different from those of the recent past. Regulation of rural electrification takes on added dimensions when applied to the standard model posed by one major national utility. As such, this creates significant challenges as well as opportunities which are illustrated in Figure 2. Rural electrification requires the traditional tools of regulation, a new mindset and additional new tools. This stems from the facts that: (a) market characteristics are very different (consumer, supplier, technology) and (b) the required role of the regulator is expanded to new areas.

FIGURE 2 THE NEW ROLE OF ERB



The purpose of this paper is to explain how the market is likely to differ from the one the ERB currently regulates and to provide some general guidelines based on experience in other countries. The industry can shape regulation; the adoption of old technical standards from grid based systems to off-grid systems is an example of the industry shaping regulation. On the other hand, regulation can drive the industry and this is the pattern that world class regulators, and the ERB, have followed. In this case, regulation looks to provide the framework that will help industry move forward; in our example, this would be the adoption of lower cost technical standards for off-grid systems, thereby reducing cost and increasing both demand and supply.

A new regime has emerged precisely because the old regime has not worked well. This is not to say that the engineering, regulatory and legal skills used in the old regime are not needed. While the principles are the same success is not to be found in the application of old approaches in the new environment. Experience has demonstrated that approaching problems from the inertia led stance of the old regime will not work. New approaches which build upon and use already present skills are required.

For example, in many cases, regulation has substantially increased the costs of rural electrification by adopting technical standards from urban grid based systems that are "over designed" for the needs of rural electrification systems. In other cases, as renewable generation became increasingly important as well as available, grid codes were not modified to accommodate the differences between conventional thermal or large hydro systems or the entrance of seasonally based renewable power. This results in a market with fewer renewable energy sources, even when their entry was warranted on purely economic grounds.

This environment frames the needs and challenges facing regulation. While many regulatory principles are the same for large scale, grid-connected power regulation and rural regulation the application, focus and intensity differ. The following sections provide further clarification of this difference, building upon this paper's purpose of examining the role of the regulator in rural electrification in its traditional protector role and as an agent of change.

1.4. Rural Electrification Defined

At the outset, defining and understanding the characteristics of what rural means is imperative. Definitions of rural vary widely, often depending upon the extent to which the country is already electrified. Legal definitions may differ from the way in which the market organizes and industry acts.

The Rural Electrification Act of 2003 defines rural area as " (a) any area which is not an area declared a city or municipality under the Local Government Act; or (b) such other area as the Minister may, by statutory order and in consultation with the Minister responsible for local government, declare a rural area."

Rural electrification is likely to take place then through: (a) expansion of the national grid; (b) off-grid stand alone power systems such as solar home systems or small hydro units; and (c) isolated mini-grids using renewable energy resources. Throughout this paper we define "off-grid" as anything not connected to the national electricity grid. So, even isolated mini-grids qualify under this definition. Additionally, we include under the heading of rural electrification, expansion of a rural supply to the national grid. This could be, for example, the development of power at a sugar mill where the economic size is greater than the local market can sustain. Expansion to the national grid would provide the foundation for generation and support, then, rural electrification. Finally, alongside rural, we emphasize renewable electricity.

Grid expansion is likely to take place and is certainly more often economically justified in areas contiguous to the areas "declared a city or municipality" that are already served by the utility, or along a major transmission corridor where there is dense settlement. These are termed peri-urban areas. In areas remote from transmission and/or distribution assets and that are sparsely populated, off-grid electrification is likely to take place. UNIDO, in their ICT project, defines rural off-grid electrification as (a) anything more than 20 km from an existing ZESCO 11 kv line or (b) anything more than 10 to 20 km from a planned ZESCO 11 kv line[6].

The characteristics of demand and supply are significantly different between areas that are and will likely be connected to the grid and more remote areas or off-grid areas. Technical standards, tariffs, and the economics of supply are vastly different between these areas and require different approaches in regulation. Thus, for the purpose of this report, rural electrification is taken to mean remote, off-grid (off the national grid) electrification as defined by UNIDO. However, much of this discussion is appropriate to peri-urban expansion in the Zambian context. It is left to the ERB to decide on a more precise definition that fits their particular circumstances.

1.5. Additional Barriers to Rural Electrification[7]

Several of barriers to rural electrification that can be addressed by regulation have been mentioned above. Best practices are evolving in rural electrification in response to a multitude of barriers. Additional barriers that can be addressed by regulation include:

- **Nonexistent or Inappropriate Regulatory Policies:** A variety of policies exacerbate the high first-cost problem of off-grid technologies. Most notably, many developed countries tax imported renewable energy generation equipment while subsidising kerosene and other fossil fuels. This can make it more cost-effective for customers to continue to use kerosene or for companies to invest in fossil generators even when a solar or wind system would be more economical if prices reflected true economic costs. Most fuel subsidies also have the perverse effect of providing the greatest benefit to wealthier portions of the population who purchase the most fuel that are least in need of government assistance.

[6] Based on discussions with UNIDO advisor, Dr. Lemba D. Nyirenda, March 16, 2005
[7] This section is based on a paper by Dr. Anton Eberhard.

- **Limited Ability to Pay for Services:** As rural households are generally associated with poverty and subsistence living, it is not reasonable to expect all or even a majority of residents to be able to pay for the services that off-grid technology can render. Couple this with the fact that employment opportunities in rural areas are very limited and this places the consumer in a situation where s/he is not able to afford or access any off-grid services. Since the regulatory objective is to provide affordable services *and* ensure a fair return for investors, energy service delivery must be integrated with income development in rural households.
- **Preference for Grid Electricity:** There is a preference among consumers for grid connected electricity for a variety of reasons. Potential consumers need to be educated and informed about off-grid technology, its long-term financial and environmental benefits, and the associated development impacts that can be derived from it. Also, that the off-grid system should be utilised for the creation of rural industries and hence lead to a better way of life by incrementally alleviating poverty and reducing the hard labour that many of the people face daily.
- **Uncertainty Regarding Grid Expansion:** The greatest threats are the uncertainties regarding the extension of the national grid. Even a rumour that the grid is to be extended in the off-grid areas will discourage many potential customers of off-grid electrification. Thus the cooperation of the utility company in integrated electrification planning is essential. (This is also a problem for potential investors that will be addressed later.)

2. The Rural Market for Electricity

2.1. The Ideal Rural Electricity Market

Ideally, rural electrification will take place in a competitive environment where law, rules and regulations: promote and engender efficient supply; safeguard consumer interests; reduce risk to investors; keep regulatory and administrative costs to a minimum; attract private investment; and fuel rural economic development.

2.2. Rural Electricity Market Assessment

The current market for electricity in rural Zambia can be characterized as virtually non-existent since less than 2 percent of the rural population has electricity access. In actuality the percent of rural people with electricity access is far less. This is because the bulk of what is classified as rural electricity is ZESCO supply to regional towns and administrative centers that by definition fall outside rural areas. Rural areas are far from the grid, demand is low, as is population density, formalized industry is absent and ability to pay is low. Even if increased electricity access would increase incomes, the problem confronting potential consumers is how to pay for it. Most of rural Zambia is below the poverty level. Electricity is being supplied in rural areas by a mix of entrepreneurs, charities and projects being supported by donors. There are few examples of electricity being sold for a profit in rural Zambia[8]. Most consumers are schools, clinics, churches and residences who can't afford to pay full cost of electricity. These factors explain why the traditional grid connected supply model has failed. The following sections discuss the current and future markets.

2.3. Electricity Supply

There is little to say about the current rural energy service suppliers. Most rural electricity is being directly supplied through the government: ZESCO has provided some rural electricity either through expansion of the national grid and through small minigrids power by diesels or small hydro plants; The Zambian Social Investment Fund (Zamsif) provides funding for the Ministries of Education (MOE) and Health (MOH) use of solar panels at remote schools and clinics. The Ministry of Energy and Water Development (MEWD) oversees several projects in solar and wind. The private sector is quite small and is mainly subsidized from donor, Government or charity funds.

Future rural energy service suppliers will be very different than the large national utility with which the ERB is familiar. For the most part they will be individual entrepreneurs, small companies, NGOs, church groups, farmers, rural based industries and communities. They will be inexperienced with power, have shallow pockets and lack

[8] Even these cases require that the supplier be subsidized in order to make a profit.

technical skills. What they lack in technical knowledge and capital, they usually more than make up for in business acumen, local knowledge, energy and enthusiasm.

Table 1 below presents the characteristics of the new rural electrification regime compared with the old system.

Table 1: New and Old Rural Electrification Regime Characteristics

Characteristics	Old Regime	New Regime
Provider	Large, Vertically Integrated, State-owned Utility	Small, mostly private sector investor/operators
Networked	Grid Connected	Off-Grid (1)
Technology	Conventional	Mostly Renewable
Scale	Large Scale	Small Scale
Funding	Government	Private Sector/Government
Demand	Low	Very low
Market	Monopoly	Competitive
Ability to pay	Low	Low
Generation Cost per kwh	Low	High
Total Cost	Very High	High but lower than grid expansion
Focus	Political	Income generation driven

Notes: (1) Off-grid in this case means unconnected to the national, high voltage transmission grid. Many rural suppliers will develop small distribution min-grids.

In the new environment, electricity will be provided by smaller entities that should have better local knowledge and are better able to manage costs. At the same time, they will have limited access to capital and technical know how. It might be a church organization, as in the case of the Mutanda hydro project, a 2.5 kwp run of the river hydro plant. It might be a sugar mill looking to generate power for itself and sell excess to the surrounding community. It could even be a local farmer or businessman. In other cases, it will be dealers offering not electricity but solar home systems and, if the conditions are correct, it could be retailers offering to install and lease solar home systems.

Zambia is moving from primarily a grid based rural electrification program through the national utility to opening the doors to a variety of business models. The business models used will be a function of the laws and regulations, the size of the market and the technology and resources available to generate power. This wide variety of business models to supply electricity services is primarily comprised of:

1. Rural electricity generating entities[9] that supply electricity to distributors.
2. Rural entities that generate power for self consumption and sell the excess to distributors.

[9] We use entity because several different forms of ownership may arise from churches and NGOs to communities and entrepreneurs.

3. Rural entities that generate and distribute power.
4. Cooperatives that distribute power to “members”.
5. Cooperatives that generate and distribute to “members”.
6. Dealers that sell equipment to produce electricity services.
7. Dealers that lease and maintain equipment to produce electricity services.
8. Individuals that generate and supply themselves.

The first seven of these can be grouped into three broad models, concessions, cooperatives and dealers[10]. The following section briefly describes the three different business models of rural electrification.

2.3.1. Franchise/Concessions[11]

The first three rural energy supplier business models fall into what are called concessions or the right to undertake and profit by a specified activity. A simple license is a concession. In the concession model, the entity is granted a franchise to supply power. Copperbelt Energy Corporation is a franchise. Historically, this was the first of the regulated business models for electricity and the award is typically based on some form of competition.

“The concept of competitive electric utility franchising rises from the early roots of the industry, and predates the notion of "natural monopoly." During the latter 19th century, cities and towns commonly offered franchises similar to those for streetcar companies and other services to the fledgling electric utilities. Competitive bidding for distribution franchises was sometimes held on an annual basis. And in some cases cities granted multiple contracts and allowed construction of parallel distribution systems. Fierce competition led to problems such as cost-cutting that jeopardized service and public safety. And in at least one case the fever pitch of competition led a company's workers on nocturnal excursions to chop down a competitor's poles.[12]”

Often, the franchise is for a specific geographic territory. Supply can mean either distribution or generation or generation and distribution. Usually this comes with targets for electrification and quality of service which if not met can result in revocation of the franchise or other penalties. A concession can either be exclusive or nonexclusive.

