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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF NATURAL RESOURCES
AND ENVIRONMENTAL AFFAIRS (MONREA)
DEPARTMENT OF ENERGY AFFAIRS (DOE)
REPUBLIC OF MALAWI

MASTER PLAN STUDY ON RURAL ELECTRIFICATION IN MALAWI

FINAL REPORT
MAIN REPORT

MARCH 2003

TOKYO ELECTRIC POWER SERVICES CO., LTD.
NOMURA RESEARCH INSTITUTE, LTD.

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PREFACE

In response to a request from the Government of Malawi, the Government of Japan decided to conduct the Master Plan Study on Rural Electrification in Malawi, and the study was implemented by the Japan International Cooperation Agency (JICA).

JICA sent the Master Plan Study Team led by Mr. Takahisa Murata of Tokyo Electric Power Services Co., Ltd. and organized by Tokyo Electric Power Services Co., Ltd. and Nomura Research Institute, Ltd. to Malawi six times from September 2001 to January 2003.

The team held discussions with the officials concerned of the Government of Malawi, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of rural electrification and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Malawi for their close cooperation throughout the study.

March 2003

Takao KAWAKAMI
President
Japan International Cooperation Agency

March 2003

Mr. Takao KAWAKAMI
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. KAWAKAMI,

Letter of Transmittal

We are pleased to submit you the report of the Master Plan Study on Rural Electrification in Malawi. The report contains the comments made by the Department of Energy under the Ministry of Natural Resources and Environmental Affairs and related institutions in the Republic of Malawi, and the advice of the related institutions of the Government of Japan.

This report presents a best option and an execution plan of the Master Plan Study on Rural Electrification in Malawi. We trust that realization of the study will much contribute to people for supplying electricity and power industry in rural area.

In view of the urgency to increase the access to electricity in rural area, and of the need for socio-economic development of the Republic of Malawi as a whole, we recommend the Government of Malawi to implement this study as a top priority.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and Ministry of Economy, Trade and Industry.

Very truly yours,

Takahisa MURATA
Team Leader
The master plan study team on
The master plan study
on rural electrification in Malawi

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Executive Summary

Various challenges lie ahead of the Republic of Malawi, and among those, the issue of poverty is extremely significant. Poverty has various causes, and cannot be resolved by any single approach, although in general, it requires the promotion of education and socio-economic development. At present, however, the infrastructure in Malawi is too underdeveloped for the execution of full plans and programs to these ends.

The power supply is one of the major pillars of infrastructural conditioning. As evidenced by the rate of electrification, the supply in rural areas is woefully inadequate. The rate is extremely low; it is only 4% nationwide and 20% even in urban areas taken separately. In rural areas, it is less than 1%.

Naturally, the government has by no means ignored this situation. While the state-owned Electricity Supply Corporation of Malawi (ESCOM) promoted rural electrification in the 1980s and early 1990s, the government took over direct responsibility for rural electrification from ESCOM in 1995 and made arrangements for preparation of programs and procurement of funds. Nevertheless, in light of the extremely low electrification rate, there is a strong need for a both strategic and accelerated promotion of electrification in order to extricate the country from the prevailing poverty and place its economic development on track.

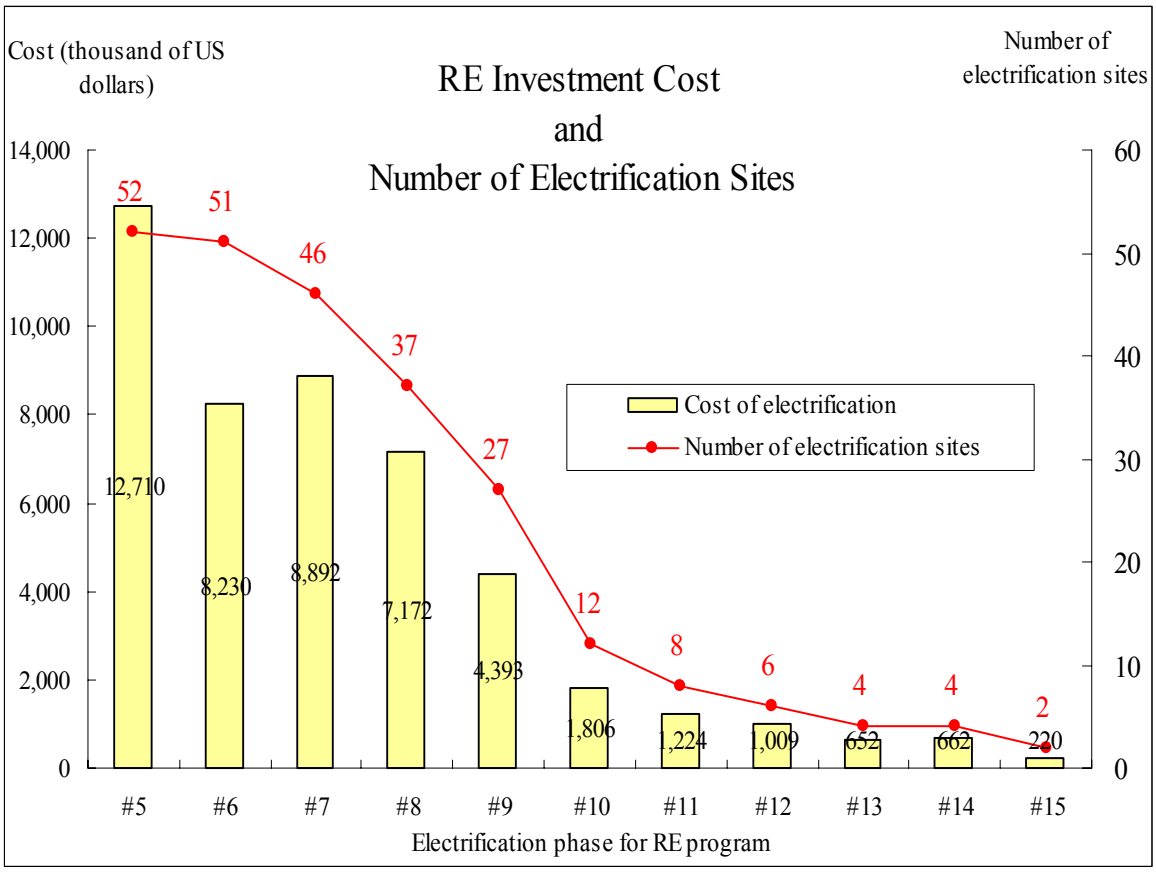
As proposed in this document, the most effective approach to increasing the electrification rate would lie in deployment of an ongoing series of programs targeted at trading centers, which offer the best prospects for inducing extended socio-economic effects. (Trading centers are places where local residents often gather due to their assortment of public facilities, mills for grinding the dietary staple of corn into flour, and all kinds of private shops.)

The Phase 4 rural electrification (RE) program currently being promoted by the government must be followed in rapid succession by fifth and sixth phases. If each phase electrifies 54 trading centers (two in each of the 27 districts), all of the 249 trading centers not yet electrified in the country would be electrified upon the completion of 11 more phases.

This would entail an investment of some 47 million dollars. The first three phases (five through seven) would be the most important; their completion would increase the electrification rate for the subject locations to about 60 percent.

However, to continue investing on this level, the government would have to make a firm commitment and prepare setups to this end. In the current Phase 4 RE program, the government is clearly responsible for the preparation of plans and procurement of funds, but still must rely on ESCOM (in the form of consignment) at the stages of construction of actual facilities as well as operation and maintenance (O&M).

This is because the only principal with the ability to execute RE programs at present is ESCOM. For the continued execution of the succeeding 11 requisite phases, nevertheless, the construction and O&M work could not depend entirely on ESCOM.



Source: Prepared by the JICA Master Plan Study Team (JICA MP ST)

Fig. 1 RE investment cost and number of target trading centers

The resolution of these difficulties in the institutional aspect necessitates an increase in the parties participating in the power market through the program of restructuring now being promoted by the government. More specifically, there must be a shift from the prevailing setup of domination of the power business by a single enterprise (ESCOM) to one with a diversity of entrants, i.e., independent power distributors, small-scale independent energy service companies (ESCO), and electric cooperatives organized by local residents. Unless this is done, it will, in effect, be difficult to implement RE projects with the flexibility needed for adaptation to greatly different circumstances and conditions. This is to say that, for the successful execution of the RE program, promotion of the power sector reform intended by the government is a crucial condition in the institutional aspect.

Besides the diversification of the parties involved in RE, the government must devise ways to assist RE. Under the current scheme, the government raises funds for facility construction, consigns the construction work to ESCOM, and transfers the completed facilities to ESCOM, which is assigned to carry out the O&M. This methodology has already begun to impose a both tangible and

intangible burden on ESCOM (especially in terms of indirect cost and human resources), and problems of this nature could very well surface in the near future.

The electrification will gradually proceed to smaller trading centers with worse physical conditions. In such cases, there would be a strong possibility of higher costs in investment and O&M as well as poor prospects for retrieval of the same through tariffs (power rates). As a result, such projects would show a deficit when taken separately, and their continuation would require subsidization in some form (to compensate for the deficit). Obviously, funds would have to be furnished not only for the initial investment (as has been done thus far) but also for the operation.

Therefore, necessary resources must be mobilized in order to achieve the desired level of rural electrification. This includes the continued effort for institutional reform in the power sector, and the pursuance of various sources of funds in order to ensure smooth and seamless continuation of the implementation of this Master Plan. An adequate level of resource endowment to the DOE for necessary capacity building, and coordination with other initiatives will be an important part of the overall effort.

1 Background and Objectives

1.1 Background

(1) Importance of rural electrification (RE)

Like those for other elements of the socio-economic infrastructure, programs for RE in developing countries are incorporated into the national plans for power resource development, for electrical supply as a type of universal service. They have also provided means of raising the standard of living among the residents of rural areas. They are, in addition, a means of social advancement grounded in meeting the basic human needs (BHN) of rural residents, who are being left behind in the preceding development of urban areas. The widening of access to electricity through the promotion of RE acts first and foremost to improve the lives of residents, generate income on the individual level, and increase revenue. As secondary benefits, it also has the effects of transforming and stimulating local economies and improving public services.

Electrification is obviously not sufficient in itself for achieving advancement in rural areas, but there can be no doubt that it is an important factor in the same. To eliminate the various problems in rural districts stemming from poverty, it is necessary to link RE with other programs of social or industrial development in order to induce synergistic effects.

The Government of Malawi's Vision 2020, which strongly points out the need for better infrastructure development, including Rural Electrification, recognizes these points. In order to achieve this vision, GOM has adopted the poverty reduction strategy, which identifies access to electricity as one of the priorities. For this reason, the government has placed the sustained economic advancement of the poverty stratum, capacity building (human resource development), and improvement of the standard of living in poor communities at the very foundation of its national strategy.

To accomplish these policy agenda, it must hasten its efforts to condition the climate for growth, and especially to improve the infrastructure in rural areas. As of the end of 2000, only 4 percent of the population has access to electricity. Of this, 30 percent of the urban population, and 0.5 percent of the rural population has access to electricity. As can readily be observed from this low electrification rate, Malawi is marked by very low levels of socio-economic development.

The major objective of RE is to reduce poverty by creating employment opportunities through the growth of small-scale industrial activity that is grounded in agriculture and made possible with the supply of electricity.

(2) History and current status of RE

In Malawi, RE has been promoted by the state enterprise ESCOM based on financial support from developed countries. ESCOM has thus far implemented three RE program phases (Phases 1 - 3). The cost for these phases put a great strain on ESCOM finances. At the same time, ESCOM itself was faced with other management problems as a corporate enterprise, and it must overcome these to meet the government's demands for higher levels of productivity, improvement of its power supply services, and balancing of its finances. This situation has made it difficult for ESCOM to promote any further RE activities.