An exclusive concession is time bound and gives the concessionaire the exclusive right to supply power to a specific area. The concessionaire is a monopolist in the same sense as the distribution utility that supplies urban consumers. The principal differences from their urban counterpart will be in the type of equipment, the characteristics of demand and their technical/financial capabilities. In addition to the franchisee that

[10] See Appendix 2 for an interesting presentation of six developing countries’ experience with new business models.
[11] The law currently gives ERB the power to grant licenses (concessions). REA has a concurrent role in that promotes rural electrificaiton and determines which projects will receive finaning from the Fund. However, the ERB alone grants licenses or concessions.
[12] Scott Ridley, “Seeing the Forest from The Trees: Emergence of The Competitive Franchise “, *The Electricity Journal* May, 1995 issue

provides electricity for a profit, Zambia is also likely to see non-profit franchise rural energy suppliers in the form of Churches, Communities and NGOs.

2.3.2. Cooperatives

A cooperative is defined as a jointly owned commercial enterprise that distributes goods and services, and often produces the good or service, and is run for the benefit of its members. A Rural Electric Cooperative (REC) is a type of rural electric utility that is owned by the members it serves. Its profits, or margins, are put back into the cooperative to help run the business efficiently, or are returned to the customer-owner. A REC exists solely to provide high-quality service at the lowest possible price for its customer- owners. There are two principal types of RECs, an integrated REC and a distribution cooperative. An integrated REC generates, transmits and supplies its all or the majority of its own electricity. A distribution cooperative is a non-profit, customer-owned electric company that purchases electric power at wholesale and distributes it to its customers.

A REC exists for the purpose of providing its members with electric service - on a non-profit basis. Therefore, in a cooperative, the net margins do not belong to the corporation - they belong to the individual consumers who paid the money on their monthly service bills. In most types of co-ops, net margins, after reasonable reserves are set aside to pay back government loans, operating costs and other expenses, go back to the members in the form of a cash patronage refund. The funds credited to members are "capital credits," and over a period of years these membership funds take the place of federal investment. The individual member's capital credits are his ownership equity in the system. Most electric co-ops have a provision in their bylaws for repayment of capital credits on a rotating basis.

Electric cooperatives developed because many citizens who did not have access to electricity in the 1930s decided to band together and form their own companies to acquire power. Investor-owned power companies said they couldn't make a profit in areas with a small number of consumers per mile of expensive power line. The cooperative business structure already was a well-established part of the American free enterprise system for providing services that were too big for individuals to do alone. Non-profit cooperatives were a natural for distributing electricity in areas where making a profit would be difficult.

Rural Electric Co-operatives (co-ops) are owned and controlled by the consumers they serve. Members participate in the operation of the co-op by electing a board of directors to determine the rates and type of service(s) they receive. The co-op's board of directors is responsible for establishing the cooperative's basic policies, goals, and strategies. The board also hires a manager to execute those policies. Local control and local ownership makes usually results in lower costs. Similarly, in a co-op, the locally elected board of directors must balance the interests of consumers and corporate responsibilities to ensure the fiduciary health of the co-op. Co-ops have traditionally provided services directly or facilitated the acquisition of services that the community has no established way to acquire. Another fundamental attribute is that co-ops are not-for-profit organizations and their tax burden is generally lighter.

For most electric cooperatives, the board of directors of the co-op sets rates, although state commissions in 16 of the 46 states in which co-ops serve consumers regulate some aspects of cooperatives' operations. Cooperative businesses are special because they are owned by the consumers they serve and because they are guided by a set of seven principles that reflect the best interests of those consumers.

All cooperative businesses adhere to these seven guiding principles:

1. **Voluntary and Open Membership** - Cooperatives are voluntary organizations, open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political, or religious discrimination.
2. **Democratic Member Control** - Cooperatives are democratic organizations controlled by their members, who actively participate in setting policies and making decisions. The elected representatives are accountable to the membership. In primary cooperatives, members have equal voting rights (one member, one vote) and cooperatives at other levels are organized in a democratic manner.
3. **Members' Economic Participation** - Members contribute equitably to, and democratically control, the capital of their cooperative. At least part of that capital is usually the common property of the cooperative. Members usually receive limited compensation, if any, on capital subscribed as a condition of membership. Members allocate surpluses for any or all of the following purposes- developing the cooperative, possibly by setting up reserves, part of which at least would be indivisible; benefiting members in proportion to their transactions with the cooperative; and supporting other activities approved by the membership.
4. **Autonomy and Independence** - Cooperatives are autonomous, self-help organizations controlled by their members. If they enter into agreements with other organizations, including governments, or raise capital from external sources, they do so on terms that ensure democratic control by their members and maintain their cooperative autonomy.
5. **Education, Training, and Information** - Cooperatives provide education and training for their members, elected representatives, managers, and employees so they can contribute effectively to the development of their cooperatives. They inform the general public, particularly young people and opinion leaders, about the nature and benefits of cooperation.
6. **Cooperation Among Cooperatives** - Cooperatives serve their members most effectively and strengthen the cooperative movement by working together through local, national, regional, and international structures.
7. **Concern for Community** - While focusing on member needs, cooperatives work for the sustainable development of their communities through policies accepted by their members

Source: National Rural Electric Cooperative Association

2.3.3. Dealers

Dealers sell energy equipment, usually photovoltaic or solar equipment, to people living in rural areas. Units usually range up to 250 wp and are both sold and maintained by the dealer. Characterized as small, financially weak entities that often face market competition, dealers are constrained in their ability to obtain commercial financing due to their limited cash flow, poor customer base, and lack of established track records due to the preference for cash sales.

Lesson: The most successful of these models builds on existing dealer networks or retail businesses, thereby taking advantage of existing business relationships and knowledge and lowering per unit costs because many costs are being spread over a variety of products. Successful examples include Indonesia, Sri Lanka and Kenya.

In an extended dealer model, the dealer may also provide credit or lease the equipment. Zambia has limited experience with this model.

2.4. RURAL POWER TECHNOLOGIES

Most suppliers will opt for renewable energy (RE) technologies such as solar (photovoltaic), small-hydro, biomass (agricultural wastes, forestry waste, energy crops and animal waste), geothermal and wind. Data is not readily available on the resource potential or the production and consumption of these resources in Zambia. While wood, petroleum and hydropower will continue to be the major energy sources, at least in the midterm, Zambia is potentially rich in these sources of energy. The following sections present a brief discussion of the applicable off grid technologies.

2.4.1. Micro/Mini Hydro Systems

Zambia has a number of potential sites on smaller rivers suitable for local small-scale power generation. The most advantageous places for such development are in the North-Western and the Northern parts of the country, because of the topography of the terrain, the geology of the ground, the highest rainfall figures in the country and the lowest evaporation due to below average.

Suitable sites have been identified by collecting information on rivers with sufficient year-round flows. Preference has been given to sites that can sustain run-of-river schemes since the regulation of river flows by dams and water storage requires high initial costs and makes small-scale hydropower projects uneconomical. Apart from the low cost, other benefits of run-of-river schemes include, fast and easy construction, easy flood protection, minimal environmental impact and low evaporation losses.

Although substantial information has been collected relating to the large scale and small hydro potential in Zambia, little information is available on the mini/micro hydro potential in the country. It is imperative that resource assessment studies be undertaken to prioritize and direct rural electrification activities and to promote private sector investment.

A successful example of micro-hydro exists at the 2.5 kWp Mutanda site. The plant supplies a community of 82 households and a maize mill. Total out of pocket capital costs were US$37,500[13] with the community supplying labor for civil works. Annual operating costs average $3,500 and revenues are around $5,200. Revenues are comprised of tariffs ($1.05 per household) of $780 and use of the mill at around $4,400 per year. The key salient points of this project are:

- First, the income of the community is high relative to the average rural community. Income averaged $80 per month compared to $33 for the average Zambian household.

- Second, the bulk of the revenues come from an economic activity, not residential use.

- Third, despite the community's higher income, subsidies were required.

- Fourth, the community was willing to reduce the cost by contributing labor.

ZESCO has recently expanded into this project's service area. The full extent of ZESCO's subsidization is not known. However, if Zambia is to promote private investment in rural energy services then service should be provided by the lowest cost provider. If private investors can be challenged by subsidized state resources once investments have been made, then these private sources of funding will vanish. Therefore, Zambia will have to take steps to provide security for private investment.

2.4.2. Solar Energy

One alternative to grid extension is through Photovoltaic (PV) Solar Home Systems provided by dealers. Solar home systems are an increasingly important means of providing lighting in dispersed off-grid areas of developing countries. Over half a million solar home systems are installed in rural areas of the developing world in countries such as the Dominican Republic, Indonesia, Kenya, the Philippines, Sri Lanka and Zimbabwe.

The main components of solar home systems:

• *Solar cell modules: Convert sunlight to electricity and have a capacity between 12 and 60 watts.*
• *Lead-acid batteries: T*ypically car batteries which store energy collected during periods of sunlight. Deep discharge batteries are preferred but are often too expensive for the poor. The environmental impact of the batteries should be accounted for in project design and implementation.

[13] This cost appears quite high given experience elsewhere.

• *Charge controllers* or *regulators:* Manage the electric charge, protect batteries from damage, and show the status of the system.
• *Direct current (DC) appliances:* SHS use generate low voltage and special appliances are often required. Cost can be cut by local assembly of DC fluorescent lamps and controllers/regulators. This is becoming a secondary business for women in countries such as Bangladesh.

This approach is being tested in Zambia. The Zambia PV-ESCO project has been running since 1998. There are three ESCOs in operation in Eastern Province of Zambia, servicing more than 400 clients. However, results to date indicate that large subsidies are required to make this a success. This is, in large part, due to the high cost of solar relative to rural incomes. It should also be noted that ZESCO has begun expanding into the area offering subsidized power.

The MEWD has also incorporated the installation of photovoltaic (PV) solar systems in the rural electrification program. This is a technology that has shown great promise in meeting some of the energy requirements of remote rural areas in other countries. A few parts of Zambia have already started benefiting from installation of PV systems for water pumping, medical refrigeration and lighting under the rural electrification program. The MOE and MOH with funding from ZAMSIF have been implementing a rural solar electrification program.

"Based on market studies in India, China, Sri Lanka, Zimbabwe, South Africa and Kenya conducted by various international development agencies over the past 5 years, the consensus is that approximately 5% of most rural populations can pay cash for a SHS, 20 to 30% can afford a SHS with short or medium term credit, and another 25% could afford an SHS with long term credit or leasing.[14]" These countries have higher per capita incomes than Zambia so care must be taken in extrapolating to Zambia.

While it is unlikely that in the near term solar will constitute a major share of rural electrification efforts, it does lend itself to high net economic benefit activities where lower cost or lower quality energy resources are not available or applicable.

On its own the market may move more in the direction of using solar lanterns. Solar lanterns usually charge in a few number of hours and can be used to power not only light but other small appliances such as a radio. These are the major initial uses in low income rural areas. They are less costly than standard home PV systems and are mobile.

2.4.3. Biomass Based Electricity

While Zambia does not use biomass to generate electricity it does have significant biomass resources[15]. While biomass holds potential, it is not without problems. There

[14] Solar Electric Light Fund. http://www.self.org/shs_role.asp; Benefits of solar
[15] There are an estimated 50 million hectares of woodland in Zambia. This is equivalent to 66% of the total land area. The standby volume of timber is estimated to be approximately 2.7 to 4.7 billion metric tons.

are enormous environmental problems such as land degradation and suspended particulates. Large scale biomass utilization would require major changes in the planting, collection and harvesting to ensure costs and environmental impacts are minimized. It would be wise not to encourage increased use of biomass resources due to the far reaching environmental costs. A more prudent strategy is to focus on the increased efficiency in existing uses and use of biomass waste for generating electricity.

These biomass wastes include bagasse, sugar cane waste, wastes from milling and agro-processing and waste from saw mills. These waste resources can be used in generating electricity through direct combustion in boilers for steam turbines and engines or through gasification and then combustion.

2.4.4. Wind

Wind speeds in Zambia are relatively low. Wind data collected at 10 meters above the ground indicates speeds of between 0.1 to 3.5 meters per second (m/s) with an annual average of 2.5 m/s. These wind speeds are not particularly suitable for electricity generation, but are well suited for water pumping for household use and irrigation purposes. Despite this potential, only a few windmills have been installed in the country. Results from Chisamba by Conservation Farming Project indicate that windmills can be used for irrigation purposes of up to 2 Hectares.

In tests of treadle pumps (hand operated) small farmers were able to increase incomes between 600% and 800%. Irrigation allows them to: increase yields of existing crops during the traditional seasons; plant and increase production during dry season; and grow new crops. Incomes grow and risk is diversified owing to the introduction of new crops and planting/increasing yields in the dry season.

2.4.5. Geothermal

Zambia has more than eighty (80) hot springs. The Zambian hot springs are associated with zones of major deep seated fault and fracture systems along which water of mainly meteoric origin circulate to great depths and is heated through normal geothermal gradients. Most of the identified springs have not been examined in any great detail, but interpretations of geochemical data and estimation of subterranean temperature for some of them points to the existence of worthwhile and potentially exploitable low enthalpy geothermal reserves in most parts of the country. Zambia's potential has been estimated at 50 mW using conventional technology[16].

Little else has been done to utilize the springs for industrial or energy provision purposes owing in large part to the cost. At present there is no geothermal generation. However, following an initiative with the Italian Government in the mid 1980's, Kapisya was developed to the extent that 2 x 120kW turbines were installed in 1987. Unfortunately the Kapisya installation is not operational.

[16] Geothermal Association, International Geothermal Development Directory and Resource Guide, 2003, Washington, DC.

Two major problems confront the use of geothermal in the near future. First, resource assessment studies will need to be conducted and these studies are expensive. Thus, timing becomes an issue. Second, the cost of production (including exploration and development costs) are much higher than hydro, so economics is an issue. However, this should not discourage exploration and assessment. Geothermal costs are inversely related to the size of the facility so that costs will come down as the capacity to produce power is increased.

2.4.6. Cogeneration

Cogeneration is usually one of the most economically and environmentally attractive methods of producing electricity. Significant potential exists in Zambia at extractive industries, sugar mills and forest products. These facilities are usually located in rural areas and use primary energy resources to produce heat and steam. The challenge for Zambia will be to develop a business model to exploit these untapped resources. Plant owners may be reluctant to undertake the investment for a variety of reasons such as: (1) concern over what it would do to their production; (2) inability to sell power; and, (3) lack of access to financial resources.

Each of these technologies has a different cost and use profile that must be considered in determining its applicability to any given area and to the unique regulatory concerns. Table 2 summarizes the availability and potentials for the utilization of renewable energy sources and technologies. The advantages of PV are that it can be used in very small applications where other technologies are either not feasible or not economically feasible. For example, in very high value applications such as telecommunications, the cost of PV is only a minor part of the overall cost. Additionally, because of its size, it can be easily installed alongside the telecommunications equipment. Micro-mini hydro has advantages when there is sufficient steam flow and demand is larger. In time local technologies and approaches can be developed that further reduce cost. Geothermal is becoming an important source of renewable power but the economies of scale require larger capacity generation than most rural areas in Zambia can sustain.

Table 2: Availability and Potentials for Utilization of Renewable of Energy Resources and Technologies in Zambia[17]

Renewable Energy Source/Technology	Opportunities/Use	Resource Availability	Potential Energy Output
PV	Small scale use, Thermal, Electricity (water pumping, lighting, refrigeration)	6-8 sunshine hours	5.5 kWh/m2/day (modest potential especially for limited irrigation)
Wind	Mechanical (water	Average 2.5 m/s	Good potential,

[17] Adapted from "Opportunities, Barriers and Policy Dialogue Process to Promote the Use of Renewable Energy Technologies (RETs) and Energy Efficiency for Sustainable Development With Particular Reference to Poverty Reduction", Prof. F. D. Yamba, Director, Centre for Energy, Environment and Engineering Zambia Ltd (CEEEZ), March 23, 2004

	pumping/milling)		especially for irrigation
Micro-hydro	Electricity, Mechanical (water pumping/milling)	Reasonably extensive	Requires elaboration and quantification
Geothermal	Direct Heat for drying, Electricity, Heating, Greenhouses	50 MW	Requires elaboration and quantification
Biomass *(combustion and gasification)*	Electricity generation	Agro wastes Forest wastes Sawmill wastes	

Table 3 presents the average costs for mainstream renewable electricity technologies based on projects throughout the world. These represent costs from successful projects and thus represent best case scenarios. Exploration and development costs are not included in the case of geothermal. These omitted costs can be significant considering the depth required to drill, the number of wells required and the drilling costs.

The cost of renewable energy is heavily influenced as much by the cost of the technology as it is by the availability and quality of the resource that powers the technology. For example, a wind generator at the average speed of 3 m\s in Zambia will cost more than 3 times that when the wind speed is doubled on the same system. The costs presented in Table 3 are illustrative indicating the prices that can be achieved under best conditions and as such which technologies are to be preferred. The actual choice of technology will depend on the application, the size of the market, and resource quality.

Table 3 presents levelized cost estimates for various off-grid technologies.

Technology	**Levelized Cost ($c/kWh)**	**Primary Advantages**	**Primary Disadvantages**
Diesel	20(1)	Easily portable, quick to install	Expensive, imported fuel, pollution
Small Hydro	3.5 – 8.0	Low cost; can use high local content	Availability of water
Solar PV	34.5-46.0	Small scale operations below the threshold of other renewables, Easily portable, quick to install, clean	Expensive
Geothermal	5 -10 (2)	Low cost base load	Limited resource, high maintenance, often remote from population

Wind	4.1-6.0	Low cost	Zambia's winds too slow for economic generation

(1) Based on estimate of ZESCO's cost for diesel production.
(2) Excludes exploration and development costs.

2.5. Demand/Consumers

In a typical market for electricity, consumers are usually divided into three or four groups based on the characteristics of their demand; residential, commercial, industrial and agricultural. In rural Zambia, consumers will most likely fall into the following classes:

- Government (schools, clinics, offices),
- Economic Uses – irrigation, milling, agro-business, other business
- Residential Use.

Zambia's rural situation is challenging. Nationally, 95% of all rural households are involved in agriculture as their main source of income. As shown in Table 4, the percentage of households engaged in agriculture ranges from a low of 83% in Lusaka province to 97% in the Central, Eastern, Luapula, and North-western Provinces. The vast majority of Zambia's rural population are at or below the subsistence level of $1 a day. In 1991, 69.7% of the population was determined to be unable to sufficiently feed themselves. By 1997 this figure had risen to 73%.[18] Fifty-eight percent of the rural population has only two meals a day and another 11 percent only one meal a day. Zambia's rural population is very poor and sparsely located, with approximately 14 persons per square kilometer, including urban areas.

Table 4. Rural Households involved in Agriculture 2002-2003[19]

Province	Number of Households	Agricultural Households	Percent Agricultural
All Zambia	1,329,702	1,266,971	95%
Central	148,369	144,486	97%
Copperbelt	71,639	61,717	86%
Eastern	252,650	245,621	97%
Luapula	144,967	140,042	97%
Lusaka	45,907	38,154	83%
Northern	238,197	228,089	96%
North-western	103,361	100,204	97%
Southern	175,218	165,044	94%

[18] Zambia's Poverty Reduction Strategy Paper, page 22
[19] Source: Living Conditions Monitoring Survey Report 2002-2003, Central Statistical Office, Government of Zambia.

Western	149,059	143,614	96%
All Rural	1,329,367	1,266,971	95%

The average rural household monthly income was estimated to be 283,796 kwatcha (K). However, this must be viewed with caution for at least three reasons: (1) people tend to less accurately report their income than expenditures, (2) 48% of this was imputed income from consumption of own agricultural produce and the imputation may not reflect market prices for the self consumed goods, and (3) people will tend to underreport or not report at all begging or borrowing. Expenditures are a more reliable indicator.

Table 5 presents monthly expenditure data for 2002-2003. Mean rural household expenditures including self produced food totaled 386,676K per month. Since the bulk of rural peoples are at or below the poverty level, the expenditures devoted to food are not discretionary. In other words, at the subsistence level they are highly unlikely to divert spending from food to nonfood items and some portion of additional income is likely to go to food. Approximately 18% of total expenditures or 70,596K was spent on non-food items per month and mean monthly expenditures on household utilities including energy was 3,530K. Rural households consistently spend 5% of their monthly non-food expenditures on household utilities with the exception of large farmers.

Table 5. Monthly Expenditures by Household Type in Kwatcha, 2002-2003

Consumer	Total Expenditure	Nonfood Expenditure	Expenditure on Utilities	Percent Nonfood to Total Expenditures	Utilities as % of Nonfood Expenditure
All Zambia	490,530	115,536	6,932	24%	6%
Rural	386,676	70,596	3,530	18%	5%
Small Scale Farmer	377,001	65,016	3,251	17%	5%
Medium Scale Farmer	759,491	213,443	10,672	28%	5%
Large Scale Farmer	1,869,494	786,572	110,120	42%	14%
Non-Ag Household	286,862	122,322	6,116	43%	5%

Utilities represent items such as water, energy, and phone. To put this in perspective, if we assume that the average rural household spent all of its utility budget on electricity at 207 kwatcha per kwh, this family could consume slightly more than 17 kwh per month or enough to power 2, 60 watt light bulbs for a little less than 5 hours per day. However, it is unlikely that the typical rural family could spend all of its utility expenditures on lighting. Table 6 on the following page shows the principal energy sources for lighting and cooking in rural areas.

Only 3% of rural households use electricity for lighting while paraffin and kerosene are the main source of lighting, accounting for 63 percent of rural households main lighting energy source. Other surveys indicate that the bulk is actually paraffin. Note that the main source of cooking fuel, 88% for rural households, is from self collected fire wood where there is no monetary outlay. This information is valuable because it tells us how much of a rural household's money income is devoted to energy. Clearly for many families on the lower end of the income spectrum, the vast majority of energy services are self supplied – that is through the gathering of fuel wood, crop residues, and other biomass. Energy expenditures were dominated by wood, charcoal, paraffin and candles. Wood and charcoal are used mainly for cooking and heating, while paraffin and candles are the main source of lighting.

It is important to note that the above discussion assumes that people can move from their current energy source to electricity without any conversion costs. Conversion costs include the cost of installation or hookup and also the cost of new appliances for electricity. For example, a home switching to electricity would need to purchase wiring and meters as well as light bulbs. Empirical evidence from the developing world clearly indicates that households transition to different forms of energy based on complex economic, cultural, technical and social relationships. People do not just go from cooking on firewood to cooking on electricity. Additionally, if they used a certain amount of lumens or btus in, for example, lighting, they don't use the same amount when moving up from candles to kerosene or from kerosene to electricity.