To resolve the problems confronting ESCOM in connection with RE, the government decided to detach RE from its business and allow it to concentrate on electrification and improvement of services in urban areas and their peripheries.

Electrification programs carried out by ESCOM based on the on-grid method

Phase 1

ESCOM electrified 13 district centers over the years 1980 - 1989. In so doing, it made use of soft loans from the Africa Development Fund (ADF) as well as its own funds.

Phase 2

This phase was devoted to construction of a small hydropower plant with an output of 4.5 MW in the northern district of Wovwe, as well as the installation of a total of about 212 km of transmission lines (66 kV) and distribution lines (both 33 and 11 kV). Power supply was extended to four northern districts. The funding came from Germany's KfW as well as ESCOM.

Phase 3

The subjects of this phase were unelectrified trading centers and tobacco-growing districts in the central part of the country. The work was funded with soft loans from Spain.

In 1995, the government decided to promote RE directly through the Department of Energy Affairs (DOE) under the Ministry of Natural Resources and Environmental Affairs (MNREA). The approach included the extension of the distribution system (on-grid method) and dispersed sources (off-grid method) including renewable energy such as small-scale hydropower and photovoltaic systems.

RE Policy Arrangement

Since the late 1990s, the government has been conducting a review of its energy policy and reform of the power sector. RE is proceeding through coordination of measures in the context of this systematic reform of legislation. (In the government's view, RE is not the only policy task in the energy and power issues; its national strategy also encompasses other tasks such as development and utilization of national energy resources, and development of the energy industry. It has released policy papers in the form of the energy white papers and other documents setting forth strategy for power sector reform to serve as the foundation for action in this line.) At the moment, it is also drafting the RE bill that would form the basis of the legal framework in support of RE activities.

Current RE Activities

The DOE is now implementing the Phase 4 program utilizing both on- and off-grid electrification.

This involves the electrification of 53 sites throughout the country, funded by a levy on petroleum product sales and grant money from the Government of Japan. It is expected that the phase will be completed by 2004.

Despite all these efforts, RE implementation in Malawi is still facing many challenges in order to achieve the target stipulated in ***Vision 2020*** and to leverage government's goal of poverty reduction.

National Sustainable Renewable Energy Program

Promoting application of renewable energies such as solar power, wind power, biogas, and biomass briquettes, the Program covers activities in a variety of fields, from the diffusion of systems to the building of related institutions and construction of technical centers. It therefore includes RE projects that apply such energy. It receives funds from diverse entities, including the United Nations Development Programme (UNDP), Danish International Development Agency (DANIDA; the Agency, however, discontinued its support in February 2002), and the Global Environment Facility (GEF). The Japanese parties furnishing it with funds include the Ministry of Foreign Affairs and the Plant Consulting Institutes.

The individual projects promoted under the Program have mutually different funding sources and are not directly interlinked.

The NSREP Steering Committee operating the Program is not a separate governmental entity; the Department of Energy Affairs (DOE) serves as its secretariat, and its membership is composed of representatives from related aid organizations, governmental institutions, educational institutions, and the private sector.

The individual projects are executed by the funding sources in question; the Steering Committee does not have the authority to implement projects itself.

(3) RE Challenges

a) Lack of long-term Master Plan

There have been no long-term RE plans for the country as a whole, and consequently no execution of RE programs in accordance with such plans. This made it difficult for the beneficiaries to plan to utilize the electricity. The lack of a Master Plan also led to the ad-hoc response to sporadic requests from various constituencies.

b) Insufficient financial resources

The slow speed of electrification is partly a result of the lack of funds to implement more program phases. This contributed tremendously to the government's failure to accelerate the access rate from the present 4 percent to significant levels.

c) Low return of investment due to low tariffs

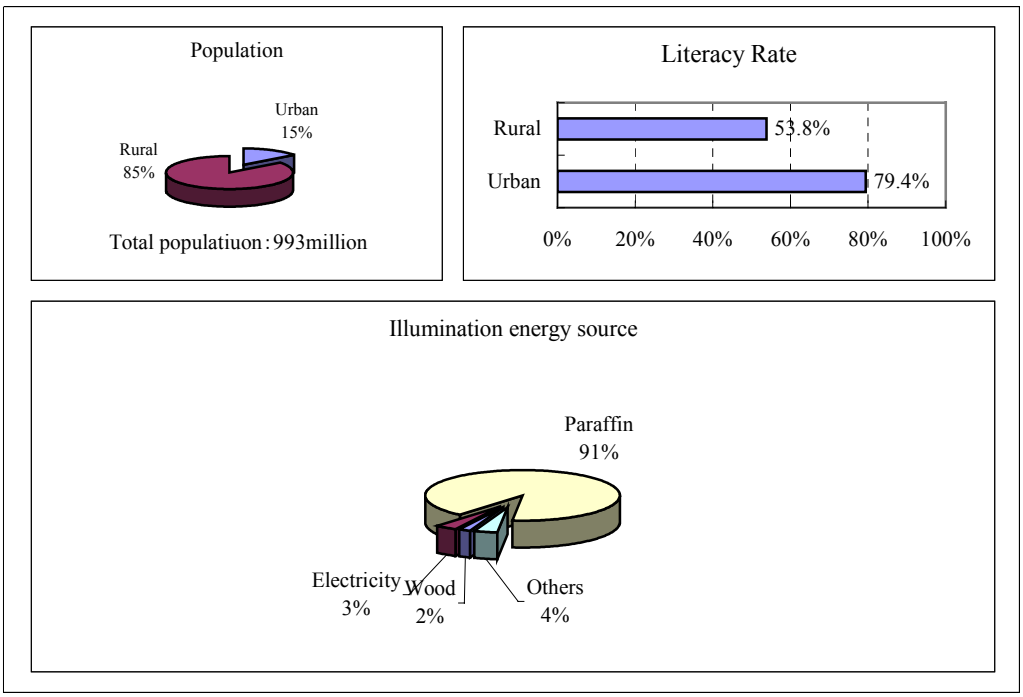
Power tariffs were set far below the long run marginal cost (LRMC), and this made it impossible to retrieve the costs of RE, which are much higher than in urban areas, on the strength of tariff revenue alone. The progress of RE programs therefore invited an increase in the financial burden on ESCOM. In response, ESCOM became reluctant to promote RE aggressively.

d) Population

85 percent of the population lives in rural areas, and yet, only 0.5 percent has access to electricity. The challenge, therefore, is to increase the access in order to achieve socio-economic advancement aimed at raising productivity, levels of education, medical services and standard of living in general.

e) Use of unclean energy sources in rural areas

The use of unclean energy sources, such as kerosene (i.e. paraffin) and firewood is causing health and environmental hazards for the rural community. Of these, kerosene accounts for about 91 percent of all illumination; electricity accounts for only about 3 percent. Promoting rural electrification will allow conversion to safer and healthier energy sources (see Fig. 1 - 1).



Source: Prepared by the JICA MP ST

Fig. 1 - 1 Issues of Malawi Rural Electrification

Examples of resolution of socio-economic problems in Malawi through electrification

1. Increase in rates of higher education and passage of examinations

Rates for passage of qualifying examinations for advance to higher grades and graduation are only about 30 percent at secondary schools without electric lights but as high as 80 percent at those with electric lights. Electricity facilitates the completion of studies required for university admission. In addition, graduation from a secondary school assists efforts to find employment.

2. Preservation of vaccine

In the medical field, "paraffin refrigerators" (fueled with kerosene) are used for storing vaccine. However, kerosene is sold for high prices in the market, and several clinics have been installed with independent power sources to preserve vaccine.

3. Curtailment of deforestation

In Malawi, forests are rapidly being depleted due to logging for firewood. This depletion is particularly serious in the south, where many hills have been left bare of foliage. Damage from flooding is consequently occurring because of the lack of vegetation to restrain runoff. To eliminate such problems, the government is pursuing the incorporation of electricity and other modern energy

1.2 Objectives

In view of the above challenges, the Government of Malawi realized that the promotion of RE in a both strategic and accelerated manner demanded the preparation of RE plans from a long-term perspective. Based on this recognition, it decided to undertake this master plan study, whose objectives are to:

- Develop a criteria for site selection prioritization and appropriate electrification method
- Select electrification sites
- Prioritize selected electrification sites as per developed criteria
- Recommend institutional and organizational framework
- Estimate funding requirements
- Prepare long-term implementation schedule to the year 2020 and
- Transfer to DOE technology needed for review of the master plan.

2 Process of Master Plan

2.1 Basic guidelines

Five basic guidelines were applied in the implementation of this master plan study, as follows.

1: Prioritize to achieve maximum economic benefits

The government has set a nationwide electricity access rate of 30 percent by 2020. With the current low level of electrification, the achievement of this target will require the implementation of accelerated programs. In other words, RE plans must aim for tangible progress as fast as possible.

To this end, the study must determine the sites that need electricity the most, based on their economic activities. The higher the economic activity is, the higher the priority for electrification.

2: Ensure continuity between phases

Although three phases of RE programs have already been implemented, the current level of RE is still low, i.e. less than 0.5 percent.

One of the reasons has been the existence of major financial constraints preventing a smooth linkage between phases. In future phases, efforts must be made to build programs in such a way that each phase will be linked to the next and that electrification will expand while preserving continuity between phases.

3: Undertake sustainable electrification projects

In the construction of RE facilities and O&M work, projects must be sustainable. The economic feasibility of programs and projects must be fully examined for this reason. In particular, it is necessary to select the optimal electrification technology in terms of cost effectiveness, clear understanding of cost and investment, operation schemes, determination of the beneficiary's willingness and ability to pay.

4: Promote the use of renewable energy

Malawi is poor in fossil fuel energy resources, and should utilize renewable energy as extensively as possible. To this end, it must probe the possibilities of micro-hydropower, of which it has comparatively large reserves, and photovoltaic power generation.

5: Promote DOE capacity building and technology transfer

The promotion of RE in line with the master plan will also require the provision of capacity building at and technology transfer to the DOE.

2.2 Identification of electrification sites

Based on the first guideline, it was determined that the RE will target the locations with the highest socio-economic activities. For this reason, the master plane has targeted Trading Centers, which contain public institutions and large concentration of economic activities (e.g. maize mills, shops, etc.)

The decision was arrived at early in the master plan study that the equality among districts must be achieved when selecting the Trading Centers for electrification. This was due to the consideration that the districts must not be penalized by their location and/or political power. In order to achieve this goal, all districts were given equal weighting, with two Trading Centers to be electrified in each phase.

With this arrangement therefore, competition was within each district, rather than between districts. In order to achieve maximum economic benefits, the Trading Centers with the highest level of socio-economic activities were given priority.

Facilities often found in trading centers

Trading centers are places where people in the area often gather. They typically contain the following facilities.

- Public facilities

Hospitals/clinics, schools, post offices, police stations, churches, orphanages, immigration control offices, etc.

- Maize mills

Facilities equipped with grinders to produce flour from corn and cassava, which are staples of the Malawi diet

- Private facilities

Restaurants, furniture stores, battery repair/recharging/sales shops, stores selling sundries, stores selling foods and beverages

2.3 Data and information collection

After the selection of the electrification sites, data and information were collected from candidate sites to study electrification priority and method. The basic data compiled from this work provided the basis for quantified analyses necessary to preparation of the master plan. To accomplish data and information gathering, the following activities were undertaken.

(1) Socio-economic study of Trading Centers

Through interviews and questionnaire surveys in unelectrified trading centers, social and economic data were collected on electrification sites in order to ascertain items such as the size of the demand, density of the demand, intensity of power needs, and types (patterns) of power use. On the other hand through interviews and questionnaire surveys in electrified trading centers, various data were also collected in order to ascertain items such as the size of the demand, density of the demand, types (patterns) of power use and impact after electrification.

Statistical data from the National Statistical Office were utilized for macro items such as

national population, number of households, number of housing units, and forms of energy consumption for lighting and cooking.

(2) Study of distribution lines

The on-grid method is the basic premise of the past RE programs phases 1 - 3 and the current Phase 4 program. This approach is also anticipated to be the main one in the succeeding programs (beginning with Phase 5). A study was therefore made of the transmission and distribution network facilities now owned and operated by ESCOM in order to ascertain the possibilities of access to them by the unelectrified districts.

The survey targets were location of the existing ESCOM distribution lines, and routes and distances to the unelectrified trading centers. At the same time, various obstacles between the ESCOM distribution line and the proposed trading center were also surveyed.

(3) Study of micro-hydropower potential

The study is not confined to the on-grid method, but also includes off-grid methods. Given Malawi's geographic condition coupled with its perennial rivers, there is potential for micro-hydropower. The study consequently explored the possibilities of hydropower application as the source for a mini grid (i.e., a small-scale, physically independent distribution network).

The study was carried out to confirm the availability for micro-hydropower potential close to unelectrified trading centers based upon the map study using geographical map and hydrological data for the targeted trading centers.

2.4 Prioritization of electrification sites

(1) Indicators for determination of electrification priorities

In order to prioritize the sites that are identified for electrification, market fees were used as the criteria. This was due to the fact that market fee indicates the extent of socio-economic activities in each trading center.

The indicators applied in assessing the level of social and economic activity included the number of public facilities such as clinics, schools, post offices, and police stations as well as demographic items such as population and number of household.

In consideration of the daily life activities of residents, it was also decided to take as indicators the number of maize mill facilities and the level of market fees, which

Market fees

The term refers to the fees paid by growers for use of facilities to sell their produce in the public market held by the local (district) government.

The district government collects these fees on a monthly basis and furnishes them to the national government.

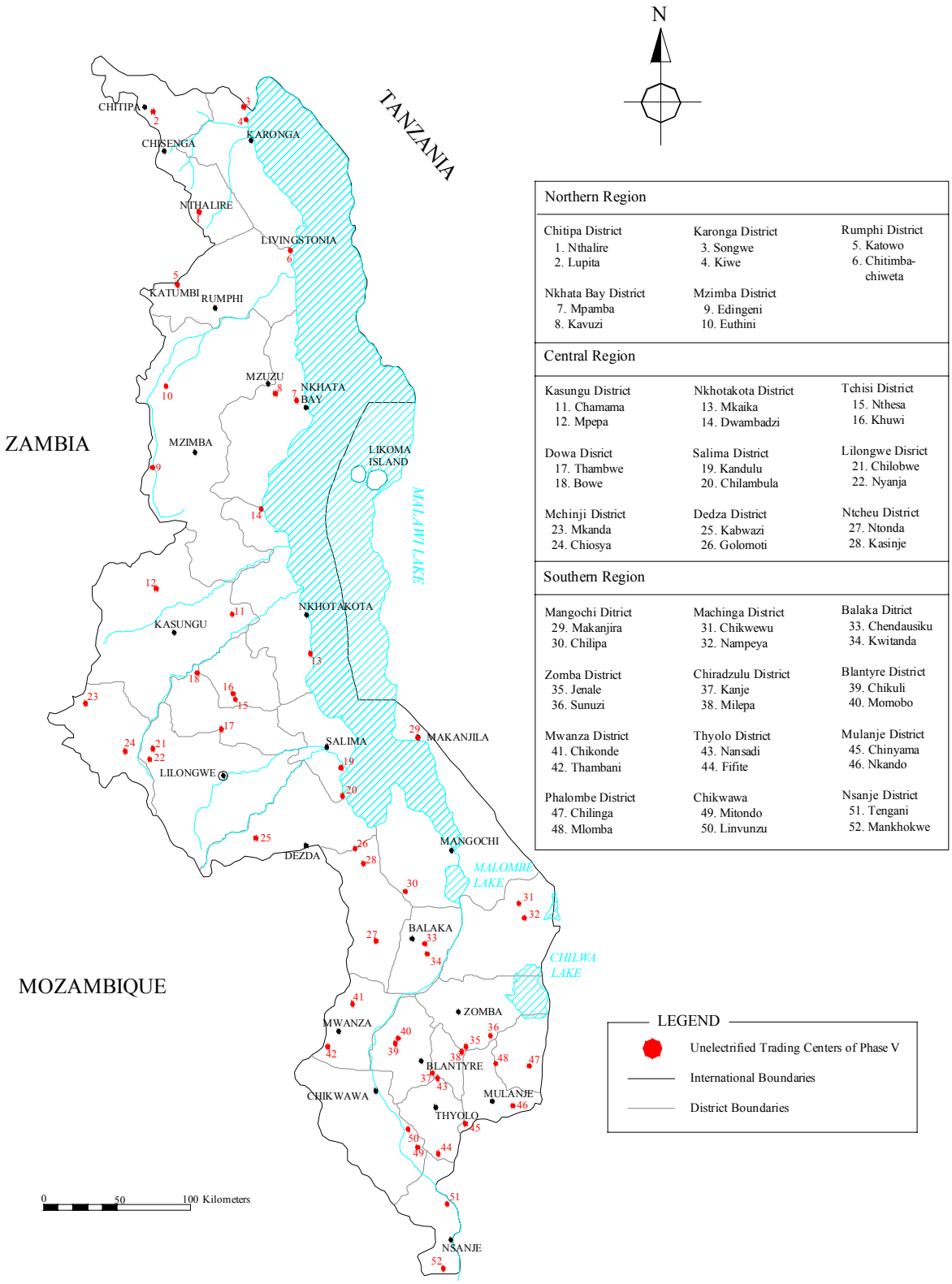
are barometers of the scale of economic activities within the trading centers.

However, once these data were collected and subjected to in-depth analysis and investigation, it was discovered that not all data were available for items at all trading centers (or, rather, that there were substantial omissions). In addition, a careful look at individual cases produced doubts about the reliability of even the data provided.

For this reason, it was decided to use the market fee revenue levels as indicators for determining the electrification priority of trading centers. This is to say that the level of market fee revenue served as the criterion for setting the order of priority.

(2) Proposed trading centers for Phase 5

Through the procedure outline above, the team has set a priority among the total of 249 unelectrified trading centers nationwide, and divided them into RE program phases. Phases 5 to 15 were identified (see Fig. 3 - 1). In order to illustrate the scope of a single RE program phase, Fig. 2 - 1 shows the locations of the 52 trading centers selected as targets of the proposed Phase 5. (Because the whole of Likoma District was already electrified, only 26 districts were considered, which made the maximum number of Trading Centers 52 per phase. It should be noted that this process was conducted before Neno was declared a district.)



Northern Region		
Chitipa District 1. Nthalire 2. Lupita	Karonga District 3. Songwe 4. Kiwe	Rumphi District 5. Katowo 6. Chitimba-chiweta
Nkhata Bay District 7. Mpamba 8. Kavuzi	Mzimba District 9. Edingeni 10. Euthini	
Central Region		
Kasungu District 11. Chamama 12. Mpepa	Nkhotakota District 13. Mkaika 14. Dwambadzi	Tchisi District 15. Nthesa 16. Khuwi
Dowa Disrict 17. Thambwe 18. Bowe	Salima District 19. Kandulu 20. Chilambula	Lilongwe Disrict 21. Chilobwe 22. Nyanja
Mchinji District 23. Mkanda 24. Chiosya	Dedza District 25. Kabwazi 26. Golomoti	Ntcheu District 27. Ntonda 28. Kasinje
Southern Region		
Mangochi Ditrict 29. Makanjira 30. Chilipa	Machinga District 31. Chikwewu 32. Nampeya	Balaka Ditrict 33. Chendausiku 34. Kwitanda
Zomba District 35. Jenale 36. Sunuzi	Chiradzulu District 37. Kanje 38. Milepa	Blantyre District 39. Chikuli 40. Momobo
Mwanza District 41. Chikonde 42. Thambani	Thyolo District 43. Nansadi 44. Fifite	Mulanje District 45. Chinyama 46. Nkando
Phalombe District 47. Chilinga 48. Mlomba	Chikwawa 49. Mitondo 50. Linvunzu	Nsanje District 51. Tengani 52. Mankhokwe

Source: Prepared by the JICA MP ST

Fig. 2 - 1 Location of proposed trading centers for Phase 5

2.5 Cost estimation of electrification method

(1) Power demand estimation for the target trading centers

Once the target trading centers were selected, the next task was to estimate the latent demand for electric power. This amounts to forecasting work required for determining the requisite size of supply, i.e., scale of the projects in promoting the RE program. This section presents an estimate of the power demand at one trading center taking 2020 as the target year.

To make the forecast, a study of power consumption at trading centers that have already been electrified in the same districts was conducted. The study collected data on the types of electric appliances used, and the times of power use, in each customer category (public facilities, shops, maize mills, and ordinary households). Statistical analysis on these parameters was also made.

The study found that maize mills and households had a big influence on the overall trading center power demand. As such, the team prepared an estimation model taking these two components as parameters, and used it to estimate the power demand (kW) and energy demand (kWh) at the target trading centers.

(2) Selection of electrification methods for the target trading centers

After the selection of trading center sites (ordering of priority) and estimation of the power demand comes the task of determining the appropriate electrification method.

As already noted, there are two major types of electrification method: on-grid and off-grid (see Table 2 -1).

Table 2 - 1 On-grid and off-grid Electrification

On-grid	Off-grid	
	Mini-grid	Stand-alone
● Extension of 33 kV distribution lines ● Extension of 11 kV distribution lines	● Micro-hydropower ● Integrated photovoltaic system ● Diesel-engine systems	● Solar home systems (SHS)

In the on-grid category, the master plan study considered extension of 33 and 11 kV distribution lines.

In the on-grid category, the master plan study considered extension of 33 and 11 kV distribution lines.

In the off-grid category, it considered mini-grids (installation of small-scale local distribution line networks) and stand-alone systems. The mini-grid type included

micro-hydropower systems, photovoltaic systems, and systems powered by diesel engines. For the stand-alone type, the study examined solar home systems (SHS), which are a variety of photovoltaic power generation.

Each of these methods has its strengths and weaknesses, and the selection varies depending on the size, geographical conditions, and demand of the target trading center. The team therefore decided to rate the economic merit and effect of each prospective method for each target trading center, with respect to the following items.

- Initial investment cost
- Lifecycle cost (cost throughout the facility service life, inclusive of O&M cost)
- O&M cost
- Cost benefit analysis

2.6 Study of RE institutional arrangement

The government has already set forth its policy on the energy and power sector reform, and is taking various institutional measures needed to promote RE.

The formulation of the master plan is premised on maintaining conformity with existing policy. The team therefore attached importance to pointing out the locus of any institutional features that could possibly pose problems in the plan's implementation, and proposing measures for their solution.

To this end, the team has studied and reviewed related policies, laws and the organizational setup for RE promotion. The focus was on required funding for RE, institutional arrangements for RE promotion in the context of the ongoing structural reform.

3 Features of the master plan

3.1 Characteristics of the RE power demand

Judging from the data obtained from electrified trading centers, the level of power consumption is basically determined by the number of electrified households and maize mills. The maize mills account for as much as 60 percent of the total consumption.

Power consumption in the average rural household comes to about 260 kWh per year. A typical household is equipped with one 60 W light bulb, one 100 W light bulb, and one 20 W radio-cassette player. In the standard pattern, these appliances are used for a duration of about five hours per day. The demand is therefore less than 200 W per household.

In a typical trading center, maize mills are installed at the rate of one for every 20 - 50 households, and have a capacity of about 20 kW each. (The people who use maize mills do not necessarily live in the trading center; some of them come from neighboring areas to have their corn ground.) Maize mills therefore have the lion's share of the demand for electric power in trading centers.