These findings lead to several major conclusions that have profound implications for regulating the market.

- First, given these income levels, some electricity services will need to be subsidized. As shown above, if rural households were putting all their utility expenditures on lighting, this would mean consumption of 17 kWh per month or enough to run two 60 W electric light bulbs for about 5 hours per day.

- Second, residential energy use will be very limited and there is a definite transitioning in energy use that takes place. The order of use will most likely be lighting, radio, fan, TV, and then an iron or some other small appliance. It will be a long time before electricity takes on uses for cooking and heating. This means that until incomes rise significantly, only a small portion of energy expenditures will be directed to electricity. **Residential consumers will consume very small amounts of electricity for the foreseeable future.**

- Third, another problem exists because of such low income levels and imperfect markets. Even if consumers were willing and able to afford the full cost electricity per kilowatt hour, they certainly could not afford the connection costs. This is called the first cost problem. For example, it has been estimated that the cost of purchasing a small solar home system would be 61% of a typical Zambian households annual income.[20] In essence, it means that even if consumers would benefit or save money by paying their monthly electricity bill, they could not afford the "first cost" of opting in to electricity consumption. With rural Zambians spending 82% of their income on food, they would be unable without some form of subsidy to purchase a SHS. This leads many countries to subsidize connection costs even if they do not subsidize consumption or to provide other forms of concessional financing.

[20] Renewable Energy Strategies for Rural Africa, AFREPREN.

- Fourth, even when the first cost problem is overcome, the low population density coupled with the low income and low demand, will mean that either: (a) the consumption will need to be met by small modular units like solar; or (b) that a base load needs to be identified and developed such as a school or clinic or a larger scale economic use such as milling or irrigation.

- Together, these first four conclusions lead to a fifth and sixth conclusion that will have profound implications for the implementation of rural electrification in Zambia.

- Fifth, where incomes and consumption are unlikely to support electricity, then rural electrification may need to focus on finding or creating a customer that can act as the base load and subsidize the other users[21]. Productive uses of electricity that will reduce costs, increase incomes or both. This must be the cornerstone for most rural electrification activities. It also means that this productive use will subsidize other consumers. Productive use here can be defined as either income generating activities such as milling or irrigation or end use in clinics or schools.

- There is an important difference between these two types of productive uses. In the first case, the productive uses are those that have economic impacts in the near term and those act to increase consumption and ability to pay because the demand for electricity grows as income increases. This first case impacts rural electrification in two ways. First, it acts as a base load with the consequent reductions in the cost of supply. Second, in the near term it increases economic activity in the area and increases demand due to the positive spillover effects. In the second case, those that consume education and health services will see an economic impact but it is usually in the distant future. The second use can benefit rural electrification by acting as a base load and reducing costs in that manner. The danger herein for the project sponsor is the payment record of the Ministry of Education and Health for such services.

- Sixth, in the case of income generating activities, subsidization will be required in almost all cases because of the first cost problem. For example, farmers will undoubtedly benefit from using electricity to irrigate their lands. Recent studies show an increase in farm incomes between 600% and 800% from the introduction of small hand-pumps on rural farms in Zambia. However, with the pump costs of US $90, farmers could not afford to purchase the pumps without some form of credit that takes into account the timing between planting, harvesting and sale and the precarious financial condition of subsistence farmers. Low cost credit schemes will also be needed for many productive uses.

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[21] This subsidization can be indirect in that the increase consumption allows economies of scale in supply and lower costs. For example, the project sponsor identifies the use of electricity for a grain mill and then uses mini hydro instead of solar. This will result in lower costs of production for all users. The subsidization can be direct when the base load use pays more than its marginal supply costs, thereby lowering the amount needed to be covered from other users.

Percentage Distribution of Households by Main Type of Lighting Energy

Consumer	Kerosene/Paraffin	Electricity	Candle	Diesel	Open Fire	Solar Panel	Other	Total
All Zambia	51	18	11	6	11	0	3	100
Rural	63	3	5	9	16	0	4	100
Small Scale Farmer	64	2	4	9	16	0	5	100
Medium Scale Farmer	74	4	6	8	4	3	1	100
Large Scale Farmer	41	37	10	4	8	0	0	100
Non-Ag Household	53	16	14	9	7	0	1	100

Percentage Distribution of Households by Main Type of Cooking Energy

Consumer	Collect Own Wood	Purchase wood	Make Own Charcoal	Purchase Charcoal	Kerosene Paraffin	Electricity	Crop Livestock Residues	Gas	Total
All Zambia	60	2	2	20	0	15	0	0	99
Rural	88	2	3	5	0	1	1	0	100
Small Scale Farmer	90	1	3	4	0	1	1		100
Medium Scale Farmer	91	2	1	2	0	3	0	0	99
Large Scale Farmer	48	0	16	0	0	29		7	100
Non-Ag Household	58	7	2	25	1	7	0	0	100

Source: Central Statistical Office, Living Conditions Survey, 2002-2003

3. Regulating Rural Electricity

3.1. The Role of Regulation

To fully understand what the ERB's role in rural electricity should or could be, one needs to start with the basic question of why the Government of Zambia regulates electricity. It is important to start there because many of those simple assumptions that form the basis for any action are often long forgotten after years of performing the action. Questioning why this was done will help ERB understand how it must proceed in the new sector, the rural sector. The Government regulates electricity, meaning for the most part ZESCO, to protect consumers because ZESCO is a monopoly and to provide ZESCO a basis for reasonable cost recovery in their rates. In other words, ERB regulates the sector because it is perceived as a monopoly, operates as such and prudent practice dictates that regulation is the answer. Of course, for now the market is mainly one player, ZESCO.

Throughout the world regulation of the electricity sector has usually come about as a reaction to some problem in the market. For example, in the U.S., the main reason for public utility regulation was to control excesses of monopolistic power and unbridled competition. In contrast, in developing countries, regulation was often imposed by donors to remove political pressure on national utilities and to raise tariffs. In this manner, tariffs and obligation to serve are regulated.

Regulation is also designed to protect investments made in plant equipment and appliances through the implementation of technical standards. ERB is well equipped to understand and deal with this aspect of regulation as it is the traditional role of regulators. However, restructuring has brought new attention to regulation in the areas of introducing competition as well as in finding ways of increasing and rewarding utility efficiency. This concept of introducing competition and promoting efficient behavior will be new to most regulators, as it is, no doubt, to ERB.

If rural electrification is to take place on the scale necessary to invigorate Zambia's economy, then regulation must focus on new areas. This chapter presents areas of focus in which the role of regulation will expand to facilitate rural electrification, the experiences of other countries and the tools available to ERB to regulate the sector. Experience has shown, as mentioned earlier, that new, innovative areas of focus often arise by involving new players in the process. So the process is part of as important as the areas. Chapter four will present our recommendations on both the process and the areas.

Create a market and protecting the investor

The market for rural electricity, long the domain of a ZESCO with monopoly supply rights, is almost non-existent. The introduction of the new law, with its accompanying policy alterations, will now change this. The private sector is now the primary instigator of rural electrification, albeit with Government funding support. It is essential to develop the rules, currently missing, by which these new market entrants will operate. The new law and policy must be accompanied by enabling rules and regulation to ensure a greater likelihood of success.

Lesson: **"**The private sector can be attracted to participate in rural electrification schemes, even in a poor country, if the appropriate legal framework and risk management options are in place, including the assurance of a level playing field in terms of competition and ability to charge full cost-recovery tariffs."[22]

A new, and perhaps most important, role for regulation in rural electrification exists in the Zambian context. This role stems from the need to promote rural electrification by helping to create conditions that are favorable to a market for rural energy services where a market does not exist for the most part. While rural markets in Zambia are far from perfect, regulation is required and has the power to correct these imperfections. ***If private parties are to risk their capital, then the rules of the game must be clearly defined, constant and robust, and measures put in place to correct for market imperfections.*** The playing field must also be level, that is competition must be fair. The main rules of the game concern competition, pricing (tariffs), technical standards and guidelines and quality or obligation to serve.

Competition

At one time or another all industries face competition, even regulated monopolies. Take ZESCO as an example. While the ERB does grant it freedom from competition with another electric utility in urban areas, it does have to compete with other fuels for lighting or cooking. The reasons for protection are well known and they apply not only to urban based utilities but also to some classes of rural industries. The questions of importance to ERB and potential RES are:

- When is competition desirable?
- What constitutes fair competition?
- How will they compete and under what conditions?
- What types of rural electricity suppliers should be protected by monopoly status?

The answers to these questions and the certainty of those answers impact the cost and risk associated with the investment in rural electricity. In rural Zambia the competition can be another form of energy, say kerosene for lighting or LPG for cooking. It could be ZESCO putting in a distribution line to the RES service territory. Or to a company selling dry cell batteries it could be a company selling solar home services (SHS).

Competition, that is fair competition, is a good thing for society as a whole. It spurs innovation, constrains prices and engenders efficiency. Every regulator knows the benefits of competition and the reasons for bridling it. We can all recall the economic textbook reasons for favoring competition and the general conditions under which

[22] Mozambique: Private Participation in Isolated Electrical Grids, World Bank, Infobriefs, No. 62, March 2001.

competition must be bridled either by allowing monopoly provision or by establishing rules of how market players may act.

A level playing field or fair competition means that companies that compete against each other, including ZESCO, face equitable and reasonable treatment. For example, unless transparent dispatch rules are established based on economic merit order, private companies could face a disadvantage in selling their power compared to ZESCO. A uniform transmission tariff discriminates against generators that are closer to the load center. A subsidy on diesel discriminates against renewable energy. Moreover, it can be effectively argued that even market pricing of diesel is not economically efficient and is discriminatory in the face of scarce foreign exchange. Regulatory intervention is required to level the playing field. When one competitor is subsidized and another is not, this is unfair competition. When one competitor controls a critical part of the infrastructure and rules are not written to allow fair and equitable access, this is unfair competition.

There are exceptions to the general fair competition rule. As discussed above, networked industries have been seen as "natural monopolies" where one firm could meet demand less expensively than multiple firms due to increasing economies of scale. This is the most often used justification for regulation of electricity. Society, as well as individual consumers, benefits from the lower costs by allowing only one company to supply electricity. This holds for rural areas as well. The key is determining the market over which increasing economies of scale hold. For example, it is clear that economies of scale apply to the distribution of electricity in Lusaka and so a monopoly is granted for the supply of networked electricity in Lusaka. Is it less clear that increasing economies of scale continue if the same company is granted a monopoly for, say, Ndola. It stands to reason then that there are economies of scale in the provision of micro-hydro to a small village. Table 4 below presents the salient characteristics of rural electricity technologies and the general practice in granting them concessions.

Table 4. Rural Energy Technologies and Concessions

Technology	**Rural Mini-Grid Under Zambia Conditions**	**Economies of Scale**	**Concessions**
Diesel	Yes	Yes	Many countries
Small Hydro	Yes	Yes	Many countries
Solar PV	No	No	No, but licensed dealers
Geothermal	Yes	Yes	Many countries
Wind	No	No	No

As Table 4 points out there are many rural electricity technologies that will benefit from concessions. This does not mean that competition can't play an important role in the provision of electricity to that small village. Nor does it mean that at some point in time that competition in that village market will not serve the interests of consumers. At this point in time, the place for competition is in deciding who will be given the supply monopoly or concession for the village. When the concessionaire has met the conditions of the concession or the market has outstripped supply, competition is again a vehicle for deciding who and how supply will be made.

In the Zambian context there are two related issues with regard to ZESCO and competition. First, it is not clear how ZESCO incorporates the true costs of supplying power when it makes a decision to expand coverage to rural areas, if it does at all. If fair competition is instituted and there is an accompanying decrease in Government rural electricity subsidies, then ZESCO's true supply costs need to be utilized when it competes to supply a particular rural area. Second, as the current situation does not protect investors, ZESCO can enter a market without regard to the cost of entry and then supply power at subsidized rates. This puts any Private Rural Energy Services (RES) provider at a risk that is difficult to measure accurately.

Zambia has already witnessed examples of this. There are two ways to deal with this in the current context. First, provide a concession that guarantees the RES a protected service area. Second, if ZESCO decides to supply an area that is already fully served, require ZESCO to purchase power from the RES at the rates and amount that it would have been providing in its service area. Both of these measures protect the RES's investment. Presumably the Government is subsidizing rural electrification in either case and a well implemented rural electrification plan will minimize the supply cost for any given market area. In other words, the time to determine who will supply power and when that relationship may change, if need be, is before any investment has taken place and potential investors should be guaranteed of this. In conjunction with these two methods of governing access, ERB can require ZESCO to prepare a least-cost expansion plan that is based purely on the economics of supply where the cost of expansion includes all the costs without regard to subsidies.

Concessions are a powerful regulatory tool that is used to protect investors and this is discussed in greater detailed in a following section of this chapter.

The ZESCO Challenge

ZESCO presents additional challenges for rural electrification because of items such as its continued subsidization of electricity, pricing of and access to transmission services and one price for power despite its cost of generation. The decision to subsidize and how to subsidize is a policy decision. It is our assumption though that the Government will wish to minimize the subsidy for any given supply project. That is that Government is indifferent as to who supplies power only that power be supplied in the most cost-effective manner, thereby lowering the cost of subsidization. The focus of this section is the negative impact that current ZESCO operating procedures are likely to have on rural electrification and what can be done to ameliorate this negative impact. Investment in rural electrification is lower and expensive than it should be, without clear, sensible market rules.

Lesson: Regulations should be set so that: independent power producers can supply power to the grid at 'realistic' prices; and connection standards are appropriate for the power to be sold."[23]

Lesson: "One of the fundamental problems facing renewable power producers is that reformed power markets have pricing mechanisms or rules that favour steady, predictable flows of power, which renewable sources are not. Another problem is that the metering systems are not set up to measure two-way flow so that there is no mechanism for dealing with home-producers or industrial self-generators who want to sell their electricity at peak renewable source periods but buy when their system is not able to generate power."[24]

Another way that ZESCO's practices discourage rural electrification is through pricing of transmission services. ZESCO currently uses a postage stamp rate. It charges a flat fee to send power from any location on the grid to any other location. However, the costs are not the same due to a variety of factors from congestion to line losses. This means it may be cheaper to supply power close to the demand center rather than further away. Private rural electrification suppliers should be rewarded for lowering the cost of supply. Conversely, the current postage stamp practice would mean that rural suppliers that are close to their demand centers are unduly penalized with higher costs. Other countries are acknowledging this problem and moving to level the playing field. For example, "a special committee on distributive generation in India recommends that wheeling prices "should be related to reasonable levels of transmission and distribution losses of the (state owned utility)".[25]

Providing for an appropriate return on invested capital is another important rule of the game. Realizing that residential use must be subsidized and the productive uses may require incubation, tariffs structuring must be creative. It must recognize the need for subsidization of capital costs for both the electrical system and, perhaps, the productive use equipment. For example, the Government may need to subsidize not only the construction cost of the mini-hydro but also the drilling of tube wells and the pump to draw water for irrigation.

Defining the market rules reduces both risk and transaction costs. ERB can perform an important role in this area. However, there is an equally important and perhaps, more direct route to reducing costs that requires ERB to take on that role.

[23] Best Practices for Sustainable Development of Micro Hydro Power, ITDG, March 2000. Similar observations appear in numerous case studies and best practice guides such as the Asian Development Bank's Best Practices for Promoting Private Sector Infrastructure Investment.
[24] Renewable Power Policy: Regulatory Approaches Worldwide, World Energy Council. 2001.
[25] Increasing Energy Access in Developing Countries: The Role of Distributed Generation, Business Council for Sustainable Energy, May 2004.

Reducing Costs

Lesson: "Privatization of infrastructure services is often followed by stricter enforcement of quality standards, which pushes up costs, maintaining or worsening the exclusion of the poor." [26]

Lesson: It is possible to significantly reduce electrification costs via lower-cost options, i.e. independent grids rather than costly transmission extensions."[27]

Costs of rural electrification are high due to, among other factors, low population density, low per household consumption, distance from the grid and scale of generation. There is little that can be done by regulators to influence these factors. These cost considerations notwithstanding, there are still important ways that costs can be reduced through prudent regulatory intervention. For example, technical standards must be written based on the needs of an isolated, rural system rather than, as is usually done, based on the grid connected system with areas of higher per household consumption. In other cases, guidelines can help local project sponsors by reducing search costs. Many of the local project sponsors will not have technical energy skills and their costs will increase as they hire consultants to determine the best configuration for technical parameters such as residential wiring and metering. By prescribing standards and guidelines costs are reduced in several ways.

- First, more realistic technical standards are used. For example, there is a significant cost reduction from three phase to single phase and from single phase to single wire earth return (SWER). Standards could mandate either single phase or SWER.
- Second, by prescribing certain equipment, costs can be reduced as the demand for that equipment increases. ERB can induce economies of scale.
- Third, through the promulgation of guidelines and standards, ERB can help to reduce the costs of determining which equipment to use or how to configure it. It can also overcome certain misconceptions. For example, in a quick survey of knowledgeable persons, we found a bias in using single phase because of the belief that single phase will not provide the power that is needed for even modest requirements or that single phase motors are not strong enough to lift water for irrigation.

Another way that regulation can reduce cost, both private and social, is through avoiding duplication. Each service area is isolated; the market is small; the ability to pay is low; and the capital costs are large relative to the market: one service provider is likely to be socially preferable. Early examples in the U.S. of multiple companies providing utility services lead to excessive investment and bankruptcy. Companies had, for example, duplicate distribution lines to the same area when one was sufficient. To be sure this promoted competition but at a cost. It was deemed that the cost of competition, i.e. duplication of infrastructure, was greater than the efficiency gains from

[26] Public Policy for the Private Sector, Note 219, October 2000, World Bank.
[27] Mozambique: Private Participation in Isolated Electrical Grids, World Bank, Infobriefs, No. 62, March 2001.

competition and so regulated monopolies or concessions were created. Competition can be interjected into the bidding process or the process that selects concessionaires and awards the concessions.

A country like Zambia can ill afford to waste precious capital in duplication. Regulation then, by restricting market entry, creates a monopoly provider to protect the investor and to lower social cost. At the same time, it must now protect consumers from the monopolist's natural tendency to manipulate price or service.

3.2. Regulatory Tools

3.2.1. Market Access – Licenses and Concessions

Regulatory agencies routinely use licenses to restrict access to the industry in general. Currently the ERB has the authority to license captive generation above 100 kW and all other generation, transmission, distribution or supply undertakings. Licensing can range from detailed requirements to a simple gathering of information about the operator and the proposed operation. Some countries do not require licenses for generation and distribution in rural areas, India for example. Others have a cap on generation. For example, several countries exclude generators below 5 MW. Nepal excludes rural hydro generators below 1 MW. The main advantages of a license for off-grid remote electrification are that it (i) provides a legal basis for any activities that the ERB or GRZ may wish to carryout and (ii) it can provide important information on the development of the industry, which information is important for planning and policy purposes. The important point for ERB consideration is that prudent regulation matches cost against the benefit of regulation and it is extremely likely that for off-grid remote electrification that there can and should be some exclusion from strict licensing requirements. The license confers on the recipient the legal right to operate in a manner provided for in the license.

The ERB also has the right to license retail dealers. For example, solar equipment dealers or ESCOs can be licensed. The dealer license can be used to set standards and help to insure consumers of the technical capabilities of the dealer. For example, experience in many African countries with PV systems has not always been good because the units were improperly assembled, installed or maintained. This has led to a loss of public faith and retrenchment of the rural solar programs. The public can be protected through licenses of dealers much as they can through licenses of generating companies.

A concession, new to the electricity sector in Zambia, confers market privileges upon the recipient. An example of these privileges is the granting of some form of exclusivity to serve the market. For example, a concession may be granted for a period of 10 years to serve a specific geographic area exclusively. With this privilege comes the obligation to provide service to all customers in the area that want service and are willing to pay for it. Countries using the concession model include Argentina, China, India, Morocco, the Philippines, South Africa and Sri Lanka. The government may provide subsidies as well as regulate the fees and operations of the concession. This was one of the main reasons for electric utility regulation in the U.S. In the Zambian context it is important as, at this time, there are no legal restrictions for the operation of ZESCO. While ZESCO's rural electrification is still subject to political direction it is not restricted to either specific geographic areas, nor is it required, by regulatory writ, to provide economic justification for expansion activities.

In addition to the need to shield investors from non-commercial decision made by ZESCO, there are a number of other reasons why competition may be inappropriate:

- Firstly, there may be some natural monopoly elements to this industry (i.e. costs may decrease significantly with size). For example, systems to offer back-up and maintenance services may involve considerable fixed and sunk costs, and so efficiency is improved if only one company supplies these services. However, it is not obvious that these factors are any more acute in this industry than in others.
- Secondly, it is apparent that private companies competing to provide electricity services in any one area may prove unacceptable or confusing to rural customers, especially since people are used to electricity being provided by a single public utility. While there may be some confusion when different systems and prices are offered by competing companies, our opinion is that rural markets are as amenable to competition as other markets.
- Thirdly, the precarious financial viability of these business operations, given the limited ability of rural consumers to pay, suggests that competition may increase risks to the point that investors are unwilling to enter the market. In this case, monopoly concessions may lower risks by providing a temporary level of protection to the "infant industry". However, concessions should be awarded on condition that, concessionaires who fail to carry out the terms of their concessions and government objectives can be penalised by the introduction of competition and reward concessionaires who implement the terms of their concession agreements and government objectives.
- Fourthly, if Government wishes to impose an obligation to supply all customers at standard prices, then companies may require a monopoly licence to ensure their financial viability. That is, the obligation implies that they will have to cross-subsidise less profitable customers with revenue from more profitable customers. This is only sustainable if other companies are prevented from "cherry picking" and so undermining the viability of the concessionaire.

It is concluded that the third and fourth reasons may have merit, and provide a rationale for the award of monopoly supply rights. Reason three suggests that a temporary monopoly should be awarded until the industry is mature enough for risks to have reduced. Reason four suggests that a longer-term monopoly right may be appropriate, although the same effect can be achieved by requiring that all companies offer standard tariff rates within an area.

3.2.2. Standards and Guidelines

Lesson: **"**The setting of appropriate technical standards is an important aspect of quality control. Without such standards the lowest capital cost is likely to dominate, with unacceptable compromises in safety and reliability. Some element of consumer protection is needed if the market for off-grid systems is to grow. There are opportunities to reduce the cost of distribution in comparison with conventional electrification, without compromising safety or reliability (experience in South Africa, Nepal, Peru), but there is a need for a national authority to co-ordinate and set the standards and to train and accredit suppliers and consultants."[28]

Lesson: "Creation of a national certification and labeling program for RE hardware systems can protect consumes from low quality products. Even small quantities of low quality hardware can be detrimental to a growing market…"[29]

Regulatory bodies provide standards from grid and distribution codes to standards for poles, wiring and meters, and standards for solar pv equipment and appliances. In selecting these standards the regulator considers safety, reliability, versatility and flexibility. The choice of these standards can dramatically impacts costs. Standards and guidelines can encourage efficient behavior or discourage it. For example, rural electrification can take place over a single-phase, two phase or three-phase system. Often the standard is three-phase simply because that is the way that normal grid expansion has taken place. The cost of a kilometer of three-phase transmission line averages around $9,000 per kilometer while the cost for single phase is around $6,000[30]. Single wire earth return (SWER) is a recent innovation in rural electrification that is taking hold due to its simplicity and cost saving.