3.2 Electrification methods

The team examined the comparative cost advantage of each method in all 249 trading centers in accordance with the process profiled in Chapter 2. Initially, it was thought that there were fairly good prospects for application of systems based on micro-hydropower. However, on-the-spot study of the micro-hydropower potential in 35 places revealed that it would be insufficient in most cases, for a variety of reasons. Only two trading centers in the northern part of Malawi were deemed suitable for the off-grid method (micro-hydro and diesel). The results showed that the on-grid method was superior in almost all of the target trading centers.

It should be noted that, while off-grid methods are thought to be superior in very few of the unelectrified trading centers taken up in this study, this should not be taken as a rejection of these methods in Malawi. It is merely the conclusion derived from study and evaluation restricted to the 249 trading centers.

Table 3 - 1 presents the results of the overall ranking of electrification methods in the 249 subject trading centers. The results showed that the general trend in the ranking of the methods is as follows (in descending order): on-grid, diesel system, micro-hydropower, and photovoltaic system (see Table 3 - 1).

Table 3 - 1 Electrification method ranking results

Item	First	Second	Third	Fourth
Low level of initial investment	Distribution line extension (Diesel mini-grid)	Diesel mini-grid *1 (Distribution line extension	Micro-hydropower mini-grid *2	Photovoltaic mini-grid *3
Cost versus effect	Distribution line extension (Micro -hydropower mini-grid)	Diesel mini-grid	Micro-hydropower mini-grid (Distribution line extension)	Photovoltaic mini-grid
Profitability	Distribution line extension (Micro -hydropower mini-grid)	Diesel mini-grid	Micro-hydropower mini-grid (Distribution line extension)	Photovoltaic mini-grid

*1 : Diesel system only

*2 : Micro-hydropower plus diesel system

*3 : Photovoltaic system plus diesel system

*4 : In Phase 8, the ranking of on-grid and off-grid methods was reversed in some trading centers.

Source: Prepared by the JICA MP ST

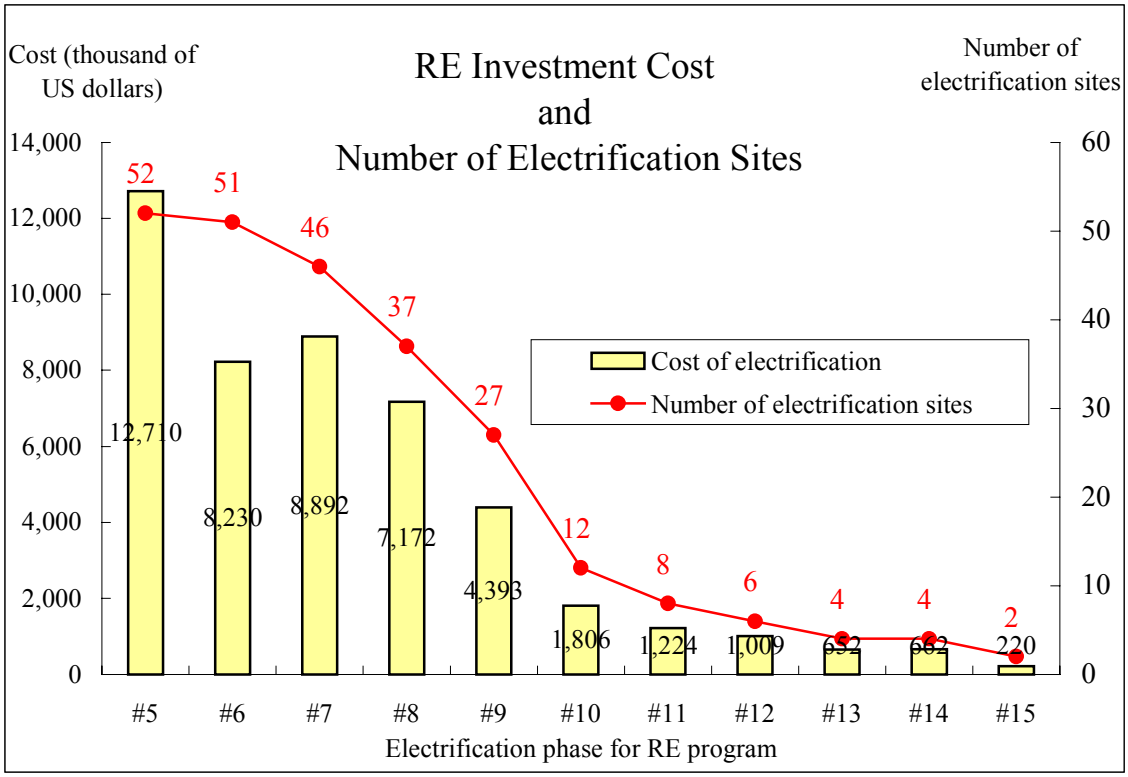
It can be added that solar home systems (SHS) are already in widespread use among tobacco farms, households, and boarder posts (checkpoints along the national border) in the remote areas without access to distribution lines.

3.3 Funding issues

(1) Capital investment

The total investment required for electrification of the 249 trading centers covered in this study is estimated at 47 million dollars. If each phase electrifies two trading centers per district, electrification of all centers would take 11 phases. The required investment is estimated at 12.71 million dollars in the proposed Phase 5 and much less in the preceding phases. This is because, as the sequence proceeds, there would emerge districts that graduate from the program because of electrification of all of their trading centers. This would mean a decrease in the number of trading centers that would be target for the program.

Taken together, the first three phases (Phase 5 - Phase 7) could electrify about 60 percent of all of the targeted trading centers, and account for about 63 percent of the total investment (see Fig. 3 - 1).



Source: Prepared by the JICA MP ST

Fig. 3 - 1 Electrification investment cost and number of target trading centers

(2) O&M financing

When looking at O&M cost, one must take into account of the cost of depreciation, as well as the labor costs, overheads and other expenses. Without considering the depreciation cost (which will be applied for replacement of the facility), it will be impossible to continue operation after the useful life of the initial investment has ended.

RE programs entail a particularly high initial cost due to the need for all kinds of investment in remote areas. In addition, the target trading centers tend to have a low population density and low level of economic activity, and this lowers the demand while driving up the O&M cost. Furthermore, because there are few beneficiaries to shoulder the cost, the burden per customer becomes higher.

Assuming that each trading center pays for all of the O&M cost by itself, it was revealed that only a small number of trading centers can sustainably be operated with the current tariff level. On the average, the required tariff would be 2 to 3 times the current level, and in some cases, it may even reach above 10 times. Considering the lower levels of income in the rural area, this tariff level would be unattainable. This clearly suggests the need for O&M leverage, considering the fact that GOM policy requires uniform power tariff.

It is estimated that a uniform levy of about 5 percent in the current power tariffs would be

sufficient to cover the required leverage for O&M in trading centers that are not financially viable on their own.

3.4 Institutional issues

(1) Current status and problems in the promotion of RE

After the commercialization of ESCOM in 1995, the Government of Malawi made a decision to relieve the utility from the rural electrification obligations, which inherently have a large social component with low returns on investment, and took over the RE obligation itself. Meanwhile, ESCOM devoted itself to power supply service only in urban and peri-urban areas. As a result, the RE program is currently carried out under the following scheme:

- Establishment and usage of the Energy Fund that benefits from a levy on petroleum products sales.
- Contracting out of the construction work of RE infrastructure to ESCOM.
- Transferring of the complete infrastructure/assets to ESCOM and converting the assets to government equity.
- ESCOM carries out power supply in rural areas using the transfer assets.

In other words, a new institutional framework was established: the government holds necessary investment cost for RE and contracts the construction work out to ESCOM, and ESCOM operates the facilities.

However, in some cases, it seems unviable to continue RE implementation through this arrangement. In such cases, although the initial capitalization for RE is paid by the government, it is difficult for ESCOM to fully recover both costs of depreciation and of operation and maintenance at the current average power tariff level.

This current arrangement poses conflict between ESCOM business and RE promotion.

(2) New scheme of RE promotion

The government is committed to the implementation of the power sector reform strategy aimed at establishing a new electricity supply industry structure. The Rural Electrification Bill and the Electricity Bill are being drafted, pursuant to the approved Energy Policy and Power Sector Reform Strategy.

The current RE implementation arrangements are neither consistent with the approved Energy Policy, nor are they conducive to the successful implementation of the RE program. It is therefore necessary to introduce new RE business models that address the

inconsistencies.

Although the following models have both some advantages and disadvantages, they have the potential to be applied in Malawi's RE program (see Table 3 - 2)

Monopolistic Utility

A Monopolistic Utility, such as ESCOM, has often started as a state enterprise that covers the whole country or region. It's size makes it easier to internally cross-subsidize the costs of RE, and its skill base makes it technically possible to undertake the task. In many cases, such as in Malawi, they are facing the prospect of privatization or commercialization, which often makes it difficult to continue some of their unprofitable operation including RE.

Independent Power Distributor (IPD)

Independent Power Distributors are firms that will undertake power distribution in a relatively large scale. They are strongly profit oriented, and likely to be very cost effective in many cases, but will require a significant risk-adjusted returns to participate in the market.

In accordance with the approved Power Sector Reform Strategy, such as IPDs could possibly enter the power market in Malawi in the future but could not be expected to choose RE projects on their own. To facilitate participation of IPDs, it is prerequisite to open the market of urban areas and arrange fair market environment for competition with ESCOM, or provide some compensation for the unprofitable operation of RE.

Energy Service Companies（ESCOs）

Generally speaking, ESCOs apply a business model of energy supply adapted to the needs of specific customers as opposed to the network business model of ordinary electric utilities. The major ESCOs are vendors of SHS and petroleum products.

ESCO-type enterprises therefore would be potential RE participants in Malawi. ESCO-style business would be especially suited to RE promotion by means of off-grid systems utilizing SHS.

The list of parties that could possibly enter the power sector for participation as ESCOs would by no means be limited to those with such business experience in other countries. ESCOM could very well launch new ESCO business by establishing a separate firm staffed with some of its current employees (i.e., the establishment of ESCOM-ESCO). This can also be a measure to solve the current problems of ESCOM in promoting RE projects.

The reason behind the expectations for ESCOM-ESCO is that ESCOM possesses all of the necessary business resources in both the technical and staffing aspects. However, successful operation of ESCOM-ESCO would demand a slimmer organization capable of operating at lower cost than the current ESCOM.

Electric Cooperatives (ECs)

ECs are grounded in the idea of having local citizens pay membership dues, and using these dues as funding for establishment and operation of a cooperative association. The supply of electricity is restricted to EC members.

ECs do not yet exist in Malawi, and their establishment would have to start from scratch. This would not be an easy task. Nevertheless, the job would hold considerable value for stimulating economic development in rural areas, and the attempt to promote RE through ECs could be worth the effort. ECs are likely to operate systems using micro-hydro power.

Either of these models can potentially be applied to RE implementation in Malawi, provided that there is 100 percent capitalization by government and leverage O&M of unviable projects.

Table 3 - 2 Business models for RE implementation

<table>
<tr><td colspan="3" rowspan="2"></td><td colspan="2">On-grid</td><td colspan="3">Off-grid</td></tr>
<tr><td>Relatively Large Demand</td><td>Relatively Small Demand</td><td>PV</td><td>Mini-hydropower</td><td>Other Renewables</td></tr>
<tr><td colspan="3">Tariff Level Required for Cost Recovery (as Compared to Current ESCOM Tariffs)</td><td>○
(Possibly About the Same)</td><td colspan="3">△
(Possibly Higher)</td></tr>
<tr><td rowspan="5">Operation</td><td colspan="2">Monopolistic-Utility</td><td>○
(Probably Possible)</td><td colspan="3">△
(High O&M Costs: Feasibility Difficult)</td></tr>
<tr><td colspan="2">IPD</td><td colspan="2">×
(Low Profit Rate: Participation Doubtful)</td><td colspan="3">Not applicable</td></tr>
<tr><td rowspan="2">ESCOs</td><td>ESCOM-ESCO</td><td colspan="5">○
(Probably Possible)</td></tr>
<tr><td>Other Private ESCOs</td><td colspan="2">×
(Probably Impossible)</td><td>Probably the Market with the Best Prospects)</td><td>△
(Participation Doubtful)</td><td>??
(Depends on the Individual Case)</td></tr>
<tr><td colspan="2">ECs</td><td colspan="2">??
(Uncertain, but Worth Trying)</td><td colspan="3">○
(Probably Possible)</td></tr>
</table>

Source: JICA Study Team

The effective functioning of the various RE business models proposed herein depends on the progress of the structural reform now being promoted by the government in the power sector.