Regulators have traditionally adopted higher standards than are needed for rural electrification for four main reasons:

- First, electricity standards were often instituted by colonial powers based upon their needs to have electrified urban areas. This set the stage for future standards to be over-designed.
- Second, there is inertia in adopting rules and practices that are in place and with which the industry is already familiar.
- Third, regulatory staff is often hired from the utility and they rely on the standards with which they are already familiar.
- Fourth, there is a tendency to adopt the best, latest standards which often come from developed country standards. Designed under very different conditions then those existing in developing countries rural areas, they may not be the most effective instrument. "While lower cost alternatives do exist in developed

[28] Decentralised Rural Electrification: The Critical Success Factors, Intermediate Technology Development Group.
[29] Non-grid Renewable Energy Policies, Center for Resource Solutions, 2001.
[30] NRECA, February 2000.

> countries, they are no longer the norm so they are not necessarily considered when setting standards in developing countries.[31]"

Another advantage of standards or guidelines is that, through standardization, a variety of costs can be reduced. This becomes especially important given that much of the village electrification will be carried out by small, inexperienced entities. Guidelines and standards will help reduce information costs. For example, if guidelines recommend single-phase power for village electrification, then several positive things happen. First, the supplier's costs will be lower because they will spend less time on deciding which approach to use. Second, equipment costs will be lower, because there is a larger market for single-phase equipment. For example, single-phase motors may not be readily available in the market and therefore, are expensive. If guidelines shift people in the direction of single-phase power, the demand for single-phase motors will increase and with time, costs will decline.

The following sections present areas where reduced standards have been applied successful elsewhere and where these reduced standards have resulted in significant cost savings without any significant deterioration in other parameters. This section is not intended to serve as complete guide but rather to illustrate ways that thinking beyond conventional practice can help to reduce cost. An elaborate bibliography is presented to assist ERB and appendices contain important detailed guides from publicly available sources.

1. **Poles:**

Most countries adopt the U.S. or European standard heights for the electric poles and thereby use taller poles than are really required for the necessary clearance. Smaller heights also mean smaller diameter poles. It has been estimated that reducing a treated wooden pole from 12 meters to 10 meters, 17%, lowers costs by 24 percent. Or reducing a pole from 10 to 8 meters lowers costs 28 percent[32]. Even greater cost reductions have been seen in village mini-grids through the use of indigenous materials or even live trees. The point being made here for the ERB is that it should not blindly adopt existing pole standards but rather look at the conditions that are expected to exist in these areas and look at life cycle costs to develop appropriate local standards.

2. **Longer Spans**

Increasing the length between poles or span is another way of reducing cost. Clearly, the longer the span, the higher the pole must be. There exists a trade off that should be examined. Line costs decrease with increasing span despite higher pole heights. Longer spans are suited for relatively flat areas. El Salvador, for example, uses 10.6 meter poles with spans averaging 135 meters compared to an average of 90 meters with poles of similar lengths in other countries.

[31] Bill Baker and Sophie Tremolet, Utility Reform, World Bank, October 2000.
[32] Reducing the Cost of Grid Expansion for Rural Electrification, ESMAP, World Bank, February 2000.

3. Phase

Medium voltage lines in rural areas of developing countries are typically three-phase following on the urban requirements. Three-phase has been preferred because of its higher efficiency in transmitting power. While the argument for preferring three-phase of high and medium voltages long distances and/or to large load centers is sound, the same economics does not necessarily apply to rural lines serving low load centers and at distance from the main line or power source. "For example, an 11-kV, single-phase line constructed with a very small conductor could serve a load of 1,000 kW-km, with voltage regulation still within 4 percent. Such a line could serve two remote communities of 100 to 200 household each, located 20 kilometers from the main line (or power source), each with a peak demand of 25kW. This reflects a typical demand for grid-connected rural consumers."[33] As mentioned earlier, going from a three to a single-phase can reduce costs by 30 to 40 percent. It should be noted that using single-phase for rural electrification is not a new approach. In the 1930's when only 11% of the U.S. rural population has electricity access, a major new effort for rural electrification began and it began with a rethink of the then current three-phase standard. The result was a substantial reduction in cost. Today, many rural towns in the U.S. continue to be served by single-phase power

Single-phase power meets the power requirements of rural households and rural industry. Single-phase motors up to 10-horsepower are readily available. However, even larger three-phase motors can be economically and safely driven by single-phase power.

4. Single Wire Earth Return

Single wire earth return systems are the cutting edge of rural electrification and result in significant cost savings over single-phase. Costs are saved by using just a single high voltage conductor for the power grid, while routing the AC return current through the earth. This system is mostly used in rural areas where large earth currents will not otherwise cause hazards. Signal grounds serve as return paths for signals and power at low voltages (less than about 50V) within equipment, and on the signal interconnections between equipment. Many electronic designs feature a single return that acts as a reference for all signals. SWER can be found in countries such as Australia, Botswana, Brazil, Canada, India, Namibia, New Zealand, South Africa, and Tunisia.

Nampower in their January 2003 newsletter had the following to say about SWER.

"Powering the Nation and Beyond Single Wire Earth Return (SWER) power networks have been introduced to Namibia during 1994 to bring power to some of the more remote areas of the country.

[33] NRECA, February 2000, page 32.

Though fairly new, the SWER system has thus far proven to be a technically and financially effective method of providing rural as well as commercial farming areas and customers with power.

In general, the justification for using SWER for customers living in low-density areas is typically based on economics. The high cost of typical power lines and in the case of Namibia, the low consumer density of much of the un-electrified rural areas and communal and commercial farmland has made it imperative to explore every possible avenue in an effort to reduce the capital cost of electrifying those areas. The first advantage of a SWER scheme is its simple design, which allows for speedy construction. This applies particularly to the stringing of a single conductor as opposed to three conductors as for the conventional three-phase line and the fact that longer spans and therefore fewer poles can be used.

Similarly, a SWER line has reduced maintenance cost, as only one conductor is involved. Finally, the system is more reliable as every supporting structure is earthed by means of an earthing mat, minimising fault occurrences due to lightning. Although the system is still sensitive to lightning, technicians found the SWER to be far more reliable than the conventional three-phase line. Due to the remote location of these lines, vandalism is either minimal or completely absent. Since the introduction of the SWER system by NamPower in Southern Namibia five years ago, the system has operated with minimum call-outs and system outages. “

5. Metering

Companies must receive payment for the electricity they supply and metering is the means of measuring the service that each consumer receives. Metering is often driven by the tariff and the tariff often driven by regulation. Conventional energy meters are the most common method and they measure kilowatt hours consumed. These meters must be read to determine consumption and bills are prepared on this basis. In this manner the large utility recovers the cost of providing electricity.

The conditions facing the Zambian rural electricity supplier are very different, requiring a less expensive yet equally justifiable method for many rural consumers. Isolated rural distribution systems will be served by a power plant of limited capacity that will not be able to fulfill temporary spikes in demand by drawing on the resources of the national grid. Thus, metering needs to act as a brake on consumption and ensure an equitable distribution of power among customers. Conventional kilowatt hour meters cannot do this. Additionally, in most Zambian rural applications, the cost of conventional meters, meter reading and bill preparation will exceed the consumption amount by several hundred percent. Economics demand a different solution to allow for more distribution of power. Metering on the basis of power consumed, rather than per kilowatt hour, is the answer. For example, a typical rural household might use a few lights (preferably fluorescent tube lights) and radio and fan. This will normally be no more than 40 to 50 watts.

3.2.3. Tariffs

The issue of tariffs is of critical importance particularly in the face of subsidies. There are several lessons to be learned from years of successful experience if ERB is to use tariffs as an effective mechanism in rural electrification. The most important of these are:

Lesson: Subsidies on fuel unfairly bias the market against renewables and impose greater economic costs on the country because of the cost of foreign exchange and the recurring expenditures on fuel.

Levelling the playfield encompasses many things and subsidies on fuel are no exception.

Lesson: Charging the right price is important to the success of rural electrification efforts and rural customers can often pay the full cost of electricity. It is often believed that rural people can't afford to pay high prices for energy. "There is a widespread belief that electricity tariffs need to be extremely low, often well below their true supply costs, if rural electrification is to benefit rural people. The facts do not support this."[34]

Many rural peoples use batteries for powering lights, radios and small appliances. Batteries can provide electricity at a cost of between $3 to $10 per kWh. Consumers use kerosene and paraffin for lighting and inferior quality lighting at that. It would take 60 candles and 20 kerosene lamps to provide the same light quality as a 60W incandescent light bulb. Recent experience in Uganda and Laos indicate that rural consumers are willing and able to pay about $5 per month for alternatives to electricity such batteries, LPG, kerosene, battery charging. So strong was the willingness to pay, that private, unlicensed suppliers sprung up in Laos to fill this need. Zambia has direct experience here. Zambia also has relevant experience as shown by O.S. Kalumiana's observation that "a substantial number of rural households who desire SHS are able and willing to pay the service fee which in some cases is higher than that paid by urban electricity customers."[35]

Lesson: "Pricing (and subsidies) play an important role in determining project viability. A rational system of cost recovery (coupled with smarter ways of allocating subsidies where needed) is the most important factor in determining the long-term sustainability of RE programs"[36] and therefore in attracting investment to the sector.

We have already seen that rural people are paying a high price for energy and therefore can pay reasonable prices for electricity. In setting a tariff, the regulator must be sure that at a minimum operating and maintenance costs and capital

[34] Rural Electrification in the Developing World: A Summary of Lessons From Successful Programs, Douglas Barnes and Gerald Foley, December 2004, ESMAP.
[35] Rural Energy Access: Promoting Solar Home Systems in Rural Areas in Zambia – A Case Study, AFREPREN. O.S. Kalumiana.
[36] See Appendix 1.

replacement costs are covered[37]. In many cases this price will be higher than the price charged to grid connected customers.

Experience has shown that subsidies should not cover operating costs. The first best subsidy is concessionary financing and the second is capital investment subsidies. Provided that the tariff does allow capital replacement recovery and regulations are technology neutral, capital investment subsidies have little to no ill effect.

The tariff should be sufficiently high to recover all operating costs and include a provision for capital replacement. It is not always necessary to include a profit component if the rural supply entity is a community, a non-profit or a cooperative. The extent to which a subsidy is given should be reflected in the tariff calculation.

Lesson: "A flat kilowatt-hour tariff in an entire geographic area does not leave any possibility of promoting financially viable (rural electrification/renewable) programs unless a permanent subsidy for operation is available—which is not an acceptable solution. This is a common problem for many electric companies in rural centers, where they operate small power stations whose fuel costs higher than they can recoup by charging the legally allowed minimum sale price for electricity. Because the decentralized production of electricity is generally more expensive than grid production, it thus cannot be sold at the same price except with a subsidy." [38]

The connection to the lesson above is that a flat kilowatt-hour tariff would most likely result in an operating subsidy being required. This is already seen in Zambia in areas with a uniform national price. In areas served by ZESCO diesels, the cost of operation is thought to be as high as $0.20 per kwh, as compared to approximately $0.045 per kwh tariff. Thus, even though there is no explicit subsidy for operating costs, it is implicit in the one tariff fits all policy.