The provision of equal opportunity in the market is a prerequisite for encouraging participation by newcomers, i.e., entrants other than ESCOM. This, in turn, demands the breakup of ESCOM's current monopolistic setup through the structural reform. Conversely, the models for new entrants are not going to function if the reform does not progress.

In this context, different institutional schemes for the promotion of RE from Phase 5 must be prepared before and after the implementation of the structural reform.

In advance of the structural reform

These factors make it necessary to follow the business model applied in Phase 4 as the setup for RE promotion in the period until completion of the structural reform. In other words, there will be no choice but to have ESCOM ring-fence RE-related business and urban business, and to make a separation between the two in accounts. In addition, the government is to assume the burden of the initial investment and contract out of the facility construction to ESCOM. Upon their completion, the facilities will be transferred to ESCOM, and the government will hold ESCOM stock in a quantity equivalent to the asset value of the facilities.

After the structural reform

With implementation of the structural reform, a new business setup can be prepared in the distribution division.

As stated by the government in its official policy, it has been decided to reallocate franchises now monopolized by ESCOM among other operators in accordance with concession agreements. This kind of market climate will make it possible for ESCOM and the new entrants to compete for business under the same conditions. To obtain concessions, entrants would have to consider the size and profitability of the market under the contract terms established in each franchise, whether urban or rural, and build diverse new business models with operational configurations matching the market attributes.

(3) Funding issues and the schedule for the RE program

The procurement of requisite funding is a key factor in the schedule for program promotion. The funding required for implementation of Phase 5 is estimated at about 1.1 billion MK. To promote the project, the government must procure this funding from the current Energy Fund (the future RE fund) and financial aid from donors. Judging from the scale of the Energy Fund as the domestic source, the government could obtain levy revenues of about 120 million MK per year at present.

The problem is that it is uncertain how much of the requisite funding can be procured from the Energy Fund and how much time it will take to obtain this funding. In light of the current scale of levy revenue, it would take about three years to obtain 30 percent (i.e., 330 million MK) of the requisite funding from the Energy Fund. Similarly, to obtain about half

(550 million MK) from the same fund would take about five years.

In estimates of the RE project schedule from the standpoint of project implementation including the front-end arrangement, engineering, procurement, and construction works, it would probably take four to five years to implement a single phase. To accelerate the project (and thereby shorten the schedule) would require quicker procurement of funds. This, in turn, would demand either an expansion of the sources of domestic funding or an increase in the rate of procurement from external sources.

(4) Need for a cost leverage mechanism for operations

In its current policy, the government has confined its assistance for RE to funding required for initial investment. There must be studies of the prospect of furnishing funding for operations.

The RE cost for the trading center (TC) service envisaged in Phase 5 could in many cases not be met by the average power tariff of ESCOM. In other words, operators would fall into a situation of deficit that deepens as the operation continues.

To resolve this problem, it would be necessary either to instate a tariff scheme with levels that differ with the district in order to retrieve costs or some kind of mechanism for relieving RE cost burden if tariff levels are to be uniform nationwide.

The instatement of district-specific tariffs (i.e., that vary with the district) would not be a realistic option. In some TCs, the RE cost would be from five to ten times as high as the current tariffs, and could not be passed on in its entirety to the customers. Furthermore, if the government's current policy of having all customers shoulder an equal tariff burden is to be upheld, some kind of mechanism for financial support would have to be devised.

In connection with this prospective financial support, there are two tasks for the government: assurance of funding sources for the financial support (or financial contribution) and construction of the financial support mechanism.

As described above, judging from its size, the existing Energy Fund would be capable of providing funds only for the RE program facility investment; it does not have the financial margin for contribution of the balance of operating (business) payments. Therefore, this financial support must be funded by the new financial sources planned in the Rural Electrification Bill.

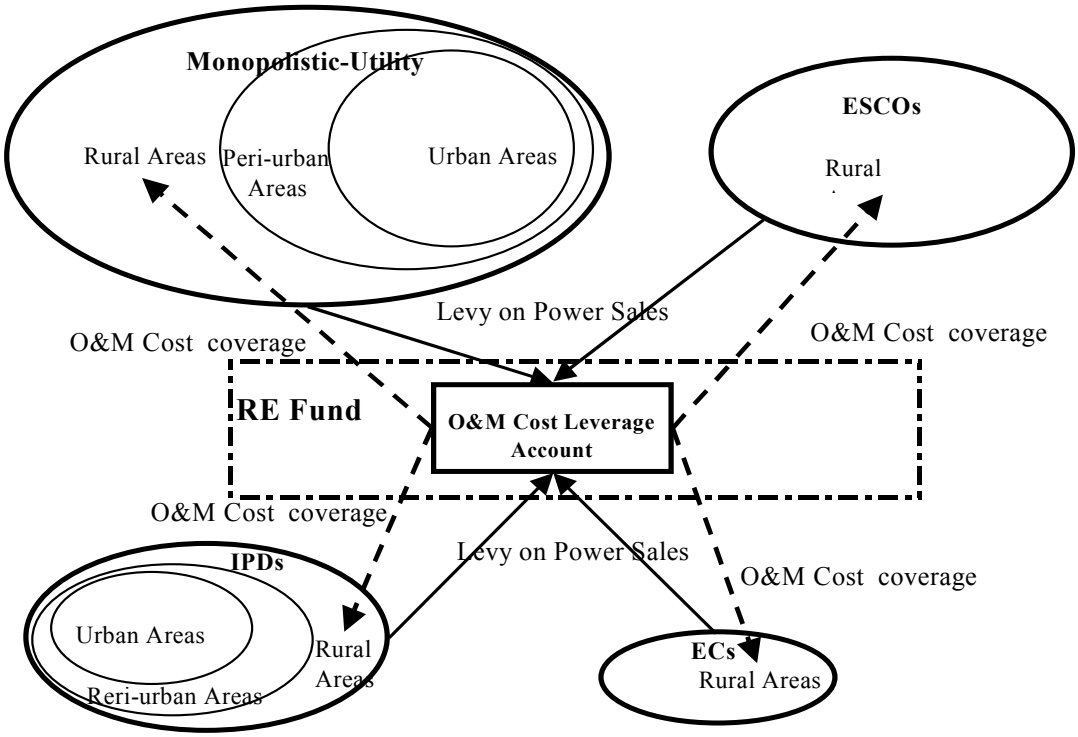
As for the financial support mechanism, the key point is assurance of transparency. This is why the government should not apply a mechanism based on cross-subsidization, which is liable to blur the relationship between the parties shouldering the cost burden and the

beneficiaries. Here, the term "transparency" refers to a situation in which both the amount and source of the financial support are clear and a third party can learn how much money was received by which parties. The mechanism of the existing Energy Fund (the future RE fund) could be applied to assure such transparency.

The regulations proposed in the RE Bill would permit imposition of levies on the sales of operators, and the revenue from these levies would be pooled in the RE fund. At present, the aid from this fund is to be confined to facility investment. However, application of part of the fund to compensation for loss incurred in the operation of RE projects is an option that should be considered.

Fig. 3 - 2 envisions the establishment of a plural number of operators in the distribution subsector liberalized by the structural reform. It was assumed that some operators would provide service in franchises with both urban and rural areas, while others would operate RE projects only in rural areas. It was also assumed that the levy funding the O&M cost leverage would be imposed on all operators alike, in correspondence with their sales, and that the revenue would first be pooled in the O&M Cost Leverage Account of the RE Fund.

By the same token, leverage money would be furnished from the O&M Cost Leverage Account in the RE Fund for deficits incurred by these operators in running the RE programs.



Source: JICA Study team

Fig. 3 - 2 Mechanism of cost leverage for O&M of the RE program

Although the basic cost leverage mechanism can be diagrammed as shown in , detailed studies would have to be made of matters such as the standard to be applied in determining the amount of funding for RE operations and the nature of the limitations to be imposed on the funding. The RE projects will presumably differ in respect of preconditions such as scale, type of operation, and economic merit. While these matters should be examined through a feasibility study conducted after determining the detailed RE districts and operation models, the general principles to be applied are as follows:

a) Parameters for determining O&M cost leverage (e.g., balance of operating payments, number of customers and amount of sales, and conditions for discontinuation of the subsidies)

b) In franchises containing both urban and rural districts, there must be a clear separation for RE in the accounts. Otherwise, operators will be able to transfer a worsening of their earnings in urban districts to the RE program.

c) The concession agreement must clearly define the ownership rights to the facilities constructed. The ownership rights to facilities constructed with governmental financial support naturally should belong to the government. For those constructed with investments by the operators, the government would have to make buyouts at residual value upon the expiration of the concession agreement.

(5) Need for expansion of the RE fund scale

Besides the provision of funds for initial investment in RE projects, the government must also consider the prospect of using the RE fund (the current Energy Fund) for providing necessary O&M cost leverage for the future RE project as described above.

At present, the fund is definitely not large enough to serve as a source for such subsidization and financial support. Among the variety of funding sources noted in the RE Bill, the levy on power sales is expected to be the biggest after that on petroleum products.

The level of the levy needs careful study, although it is estimated that the amount does not have to be too significant. The cases of neighboring countries also exhibit higher rates; the levy on electricity has been increased from 3 to 7 percent in Zambia and from 1 to 6 percent in Zimbabwe. In sum, the government must determine the advisable rate of levy with reference to the requisite scale of funding and levy level, and with consideration of precedents in other countries.

(6) The DOE role

In the context of the master plan, we assume that the DOE will continue to play the coordinating role for RE planning and implementation as dictated in the Energy Policy.

Specifically, this function will include but not limited to the following;

- Resource mobilization

DOE should provide leadership in resource mobilization, both domestically and internationally. Domestically, this will involve preparation of necessary legislation and working with Ministry of Finance and other stakeholders to expand the resource base of the Rural Electrification Fund to include levy on power sales, access to HIPC resources and proceeds of the on-going public asset privatization process. Internationally, DOE will have to engage existing and new cooperating partners with a view to realizing support for any financing gaps for its RE program. Synergies should be developed between this master plan and the on-going work of the World Bank under its Energy Access Program to ensure that the resources under this program adequately support this Master Plan.

- Data Update

Although the study has made detailed surveys of the current situation, these are bound to change in the near future. Therefore, it is necessary to review the situation in each TCs in order to re-evaluate the priorities between the TCs. In order to achieve this, a constant update of the various data, in cooperation with other government entities if necessary, is vital to achieve a fair and effective electrification.

- Detailed planning

Although this Master Plan study has made an overall study of the whole country, it has not been able to study every TCs in detail. It has relied on a generalized method to assess the priorities and the costs etc.. Therefore, the DOE must undertake detailed studies of the TCs to be electrified, in order to assess their demands, costs, and the best institutional arrangement. While the study team is confident that there are no major omissions, it is possible that there are some unforeseen obstacles, which requires additional attention. These factors should be carefully studied, in order to create and implement a detailed feasibility study and implementation plan of various phases.

Technology transfer and check of data through case studies

A case study was made of the trading centers ranking first and second in terms of electrification priority in each district in the overall RE program prepared for the master plan, in order to investigate estimated demand (kW and kWh), the initial and lifecycle cost based on the electrification method, the degree of benefit, and project profitability.

One of the main objectives of this case study was to transfer the know-how needed for subsequent reviews and detailed planning of the RE program to DOE personnel.

Also, toward the end of the implementation of the 11 phases, there will be very few

remaining TCs per phase, which can be combined into single phases. Such planning would also be the role of the DOE.

- Management of the RE Fund

  Energy policy identifies DOE as the manager of the RE Fund. We find this arrangement satisfactory and it is therefore our recommendation that the status quo prevails with the proviso that issues of accountability, access, disbursement etc. are handled in a transparent manner. This entails setting up of a multi-sectoral RE Fund Management Committee, and publication of audited accounts.

Additionally, in making the concrete RE programs, the DOE must perform the following tasks:

- Updating of data collected in this study and reassessment of the order of TC priority for electrification;
- Detailed planning for individual program phases; and
- Management of RE project implementation and enhancement of management skill.
- Need for review of the overall RE program in the master plan

4 Recommendations

This study has prepared the framework for RE planning in Malawi to 2020. It should be noted that the findings presented here merely constitute a basic foundation; promotion still must address the tasks of program review, accumulation of data, and refinement of analytical techniques.

Similarly, in the implementation of RE, many issues remain to be resolved in the institutional aspect. The items proposed below should be tackled at an early date.

- Swift implementation of Phase 5 RE plan.

  The Master Plan has identified 52 TCs for the next phase of RE. These should be undertaken without delay, as a seamless continuation of the current Phase 4 RE. Phase 5 implementation will require a detailed feasibility study for the target trading centers. Also, the scheduling of the 52 TCs needs to be developed.

- Selection of trading centers as future program targets and determination of electrification methods

  Phase 5 will require several years to implement. During that period, the planning for Phase 6 will be needed, in order to carry out the RE in a seamless manner. By that time, it is highly likely that the situations have changed for the various TCs. Therefore, it is better to continue with the data collection, and reorder the priorities based on those data, if necessary.

  The criteria for selecting electrification sites and methods presented in this report are the simplest and most dependable under the prevailing circumstances. Efforts consequently must be made to improve arrangements for compiling statistical data and storing technical data related to electrification in order to increase the precision and reliability of criteria and selections.

- Coordination with other Initiatives

  In the master plan prepared through this study, the electrification sites are confined to trading centers. However, in order to bring the current dismal rural electrification rate higher, efforts must be made for a parallel electrification of areas remote from trading centers. In such areas, off-grid methods, especially SHS, would be an effective strategy.

  Rural Electrification using SHS in remote areas is already being tackled in the "Barrier Removal to Renewable Energy in Malawi Project", also undertaken by DOE with the assistance of UNDP. DOE should try to coordinate with this project in order to achieve the optimal RE for Malawi in a harmonized manner.

- Mobilizing Resources / Resource endowment

  Use of the current Energy Fund is limited to initial investment for RE projects. As is

clear from the examinations in this study, the total RE cost (inclusive of O&M) will definitely be much higher than could be covered by the current average ESCOM power tariff. To make RE sustainable, it will therefore be necessary to incorporate some kind of financial support not only for initial investment but also for O&M.

Because this financial support could not be funded entirely from the fund consisting of revenue from the tax on petroleum products, there needs to be some additional sources of funding from various resources. This can either come from domestic sources, including the expansion of various levies, or it could come from foreign sources through various forms of aid. The Government of Malawi should pursue these options in order to ensure a smooth implementation of RE phases, in order to promote its goals.

Apart from the funding requirement, GOM should also ensure that DOE can enhance its capacity in order to properly implement the Master Plan. The structural reform and the necessary financial control will significantly increase the role of DOE. GOM should consider various forms of resource endowments in order to ensure the smooth functioning of DOE in its ever-expanding roles.

- Forge ahead in passing legislation

The Government of Malawi has already established the framework for power sector reform, and is currently pursuing necessary legislations, such as the establishment of a Rural Electrification Bill. These legislations will enable diverse entities to participate in the power market, which is currently dominated by ESCOM.

The progress in these power sector reform will strongly affect the promotion of the RE programs. Pending this reform, government will be able to reallocate franchises among new operators and conclude concession agreements with individual ones. On this occasion, the DOE should exercise leadership by, for example, encouraging entry by new operators and backing the implementation of the program.

5 Attachments

shows the following explanation

- Region: Regional name when the Malawi is divided in to three region as North, Central and South
- Name of District: District name where has unelectrified trading center as an electrification target
- Name of TC: Name of unelectrified trading center as an electrification target
- Annual Peak Demand: Annual maximum peak demand (kW)
- Annual Energy Demand: Annual energy demand (kWh)
- Appropriate Electrification Method: Most appropriate electrification method for targeted trading center
- Electrification Cost (1,000US$): Initial investment cost for electrification (1,000US$)
- Investment Cost: This cost for electrification at initial stage
- D/L Extension (1,000US$): Electrification cost by distribution line extension (1,000US$)
- Micro-hydro with Off-grid (1,000US$): Electrification cost by mini-grid using micro-hydropower and diesel power (1,000US$)
- PV with Off-grid (1,000US$): Electrification cost by mini-grid using photovoltaic power and diesel power (1,000US$)
- Diesel with Off-grid (1,000US$): Electrification cost by mini-grid using diesel power (1,000US$)

The "D/L Ext." noted as the most appropriate electrification method for almost all subject trading centers indicates "distribution line extension," which was found to be the best for them. The initial electrification cost is noted in the "electrification cost" cell in thousands of (US) dollars. The aggregate total of this cost for all districts is equivalent to the requisite initial electrification cost in the phase in question. The advisable method for each trading center is noted in the "appropriate electrification method" cell.

Most appropriate electrification method will be decided based upon the evaluation of electrification investment cost, life cycle cost, benefit and profitability. The most appropriate electrification method will be denoted in the cell of appropriate electrification method.