The cost, not the price, is the issue underlying successful rural electrification. The cost of rural electrification is a function of the technology, the delivery mode, business models, risk and regulation, and access to capital. Grid expansion has been very costly compared to decentralized delivery options particularly when serving very small loads. Many rural electrification programs have chosen the most costly method, grid expansion, and this coupled together with price subsidies have rendered the programs unsustainable.

Price Adjustments: Most forms of price regulation involve detailed understanding of the service provider's cost of service. Given that most RES will be renewable energy, the major costs will be labor, routine maintenance and capital replacement. Bench-marking is an effective way of comparing and assessing prices. Prices can also be adjusted based on performance and financial indicators. These rules must be clear and transparent.

[37] This is a stricter provision than many regulators follow. Their recommendation is to cover operating and maintenance costs at minimum. It is our contention, particularly in a subsidized program like Zambia's, that rural electrification will not be sustainable if there is no provision for capital replacement.

[38] Best Practice Manual: Promoting Decentralized Electrification Investment, ESMAP, October 2001.

How often and under what conditions will prices be adjusted? The simplest answer would be a fixed number of years such as every two or five years. For example, Argentina sets a price cap on the distribution margin for five years. However, it may also be necessary to let the concessionaire petition for an early price adjustment or for market conditions to trigger a price adjustment

Lesson: "Selling electricity per kilowatt-hour prevents the marketing of fixed-price "electricity services" that are specially adapted to small consumers. On the basis of the logic of the grid, the company sells electricity delivered directly to the house. It is "logical" then to measure the consumption and to invoice in proportion to volume consumed, establishing a range of tariffs that take into account social considerations or economic promotion. As is already evident in cities, this system has led to problems: most families do not have the means to finance the cost of connection and metering, while the cost of servicing customers with low electricity consumption is uneconomic for the utility."[39]

3.2.4. Environmental Impact Assessments

Zambia's Environmental Impact Assessment Regulations of 1997 states that "Hydro power schemes and electrification" require an environmental brief (Appendix C) along with preliminary environmental impact assessment. This would apply to all rural electrification projects. The relevant regulations are:

PROJECT BRIEFS[40]

3. (1) A developer shall not implement a project for which a project brief or an environmental impact statement is required under these Regulations, unless the project brief or an environmental impact assessment has been concluded in accordance with these Regulations and the Council has issued a decision letter.

(2) The requirement for a project brief applies to:-

(a) a developer of any project set out in the First Schedule, whether or not the developer is part of a previously approved project;

(b) any alterations or extensions of any existing project which is set out in the First Schedule, or;

(c) any project which is not specified in the First Schedule, but for which the Council determines a project brief should be prepared.

4. A developer shall prepare a project brief under regulation 3, stating in a concise manner:-

Project brief and environmental impact assessment

(a) the site description of the environment;

(b) the objectives and nature of the project and reasonable alternatives;

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39 Best Practice Manual: Promoting Decentralized Electrification Investment, ESMAP, October 2001.

40 Environmental Impact Assessment Regulations of 1997, Government of Zambia, Gazette February 21, 1997, Part II

(c) the main activities that will be undertaken during site preparation, and construction and after the development is operational;
(d) the raw and other materials that the project shall use;
(e) the products and by-products, including solid, liquid and gaseous waste generation;
(f) the noise level, heat and radioactive emissions, from normal and emergency operations;
(g) the expected socio-economic impacts of the project and the number of people that the project will resettle or employ, directly, during construction and operation etc;
(h) the expected environmental impact of the project, taking into account the provisions of paragraphs *(c) to (g);*
(i) the expected effects on bio-diversity, natural lands and geographical resources and the area of land and water that may be affected through time and space; and
(j) A description of adverse impact mitigation measures and any monitoring programmes to be implemented.

5. (1) A developer shall submit six copies of the project brief to the Council.
(2) If the Council considers the project brief to be complete, the Council shall transmit the project brief to the authorising agency for comments within seven days of receiving the project brief.
(3) The authorising agency referred to in sub-regulation (2) shall make comments and transmit them to the Council within thirty days of receiving the project brief.
(4) Where the agency fails to make comments or transmit the project brief to the Council wiithin the period specified in sub-regulation (2), the Council shall proceed to consider that project brief.

6. (1) The Council shall consider the project brief and the comments received.
(2) If the Council is satisfied that the project will have no significant impact on the environment, or that the project brief discloses sufficient mitigation measures to ensure the acceptability of the anticipated impacts, the Council shall within the forty days of receiving the project brief from the developer, issue a decision letter, with conditions as appropriate, to that effect, to the authorising agency."

While these requirements are not particularly onerous for large projects, they can be both very expensive and unnecessary for most of the off-grid rural electrification projects Zambia is likely to see. Many countries have adopted a waiver for small scale projects that have been determined to be relatively environmentally benign, such as small scale wind power, run of the river hydro or solar home systems.

4. Recommendations for Zambia

The ERB has an excellent opportunity to shape the way that rural electrification takes place, reduce costs through the choice of appropriate standards and guidelines, protect consumer and investor alike and promote rural development in the process. Based on the ERB's past performance, the needs of the sector and the information put forward in this paper, the following recommendations are put forward for consideration in the regulation of rural electrification.

4.1. The Process

One of the most common elements of successful RE programs is how regulators have infused the regulatory process with elements of the traditional and nontraditional. Successful programs require innovation and innovation requires looking at things a new way. This will often mean bringing people into the process that have not, heretofore, been part of the system.

We recommend that ERB set up committees to help develop RE regulations[41]. Three such committees could be:

1. Market Committee. The role of the market committee would be concerned with two broad aspects – (a) identify those areas where the playing field needs to be level and how to do it and (b) identify areas where regulation needs to be explicit and/or specific to promote investment, reduce cost or reduce risk. In addition to representation from ZESCO, the committee should have membership from other electricity producers and smaller producers such as suppliers of solar equipment. It should include members of the academic community concerned with competition and markets, not engineering, members of the financial community including micro finance institutions and potential rural energy providers.

2. Technical Committee. The role of the technical committee would be to determine the needs of rural electricity systems so as to set appropriate and cost-effective standards. In addition to ZESCO and mainline engineering firms or consultants, representatives from the renewable energy equipment industry and from neighboring countries should be invited. Namibia and South Africa have relevant experience for Zambia.

3. Tariff/Pricing Committee. The role of this committee is to develop recommendations for tariffs and pricing. Membership would include ZESCO, representatives of other energy producers and consumers, academics in economics and finance, and microfinance institutions.

[41] The recommendations above are not meant to be definitive but rather illustrative and the actual composition of the committees, their scope and duties should be subjective to a collaborative process.

In all cases, we assume that REA will be on the membership of the committees. WE further recommend that ERB through its membership in RERA involve other regulatory bodies and the experts that they may be able to call upon. We also assume that donors would be invited to participate given their experience and ability to furnish subject matter specialists. Finally, we believe that communities, community organizations and NGOs should participate.

Having determined the process by which regulations will be considered, the next step is to determine those areas or those that are most important. The following section is by no means complete. It represents the recommendations that we believe are most important to be considered at the outset.

4.2. Licensing: Most rural electricity supply entities should be licensed.

Licensing is important for a variety of reasons:

- First, it provides a legal basis from which to operate and thereby affords some protection to the investor.
- Second, it provides vital information on sector operations which information can form the basis for policy and planning.
- Third, it affords the consumer some protection to the extent that the license provides it.
- Fourth, and very important in the Zambian context, is that many of the rural electricity projects will be undertaken by small, inexperienced companies. The license procedure can help serve as the basis for a business plan, helping to increase the chances of success.

It is recommended then that:

1. all entities generating less than 100 kW for self use remain unless they are connected to grid supplied electricity as well.

2. all entities supplying less than 100 kW be licensed but pay no licensing fee and the informational requirements of the license be a reduced set of licensing larger, grid connected entities. At a minimum the license should include:

(i) A scope of service plan which sets forth a description of the geographic area the applicant plans to serve, the type of customers to be served, a description of the applicant’s proposed operations (e.g., generator and supplier of electric generation services; broker or marketer and supplier of electric generation services; or aggregator and supplier of electric generation services), and the services it plans to offer;

(ii) Documentation demonstrating the applicant’s technical, managerial and financial capability to provide electric generation services;

(iii) The applicant's legal name, a description of the applicant's form of ownership, and the name of the jurisdiction where the applicant is organized or formed;

(iv) require information about the owner/operator; the type of facility that will be operated and the technical characteristics of that facility and provide reference to the technical standards and guidelines and tariff procedures that should be followed.

4.3. Level the Playing Field

Lesson: "The private sector will not invest money into electricity generation (or any other aspect of the electricity sector) unless and until there is regulatory stability. Since regulators implement the law, regulatory actions become the framework within which electricity sector investments are made. The business community looks for a constant set of regulations and guidelines upon which investment decisions depend for their viability."

Many of the lessons presented in this report point to the need to level the playing field as the most effective way of creating the market. The first and foremost way of dealing with this is to have explicit regulations that lay open any subsidies (implicit or explicit), require national utilities to operate in a commercially responsive mode, allow open access to transmission and price services on the basis of economic considerations. The following recommendations will begin this process in Zambia.

1. Prohibit subsidization of operating costs, regardless of whether power is supplied in an urban or rural area, or by ZESCO or some other supplier.

   This puts all players and all stakeholders a similar footing. Currently the government subsidizes ZESCO operating costs, while the REF will subsidize capital investment. In addition to leveling the playing field, this will also put electricity projects on a sustainable path.

2. Mandate open access for transmission services and appropriate pricing of transmission services.

   Zambia wants to increase private participation in the power sector and to make its sector more efficient. Recognizing that open access to transmission services is a prerequisite for an efficient power system, ERB should require ZESCO to operate the transmission side of its business as a separate entity that provides open access to all parties and price transmission services based on distance, time and other pertinent parameters. This will have spill over effects into rural electrification because the overall system will be more efficient and as private investors seek to exploit renewable rural resources to supply distant markets through an open transmission system, surplus power may be available for local consumption.

   Open access in transmission will increase competition and supply and lower cost.

   Pricing based on location and other economic considerations will result in lower capital and operating costs to the system as a whole. It could also spur an increase in investment in power located in rural areas near load centers.

3. Do away with a uniform tariff for electricity.

   A uniform kilowatt-hour tariff ignores the positive economic benefits of rural based power supply and unfairly shifts the balance towards ZESCO. In this case, urban customers are subsidizing rural customers and the nation as a whole is subsidizing electrification. Moreover, it is simply inconsistent with cost-based pricing principles. This is different than the postage stamp pricing of transmission services. In essence, this is the pricing at the retail level. Also, a mentioned earlier, a uniform tariff will mean the need for operating subsidies under certain circumstances. If operating subsidies are banned, then so will uniform tariffs have to be banned.

4. Provide for a full cost recovery tariff.

   The lessons learned from successful RE programs clearly point to the ability of rural people to pay for electricity and the need for the full cost recovery. The full cost is dictated by the type of subsidy, technological choice, business model, and other factors. If Zambia is to attract private capital and operators to the RE market, then it must allow for full cost recovery.

5. Develop a grid code that is not biased against renewable energy sources.

   Several countries have recognized that many of the requirements for renewable generation are too stringent and have relaxed these standards. The result has been increased investment in renewable and often rural generation. A copy of the Philippines grid code that was specifically written to deal with these issues has been provided to the ERB as a guide document for the Committee.