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase V		Name of TC (1)	Nthalire	Songwe	Katowo	Mpamba	Edingeni		Chamama	Mkaika	Nthesa	Thambwe	Kandulu	Chilobwe	Mkanda	Kabwazi	Ntonda	Makanjira	Chikwewu	Chendausiku	Jenale	Kanje	Chikuli	Chikonde	Nansadi	Chinyama	Chilinga	Mitondo	Tengani
		Peak Demand (kW)	385	113	297	115	27		142	505	50	142	153	307	273	53	132	410	375	250	64	204	111	113	255	136	79	162	384
		Energy Demand (MWh)	1,929	567	1,486	575	137		711	2,529	251	710	768	1,536	1,366	264	663	2,054	1,876	1,253	322	1,021	555	567	1,275	683	394	809	1,923
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
		Electrification Cost (1,000US$)	1023	88	527	237	71		345	277	159	134	120	484	122	235	208	1265	349	242	235	105	176	88	137	357	208	149	156
		Benefit/Cost	2.03	8.69	3.13	3.39	5.51		2.71	8.91	3.19	6.74	7.91	3.49	11.66	2.21	4.23	1.75	5.64	5.80	2.43	10.85	4.44	8.69	10.00	2.54	3.05	6.68	12.08
	Investment Cost	D/L Extension (1,000US$)	1,023	88	527	237	71		345	277	159	134	120	484	122	235	208	1,265	349	242	235	105	176	88	137	357	208	149	156
		Micro-hydro with Off-grid (1,000US$)	1,117	-	829	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	60,621	17,847	46,689	18,095	4,338		22,367	79,411	7,924	22,321	24,139	48,263	42,905	8,318	20,838	64,521	58,924	39,370	10,135	32,094	17,457	17,847	40,059	21,485	12,394	25,444	60,398
		Diesel with Off-grid (1,000US$)	274	147	232	147	105		162	330	119	162	166	236	222	119	157	288	269	213	124	190	147	147	213	157	129	171	274
	Life cycle cost	D/L Extension (1,000US$)	997	90	518	232	69		336	289	154	135	122	477	130	227	205	1,229	351	243	227	110	173	90	143	348	202	150	167
		Micro-hydro with Off-grid (1,000US$)	2,357	-	1,942	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diesel with Off-grid (1,000US$)	2,027	779	1,620	786	382		912	2,577	491	911	963	1,666	1,512	501	867	2,145	1,979	1,410	553	1,195	769	779	1,428	884	617	1,002	2,022
	B/C	D/L Extension	2.03	8.69	3.13	3.39	5.51		2.71	8.91	3.19	6.74	7.91	3.49	11.66	2.21	4.23	1.75	5.64	5.80	2.43	10.85	4.44	8.69	10.00	2.54	3.05	6.68	12.08
		Micro-hydro with Off-grid	0.88	-	0.90	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid	0.03	0.04	0.04	0.04	0.09		0.04	0.03	0.06	0.04	0.04	0.04	0.04	0.06	0.04	0.03	0.03	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.03
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Name of TC (2)	Lupita	Kibwe	Chitimba-chiweta	Kavuzi	Euthini		Mpepa	Dwambadzi	Khuwi	Bowe	Chilambula	Nyanja	Chiosya	Golomoti	Kasinje	Chilipa	Nampeya	Kwitanda	Sunuzi	Milepa	Mombo	Thambani	Fifite	Nkando	Mlomba	Linvunzu	Mankhokwe
		Peak Demand (kW)	382	382	20	176	350		63	350	70	205	43	59	190	111	264	32	401	49	116	62	17	233	156	142	138	33	182
		Energy Demand (MWh)	1,915	1,915	98	880	1,752		318	1,752	348	1,028	215	297	954	555	1,322	160	2,006	243	583	312	84	1,165	783	711	689	165	910
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
		Electrification Cost (1,000US$)	156	156	235	225	156		191	378	161	298	86	71	298	88	315	340	363	100	132	235	159	300	105	149	225	191	105
		Benefit/Cost	12.05	12.05	1.53	4.77	11.23		2.97	4.92	3.65	4.08	5.43	7.44	3.87	8.59	4.69	1.25	5.73	4.88	6.02	2.40	2.19	4.46	9.04	6.12	4.01	2.23	10.03
	Investment Cost	D/L Extension (1,000US$)	156	156	235	225	156		191	378	161	298	86	71	298	88	315	340	363	100	132	235	159	300	105	149	225	191	105
		Micro-hydro with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	60,152	60,154	3,110	27,676	55,041		10,009	55,043	10,971	32,213	6,795	9,350	29,984	17,454	41,526	5,075	63,003	7,680	18,341	9,840	2,668	36,617	24,629	22,357	21,681	5,222	28,609
		Diesel with Off-grid (1,000US$)	274	274	101	176	255		124	255	124	190	115	119	185	147	218	110	283	115	147	124	101	204	166	162	157	110	180
	Life cycle cost	D/L Extension (1,000US$)	167	167	225	223	166		185	378	157	294	84	71	294	90	313	326	366	98	132	227	152	298	108	149	221	184	109
		Micro-hydro with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diesel with Off-grid (1,000US$)	2,016	2,016	345	1,065	1,862		550	1,862	575	1,201	456	527	1,136	769	1,471	407	2,101	479	792	546	334	1,328	976	912	889	410	1,095
	B/C	D/L Extension	12.05	12.05	1.53	4.77	11.23		2.97	4.92	3.65	4.08	5.43	7.44	3.87	8.59	4.69	1.25	5.73	4.88	6.02	2.40	2.19	4.46	9.04	6.12	4.01	2.23	10.03
		Micro-hydro with Off-grid	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid	0.03	0.03	0.11	0.04	0.03		0.06	0.03	0.05	0.04	0.07	0.06	0.04	0.04	0.04	0.08	0.03	0.06	0.04	0.06	0.13	0.04	0.04	0.04	0.04	0.08	0.04
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase VI		Name of TC	Wenya	Pusi	Lara	Khondowe	Mpherembe		Matenje	Msenjere	Kamsonga	Chiseflo	Kambiri Sch.	Kasiya	Mikundi	Chimoto	Kadzakalowa	Chiponde	Ngokwe	Phimbi	Zaone	Chimwawa	Dziwe	Ligowe	Lalakani	Nanthombozi	Phaloni	Kakoma	Mtowe
		Peak Demand (kW)	374	356	113	38	224		28	32	303	184	113	316	42	113	300	244	42	38	244	38	38	113	10	125	26	204	224
		Energy Demand (MWh)	1,871	1,784	567	190	1,121		141	159	1,519	920	567	1,581	208	567	1,504	1,221	208	190	1,221	190	190	567	49	624	132	1,021	1,121
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	Diesel	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
		Electrification Cost (1,000US$)	214	156	88	110	122		176	71	226	359	88	139	191	88	139	122	264	354	122	71	86	103	206	132	115	298	180
		Benefit/Cost	8.87	11.40	8.69	0.86	10.11		2.27	5.83	7.15	3.13	8.69	11.54	2.44	8.69	11.14	10.75	1.77	1.26	10.75	6.17	5.14	7.52	1.53	6.29	3.40	4.06	7.03
	Investment Cost	D/L Extension (1,000US$)	214	156	88	-	122		176	71	226	359	88	139	191	88	139	122	264	354	122	71	86	103	206	132	115	298	180
		Micro-hydro with Off-grid (1,000US$)	-	-	-	408	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	58,755	56,024	17,847	6,008	35,238		4,452	5,020	47,706	28,907	17,847	49,672	6,581	17,847	47,259	38,382	6,581	6,008	38,382	6,008	6,008	17,847	1,592	19,617	4,168	32,094	35,238
		Diesel with Off-grid (1,000US$)	269	260	147	110	199		105	110	236	180	147	241	115	147	236	208	115	110	208	110	110	147	96	152	105	190	199
	Life cycle cost	D/L Extension (1,000US$)	223	166	90	-	127		170	70	231	352	90	148	184	90	147	128	254	341	128	70	84	104	197	132	111	294	183
		Micro-hydro with Off-grid (1,000US$)	-	-	-	1,221	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Diesel with Off-grid (1,000US$)	1,975	1,893	779	582	1,287		385	405	1,652	1,102	779	1,708	451	779	1,640	1,379	451	430	1,379	430	430	779	300	830	378	1,195	1,287
	B/C	D/L Extension	8.87	11.40	8.69	-	10.11		2.27	5.83	7.15	3.13	8.69	11.54	2.44	8.69	11.14	10.75	1.77	1.26	10.75	6.17	5.14	7.52	1.53	6.29	3.40	4.06	7.03
		Micro-hydro with Off-grid	-	-	-	0.86	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		PV with Off-grid	0.03	0.03	0.04	0.10	0.04		0.09	0.08	0.04	0.04	0.04	0.03	0.07	0.04	0.04	0.04	0.07	0.07	0.04	0.07	0.07	0.04	0.19	0.04	0.09	0.04	0.04
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Name of TC	Kameme	Iponga	Muhuju	Sanga	Jenda		Simlemba	Kasitu	Chinguluwe	Bibanzi	Khwidzi	Chawantha	Nkhwazi	Chiluzi	Kandeu	Majuni	Mposa		Muwa	Ndunde	Mudi	Kam'mwamba	Thomasi	Chambe	Chitekesa	Tomali	Mbenje
		Peak Demand (kW)	391	56	204	16	81		116	32	128	17	113	39	27	192	111	113	33		67	51	101	91	204	263	113	32	107
		Energy Demand (MWh)	1,960	282	1,021	81	408		580	159	639	86	567	195	136	961	556	567	163		336	254	504	456	1,021	1,315	567	162	538
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
		Electrification Cost (1,000US$)	468	71	120	100	88		371	159	88	159	88	206	86	120	193	88	264		146	71	146	222	283	137	117	71	146
		Benefit/Cost	4.41	7.29	9.63	3.43	7.20		2.19	2.65	9.33	2.20	8.69	2.19	4.58	9.24	4.05	8.69	1.61		3.94	7.01	4.99	3.13	4.26	10.24	6.63	5.87	5.16
	Investment Cost	D/L Extension (1,000US$)	468	71	120	100	88		371	159	88	159	88	206	86	120	193	88	264		146	71	146	222	283	137	117	71	146
		Micro-hydro with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	61,573	8,888	32,094	2,586	12,848		18,241	5,020	20,107	2,728	17,847	6,155	4,310	30,213	17,505	17,847	5,162		10,577	8,023	15,864	14,359	32,094	41,318	17,847	5,126	16,914
		Diesel with Off-grid (1,000US$)	279	119	190	101	133		147	110	152	101	147	110	105	185	147	147	110		124	119	143	138	190	218	147	110	143
	Life cycle cost	D/L Extension (1,000US$)	466	71	124	97	88		361	153	90	152	90	198	83	124	190	90	254		143	70	145	217	280	143	118	70	145
		Micro-hydro with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
		Diesel with Off-grid (1,000US$)	2,058	516	1,195	331	634		789	405	843	335	779	434	381	1,141	771	779	409		565	494	723	679	1,195	1,466	779	408	750
	B/C	D/L Extension	4.41	7.29	9.63	3.43	7.20		2.19	2.65	9.33	2.20	8.69	2.19	4.58	9.24	4.05	8.69	1.61		3.94	7.01	4.99	3.13	4.26	10.24	6.63	5.87	5.16
		Micro-hydro with Off-grid	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
		PV with Off-grid	0.03	0.06	0.04	0.13	0.05		0.04	0.08	0.04	0.12	0.04	0.07	0.09	0.04	0.04	0.04	0.08		0.05	0.06	0.05	0.05	0.04	0.04	0.44	0.08	0.04
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase VII		Name of TC	Chsenan	Miyombo	Mwasisi	Usisya	Manyamula		Kamboni		Bumphula	Msalanyama	Thavite	Malembo	Gumba	Mphati	Sharpvalle	Mvumba	Nayuchi		Mpyupyu		Mlenje	Matope	Makapwa	Mathambi	Mpasa	Ndakwera	Masenjere
		Peak Demand (kW)	208	113	113	323	224		57		163	47	113	110	113	113	518	63	72		224		38	204	38	155	38	100	204
		Energy Demand (MWh)	1,042	567	567	1,617	1,121		285		816	236	567	549	567	567	2,593	313	358		1,121		193	1,021	190	777	190	499	1,021
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
		Electrification Cost (1,000US$)	193	88	132	408	361		249		210	115	266	146	222	208	309	71	401		122		86	269	115	163	159	146	225
		Benefit/Cost	6.25	8.69	5.93	4.30	3.61		2.15		4.83	4.22	3.00	5.22	3.57	3.82	8.22	7.70	1.52		10.11		5.16	4.49	3.86	5.93	2.80	4.92	5.32
	Investment Cost	D/L Extension (1,000US$)	193	88	132	408	361		249		210	115	266	146	222	208	309	71	401		122		86	269	115	163	159	146	225
		Micro-hydro with Off-grid (1,000US$)	-	-	-	615	-		-		-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	32,761	17,847	17,847	50,807	35,238		8,994		25,643	7,433	17,847	17,269	17,847	17,847	81,427	9,867	11,286		35,238		6,085	32,094	6,008	24,423	6,008	15,693	32,094
		Diesel with Off-grid (1,000US$)	190	147	147	246	199		119		171	115	147	143	147	147	335	124	129		199		110	190	110	166	110	138	190
	Life cycle cost	D/L Extension (1,000US$)	194	90	131	405	356		241		209	112	260	145	218	204	321	71	386		127		84	266	112	164	154	145	225
		Micro-hydro with Off-grid (1,000US$)	-	-	-	1,148	-		-		-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-	-
		PV with Off-grid (1,000US$)	-	-	-	-	-		-		-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-	-
		Diesel with Off-grid (1,000US$)	1,212	779	779	1,743	1,287		518		1,007	473	779	759	779	779	2,635	546	588		1,287		432	1,195	430	970	430	713	1,195
	B/C	D/L Extension	6.25	8.69	5.93	4.30	3.61		2.15		4.83	4.22	3.00	5.22	3.57	3.82	8.22	7.70	1.52		10.11		5.16	4.49	3.86	5.93	2.80	4.92	5.32
		Micro-hydro with Off-grid	-	-	-	0.76	-		-		-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-	-
		PV with Off-grid	0.04	0.04	0.04	0.03	0.04		0.06		0.04	0.06	0.04	0.04	0.04	0.04	0.03	0.06	0.05		0.04		0.07	0.04	0.07	0.04	0.07	0.05	0.04
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Name of TC	Kapoka	Mlare	Nchenachena	Nthungwa	Eswazini		Kapheni		Malambo	Kachigamba	Makioni	Nsaru	Kazyozyo	Magomelo	Bilila	Katuli	Msosa		Masaula		Domwe	Magaleta	Sandama	Chinakanaka	Nambazo	Kanyinda	Kampata
		Peak Demand (kW)	263	38	189	153	60		59		163	157	24	438	44	344	204	65	74		224		113	19	341	146	113	174	37
		Energy Demand (MWh)	1,318	190	948	765	299		294		816	788	122	2,192	222	1,722	1,021	327	371		1,121		567	97	1,708	732	567	873	185
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
		Electrification Cost (1,000US$)	122	249	105	374	71		71		210	120	159	351	191	214	312	328	176		227		103	100	153	120	222	120	130
		Benefit/Cost	11.36	1.79	10.27	2.64	7.47		7.42		4.83	8.03	2.42	6.36	2.50	8.31	3.88	1.76	3.49		5.65		7.52	3.55	11.20	7.65	3.57	8.63	3.40
	Investment Cost	D/L Extension (1,000US$)	122	249	105	374	71		71		210	120	159	351	191	214	312	328	176		227		103	100	153	120	222	120	130
		Micro-hydro with Off-grid (1,000US$)	-	-	618	-	-		-		-	-	-	-	-	-	-	-	-		-		-	-	1,406	-	-	-	-
		PV with Off-grid (1,000US$)	41,397	6,008	29,788	24,060	9,441		9,278		25,664	24,770	3,885	68,854	7,007	54,101	32,094	10,314	11,691		35,238		17,847	3,083	53,666	23,009	17,847	27,446	5,850
		Diesel with Off-grid (1,000US$)	218	110	180	166	119		119		171	166	105	297	115	255	190	124	129		199		147	101	255	162	147	176	110
	Life cycle cost	D/L Extension (1,000US$)	129	240	109	365	71		71		209	122	153	356	185	221	308	316	171		228		104	97	163	121	218	123	126
		Micro-hydro with Off-grid (1,000US$)	-	-	1,303	-	-		-		-	-	-	-	-	-	-	-	-		-		-	-	2,337	-	-	-	-
		PV with Off-grid (1,000US$)	-	-	-	-	-		-		-	-	-	-	-	-	-	-	-		-		-	-	-	-	-	-	-
		Diesel with Off-grid (1,000US$)	1,468	430	1,125	961	530		526		1,008	979	370	2,267	462	1,838	1,195	558	599		1,287		779	344	1,827	928	779	1,059	426
	B/C	D/L Extension	11.36	1.79	10.27	2.64	7.47		7.42		4.83	8.03	2.42	6.36	2.50	8.31	3.88	1.76	3.49		5.65		7.52	3.55	11.20	7.65	3.57	8.63	3.40
		Micro-hydro with Off-grid	-	-	0.87	-	-		-		-	-	-	-	-	-	-	-	-		-		-	-	0.79	-	-	-	-
		PV with Off-grid	0.04	0.07	0.04	0.04	0.06		0.06		0.04	0.04	0.10	0.03	0.07	0.03	0.04	0.05	0.05		0.04		0.04	0.11	0.03	0.04	0.04	0.04	0.07
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase VIII		Name of TC	Chisenga	Chihepasha	Nkhozo	Ruarwe	Luwelezi				Ng'ombe	Chinkhwiri	Michulu	Kabudula	Gumulira		Pengapenga	Mkumba	Ngwepele		Nachuma		Chigwaja	Kanenekude	Chipho	Msikawanjala			Lulwe
		Peak Demand (kW)	94	38	117	268	81				29	131	113	36	34		121	287	133		113		113	53	152	48			59
		Energy Demand (MWh)	472	190	587	1,344	408				145	656	567	181	172		608	1,436	667		567		567	264	761	239			295
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	Micro-hydro	DL Ext.				DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.			DL Ext.
		Electrification Cost (1,000US$)	357	176	88	641	117				71	252	357	191	235		146	197	295		132		103	235	163	86			191
		Benefit/Cost	2.00	2.53	8.85	1.01	5.47				5.60	3.49	2.25	2.30	1.84		5.61	7.78	3.02		5.93		7.52	2.21	5.86	5.64			2.84
	Investment Cost	D/L Extension (1,000US$)	357	176	88	-	117				71	252	357	191	235		146	197	295		132		103	235	163	86			191
		Micro-hydro with Off-grid (1,000US$)	537	-	-	641	-				-	-	-	-	-		-	-	-		-		-	-	-	-			-
		PV with Off-grid (1,000US$)	14,852	6,008	18,454	42,227	12,848				4,594	20,632	17,847	5,708	5,446		19,135	45,109	20,980		17,847		17,847	8,320	23,918	7,528			9,299
		Diesel with Off-grid (1,000US$)	138	110	147	218	133				105	157	147	110	110		152	227	157		147		147	119	166	115			119
	Life cycle cost	D/L Extension (1,000US$)	346	170	90	-	116				69	247	346	184	226		146	202	289		131		104	227	163	84			185
		Micro-hydro with Off-grid (1,000US$)	945	-	-	732	-				-	-	-	-	-		-	-	-		-		-	-	-	-			-
		PV with Off-grid (1,000US$)	-	-	-	-	-				-	-	-	-	-		-	-	-		-		-	-	-	-			-
		Diesel with Off-grid (1,000US$)	691	430	795	2,563	634				389	862	779	423	416		818	1,574	871		779		779	501	957	475			526
	B/C	D/L Extension	2.00	2.53	8.85	-	5.47				5.60	3.49	2.25	2.30	1.84		5.61	7.78	3.02		5.93		7.52	2.21	5.86	5.64			2.84
		Micro-hydro with Off-grid	0.73	-	-	1.01	-				-	-	-	-	-		-	-	-		-		-	-	-	-			-
		PV with Off-grid	0.05	0.07	0.04	0.06	0.05				0.09	0.04	0.04	0.07	0.08		0.04	0.04	0.04		0.04		0.04	0.06	0.04	0.06			0.06
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00		1.00		1.00	1.00	1.00	1.00			1.00
		Name of TC	Mulembe	Mwenitete	Ng'onga	Chituka	Emfeni				Kasakula	Lipri	Chikombe	Hiunjiza	Kabzyala		Kaloga	Katema	Mangamba		Khonjeni		Linjidzi	Tulonkhondo		Namphundo			Chididi
		Peak Demand (kW)	35	43	51	113	53				122	126	70	198	11		284	176	60		38		113	145		59			224
		Energy Demand (MWh)	174	217	254	567	267				612	630	349	992	54		1,422	882	299		190		567	724		294			1,121
		Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.				DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.		DL Ext.			DL Ext.
		Electrification Cost (1,000US$)	159	71	71	161	100				132	161	88	508	130		244	298	206		130		146	283		86			166
		Benefit/Cost	2.73	6.54	7.00	4.89	5.12				6.22	5.22	6.57	2.36	2.49		6.33	3.64	2.66		3.43		5.36	3.32		6.19			7.61
	Investment Cost	D/L Extension (1,000US$)	159	71	71	161	100				132	161	88	508	130		244	298	206		130		146	283		86			166
		Micro-hydro with Off-grid (1,000US$)	562	-	-	-	-				-	-	-	-	-		-	533	-		-		-	-		-			-
		PV with Off-grid (1,000US$)	5,517	6,865	8,001	17,847	8,426				19,256	19,802	11,002	31,178	1,734		44,669	27,725	9,441		6,008		17,847	22,769		9,258			35,238
		Diesel with Off-grid (1,000US$)	110	115	119	147	119				152	152	124	185	101		227	176	119		110		147	162		119			199
	Life cycle cost	D/L Extension (1,000US$)	153	70	70	159	98				132	160	88	495	124		247	293	199		126		145	278		85			169
		Micro-hydro with Off-grid (1,000US$)	734	-	-	-	-				-	-	-	-	-		-	1,209	-		-		-	-		-			-
		PV with Off-grid (1,000US$)	-	-	-	-	-				-	-	-	-	-		-	-	-		-		-	-		-			-
		Diesel with Off-grid (1,000US$)	418	458	493	779	504				821	835	575	1,166	310		1,563	1,066	530		430		779	922		525			1,287
	B/C	D/L Extension	2.73	6.54	7.00	4.89	5.12				6.22	5.22	6.57	2.36	2.49		6.33	3.64	2.66		3.43		5.36	3.32		6.19			7.61
		Micro-hydro with Off-grid	0.54	-	-	-	-				-	-	-	-	-		-	0.89	-		-		-	-		-			-
		PV with Off-grid	0.08	0.07	0.06	0.04	0.06				0.04	0.04	0.05	0.04	0.18		0.04	0.04	0.06		0.07		0.04	0.04		0.06			0.04
		Diesel with Off-grid	1.00	1.00	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00		1.00		1.00	1.00		1.00			1.00