   Mandate open competition for electricity supply to any new area.

   To level the playing field and to reduce costs, ERB can bring the forces of competition to work. All parties should be able to bid for the right to supply an area with electricity. This includes individuals, communities, churches, NGOs and even ZESCO. However, it must also ensure a level playing field not only by allowing open competition but by mandating that all parties compete using the same set of pricing rules. This means that ZESCO would, for example, be required to show the full cost of supply an area. In this manner, the country can see the transparent tradeoffs between grid expansion and alternate supply and choose that method which results in the least cost – and, therefore, presumably the least subsidy required.

6. Provide concessions or licenses which allow the holder to provide exclusive service to an area for a predetermined amount of time.

Other countries have justified the use of concessions mainly in order to reduce the risks of providing service, and so attract investment. The idea is that concessions will allow companies to capture economies of scale and so reduce supply costs.

Since the Zambian non-grid project will continue to be a learning experience, it is important that regulations do not lock-in potentially inefficient or unsuccessful strategies.

Terms of the Concession: These include determining the geographic boundaries of the concession, how long the concession will last, what the information reporting requirements will be, and basically any constant element that all competitors will need to work with.

Competitive Terms: At a minimum, these include the price to the customer and level of subsidy required in terms of both the capital cost and the service fee. Competitive terms may also include the level of service and other types of energy services that may be bundled in. these terms are the ones that each company will vary to make their proposal more competitive.

Choosing a Winner: Even though the competitive terms may be limited, it is unlikely that comparing proposals will be a simple matter. Establishing clear and transparent rules for selecting a winner is essential if a healthy range of companies is to be attracted.

Frequency and Conditions for Re-auctioning: This involves how often and under what conditions should the concession be re-auctioned. In order to keep competitive pressures on the concessionaire it will be necessary to re-auction the concession periodically. Re-auctions might also be triggered by bad performance on the part of the concessionaire or major changes in the market. The benefits of re-auctioning need to be weighed against the costs, which include the time and effort and the increased cost of financing due to increased business risk generated.

These are issues that are best answered by the proposed Committees.

4.4. Reducing Costs

All of the measures above should result in lower costs even though they are not directly aimed at cost. ERB can take direct steps to help reduce the cost of rural electrification through a variety of measures including the development, in conjunction with stakeholders, of technical standards that are appropriate for rural consumers.

1. Set the standard for the use of either single phase or single wire earth return for rural electrification.

Either of these technologies is appropriate for rural electrification and will result in significant cost reduction. The U.S. has used and still uses single phase for its rural electrification program. Loads in these rural areas are well above any that rural Zambia can be expected to experience in the near future. Other countries such as New Zealand, Australia, and Namibia have had aggressive rural electrification programs using SWER technology.

We do not recommend one technology for Zambia. Rather we recommend that ERB proactive engage and challenge the industry and stakeholders to select between the two technologies and through this selection develop a process that looks for innovative and appropriate technologies, standards and guidelines.

2. Relax standards for voltage regulation.

   Again, stepping completely out of urban specification and applying a common-sense approach to new standard setting, many countries have reduced standards for voltage regulation with a resultant significant decline in costs. “Systems which are designed to operate within a voltage limits of +-5% are roughly 15-25% more expensive than those designed to operate within +-10% limits.”[42] In areas where the number of motors in use is small, this lower standard makes great practical sense.

3. Allow the sale of power and with it the resultant metering.

   Costs can be significantly reduced by allowing companies to sell power rather than energy and to use meters such as circuit breakers. Several of Zambia’s neighbors have done this and the result has been to reduce cost and strengthen the market.

4. General technical guidelines.

   This paper has pointed to some measures adopted by other regulatory bodies in their quest to further rural electrification. These include ready boards, short poles and longer distances between poles, the use of the ground wire on high voltage transmission lines to carry medium voltages for rural electrification, reduced wiring and connection standards, and a host of other measures. It is beyond this paper to thoroughly research them and to make recommendations. Rather, the references to the innovative design manuals and best practice manuals are provided in the reference section. There is no correct recommendation at this point other than to encourage the technical standards committee to embrace the innovative spirit, to recognize that old ways of doing things are not necessarily the best and to review and study other countries’ experiences.

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1 APPENDIX 1 – Rural Electrification: Lessons Learned

No. 177 February 2001

Rural Electrification: Lessons Learned

Based on the World Bank's experience to date, Rural Electrification (RE) programs rarely support themselves financially. However, there are *external benefits* that rural populations derive from key synergies facilitated by the introduction of electricity (such as improved access to communication, education and economic opportunities, extended and more reliable health services, and improved security). RE programs should seek to maximize both economic and social benefits. Some lessons learned and good practices (drawn from the sources listed on page 3) are summarized below.

Lessons Learned

- Key to scaling-up are *conducive macro-economic conditions*, sustained *government commitment* to the project objectives, *competent public institutions* , and *decentralized decision-making*.
- Grid extension is sometimes not the most cost-effective solution; *decentralized delivery options* and *alternative energy sources*--such as solar PhotoVoltaics (P.V.), mini-hydro and other renewable energy sources--should be considered, following the principle of least-cost development. There remains considerable potential to lower the unit network costs of new connections by introducing equipment standards, reticulation design, and construction, operations and maintenance practices that are better suited for rural area conditions, instead of relying on high cost and "gold-plated" practices more appropriate for use in urban areas.
- *Criteria for selection and priority-setting* for RE should be open and objective. *Political interference* in the implementation of RE programs can add considerably to the costs of system expansion.
- The benefits of electrification are directly related to the uses to which it is put and to the costs of alternative sources of power and energy. RE should ideally be introduced in areas where there is already a *demand* for electricity-using services--usually where there is agricultural growth, rural businesses and rural incomes. However, to increase and accelerate the development impact, technical assistance and rural business services could be provided to stimulate demand.
- *Pricing policies* play an important role in determining project viability. A rational system of *cost recovery* (coupled with smarter ways of allocating subsidies where needed) is the most important factor determining the long-term sustainability of RE programs.
- *Initial connection charges* are a greater barrier to rural families than the monthly electricity bill. Extended financing arrangements are necessary to make connection more affordable.
- *Subsidization of operating costs* has widely proved to be counter-productive and to undermine the utilities' financial position, their ability to extend service, and ultimately the RE programs themselves.
- The *private sector* can be attracted to participate in rural electrification schemes, even in a poor country, if an appropriate legal framework and risk management options are in

place, including the assurance of a level playing field in terms of competition and the ability to charge full cost-recovery tariffs.

- RE programs can benefit greatly from the *involvement of local communities* - or suffer because of its absence.
- RE will stimulate economic growth and employment, if other necessary conditions are met. RE reduces *rural poverty* mainly through a general rise in income, obtained by productive uses.
- Evidence from successful rural electrification projects shows that, once electricity becomes available in an area, upper middle class and wealthy households are the first to adopt it. But if the project focuses on promoting electricity for poor households--through low connection fees and lifeline rates--the rate of electricity adoption grows significantly, even among the poorest households. Surveys reveal that, in regions with high overall adoption rates, the poor benefit significantly from rural electrification programs, and *although they may lag behind wealthy households, the poor will adopt electricity if the connection policies are appropriate*. Without a rural electrification program, or other program aimed at encouraging extensive coverage of the poor, the poor are left paying for kerosene, a meager and high-priced source of light.
- It is difficult to estimate *suppressed demand* and the *ability and willingness to pay*.
- *Demonstration projects* (the typical donor approach) are *not* a fair test of viability.

Good Practices

Power sector reform (ideally on-going at time of project appraisal):

- Establish a transparent, arms-length *regulatory framework* with legal guarantees that utilities can operate with autonomy-e.g. through management/concession contracts.
- Enforce *regulatory principles* to ensure financial discipline, adequate tariffs, and incentive-based, competitive contracting of services.
- *Separate responsibilities* between regulating authorities and operating companies.
- Open the market to *private investment and operators*.

Priority-setting

- Successful rural electrification programs have all developed their own - transparent - *system for ranking* or prioritizing areas for obtaining a supply.

Financial viability/cost recovery

- Identify *economic limits* to extensions to the grid and the economic potential of *lower-cost options* and *alternative energy sources.*
- Ensure *commercial viability* to assure RE's sustainability.
- A rational system of *cost recovery* should take into account capital investment costs, level of local contribution, number and density of consumers, likely demand for electricity; also, the willingness to pay and payment capability of the population.
- The *tariff regime* should ensure that RE programs are financially sustainable and will not drain operational resources. Tariffs should cover the full cost of medium-voltage generation/transmission, plus low-voltage operations/maintenance costs, and should provide for eventual capital replacement costs.
- The tariff structure needs to ensure that any *subsidies* are fair, equitable, and sustainable. A "good" subsidy scheme enhances access for the poor (improving the quality of life/reducing energy expense); sustains incentives for efficient delivery/consumption; and must be practicable within the financial/human resource constraints of government/power utility. Successful subsidy programs encourage the rural electrification business. A portion of the capital may be subsidized, obtained at

concessionary rates, or as a government/donor grant. Subsidies should be avoided for operating costs. A low *lifeline tariff* is acceptable on income redistribution grounds.

- *Minimize construction/operating costs:* assess technology and available standards during the planning stage; deploy low-cost equipment; use innovative technologies/approaches and local suppliers; standardize materials. Consider the use of "ready-boards" to reduce connection costs. Design the system for expected loads (much lower in rural than urban areas) to reduce construction costs; provide for future upgrades.
- Consider the provision of *financing* to spread the costs of connection fees over an extended period, or lower connection rates for the poor, so that the benefits of electrification may reach larger numbers of people; consider also arranging financial assistance for the credit/hire purchase of electrical appliances.
- *For grid electrification, it is generally important to meter all electricity consumption*. There may be some exceptions to this rule for households with very low consumption rates that are being provided electricity service by a small local generator during evening hours only. Under such circumstances, it may be necessary to charge a fixed amount for each appliance, as they can only be used for a particular period of time. This avoids unnecessary expenses involved in reading meters and the cost of the meters.
- Include *demand-side management programs* in project design to shift some of the rural load to off-peak time periods.

Implementation agency

There is no single model for an institutional structure. However, in all countries with successful RE experience, the implementing agencies had a high degree of operating autonomy and were held *accountable*; leadership tended to be dynamic and employees had job security and career prospects. Clear *contractual arrangements* between the government and implementing agencies are important.

Involvement of local communities

- Projects are more likely to be viable and sustainable if *local stakeholders* are involved in their design and implementation. One way to approach this is to set up a Rural Electrification Committee to help assess level of demand, educate consumers, and promote the wider use of electricity. This may also help reduce potential problems over rights of way for the construction and maintenance of electric lines.
- In some cases (e.g. Thailand), the community has made *contributions of capital or labor*, thereby helping to defray the costs of the program. Labor-intensive activities in the distribution and customer services function may be contracted out to village-level organizations on a fee-for-service basis.
- The establishment of *appropriate institutional and organizational procedures* for project planning, financing, procurement of goods and construction services is very important for the successful implementation of RE projects involving small communities.
- The concept of "Area Coverage Rural Electrification" (ACRE) - a distribution system based on member-owned rural electric cooperatives - has been successfully used (e.g. in Bangladesh).

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2 APPENDIX 2 – Business Models, Experience of Six Developing Countries.

3. Appendix 3. Reducing the Cost of Grid Extension

4. APPENDIX 4. Best Practice Manual: Promoting Decentralized Electrification