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern												
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase IX		Name of TC		Tilora	Kamphenda	Maula	Engutwini				Mzandu	Kasuntha	Mnema	Phirilanjuli	Kalulu		Masasa	Lungwena	Likhonyowa		Kachulu			Kasuza		Kambenje			Sankhulani
		Peak Demand (kW)		38	113	38	113				68	264	26	91	32		4	204	113		204			69		16			204
		Energy Demand (MWh)		190	567	190	567				340	1,322	132	458	159		18	1,021	567		1,021			345		81			1,021
		Appropriate Electrification Method		DL Ext.	DL Ext.	DL Ext.	DL Ext.				DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.		DL Ext.			DL Ext.		DL Ext.			DL Ext.
		Electrification Cost (1,000US$)		235	117	71	176				208	242	176	281	130		249	210	88		105			88		86			193
		Benefit/Cost		1.90	6.63	6.17	4.50				2.81	6.04	2.22	2.49	3.23		1.15	5.67	8.69		10.85			6.54		4.01			6.16
	Investment Cost	D/L Extension (1,000US$)		235	117	71	176				208	242	176	281	130		249	210	88		105			88		86			193
		Micro-hydro with Off-grid (1,000US$)		-	-	-	-				-	-	-	-	-		-	-	-		-			-		-			-
		PV with Off-grid (1,000US$)		6,008	17,847	6,008	17,847				10,719	41,539	4,168	14,409	5,020		599	32,094	17,847		32,094			10,882		2,578			32,094
		Diesel with Off-grid (1,000US$)		110	147	110	147				124	218	105	138	110		96	190	147		190			124		101			190
	Life cycle cost	D/L Extension (1,000US$)		226	118	70	173				202	244	170	273	125		238	211	90		110			87		83			194
		Micro-hydro with Off-grid (1,000US$)		-	-	-	-				-	-	-	-	-		-	-	-		-			-		-			-
		PV with Off-grid (1,000US$)		-	-	-	-				-	-	-	-	-		-	-	-		-			-		-			-
		Diesel with Off-grid (1,000US$)		430	779	430	779				568	1,471	378	680	405		275	1,195	779		1,195			572		331			1,195
	B/C	D/L Extension		1.90	6.63	6.17	4.50				2.81	6.04	2.22	2.49	3.23		1.15	5.67	8.69		10.85			6.54		4.01			6.16
		Micro-hydro with Off-grid		-	-	-	-				-	-	-	-	-		-	-	-		-			-		-			-
		PV with Off-grid		0.07	0.04	0.07	0.04				0.05	0.04	0.09	0.05	0.08		0.46	0.04	0.04		0.04			0.05		0.13			0.04
		Diesel with Off-grid		1.00	1.00	1.00	1.00				1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00		1.00			1.00		1.00			1.00
		Name of TC		Hara	Mphompha	Lwazi					Nthondo	Chankhunga	Chitala	Kachale				Kwisimba	Malundani		Sakata					Kamwendo			
		Peak Demand (kW)		26	113	38					124	117	224	96				94	204		6					146			
		Energy Demand (MWh)		132	567	190					621	588	1,121	482				472	1,021		30					729			
		Appropriate Electrification Method		DL Ext.	DL Ext.	DL Ext.					DL Ext.	DL Ext.	DL Ext.	DL Ext.				DL Ext.	DL Ext.		DL Ext.					DL Ext.			
		Electrification Cost (1,000US$)		71	252	115					146	146	180	176				222	210		115					105			
		Benefit/Cost		5.45	3.17	3.86					5.68	5.47	7.03	4.05				3.18	5.67		2.59					8.63			
	Investment Cost	D/L Extension (1,000US$)		71	252	115					146	146	180	176				222	210		115					105			
		Micro-hydro with Off-grid (1,000US$)		-	-	-					-	-	-	-				533	-		-					-			
		PV with Off-grid (1,000US$)		4,168	17,847	6,008					19,540	18,503	35,238	15,161				14,852	32,094		989					22,925			
		Diesel with Off-grid (1,000US$)		105	147	110					152	147	199	138				138	190		96					162			
	Life cycle cost	D/L Extension (1,000US$)		69	246	112					146	146	183	172				217	211		110					107			
		Micro-hydro with Off-grid (1,000US$)		-	-	-					-	-	-	-					-		-					-			
		PV with Off-grid (1,000US$)		-	-	-					-	-	-	-				-	-		-					-			
		Diesel with Off-grid (1,000US$)		378	779	430					828	796	1,287	699				691	1,195		285					926			
	B/C	D/L Extension		5.45	3.17	3.86					5.68	5.47	7.03	4.05				3.18	5.67		2.59					8.63			
		Micro-hydro with Off-grid		-	-	-					-	-	-	-				0.65	-		-					-			
		PV with Off-grid		0.09	0.04	0.07					0.04	0.04	0.04	0.05				0.05	0.04		0.29					0.04			
		Diesel with Off-grid		1.00	1.00	1.00					1.00	1.00	1.00	1.00				1.00	1.00		1.00					1.00			

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase X		Name of TC		Lupembe							Kayoyo	Nalunga	Chinguluwe	Chimbalanga					Nanyumbu		Makina								
		Peak Demand (kW)		113							90	45	113	115					38		204								
		Energy Demand (MWh)		567							449	226	567	575					190		1,021								
		Appropriate Electrification Method		DL Ext.							DL Ext.	DL Ext.	DL Ext.	DL Ext.					DL Ext.		DL Ext.								
		Electrification Cost (1,000US$)		117							193	176	88	281					71		134								
		Benefit/Cost		6.63							3.53	2.73	8.69	2.87					6.17		8.66								
	Investment Cost	D/L Extension (1,000US$)		117							193	176	88	281					71		134								
	Investment Cost	Micro-hydro with Off-grid (1,000US$)		-							-	-	-	-					-		-								
	Investment Cost	PV with Off-grid (1,000US$)		17,847							14,125	7,149	17,847	18,099					6,008		32,094								
	Investment Cost	Diesel with Off-grid (1,000US$)		147							133	115	147	147					110		190								
	Life cycle cost	D/L Extension (1,000US$)		118							189	171	90	274					70		138								
	Life cycle cost	Micro-hydro with Off-grid (1,000US$)		-							-	-	-	-					-		-								
	Life cycle cost	PV with Off-grid (1,000US$)		-							-	-	-	-					-		-								
	Life cycle cost	Diesel with Off-grid (1,000US$)		779							667	465	779	786					430		1,195								
	B/C	D/L Extension		6.63							3.53	2.73	8.69	2.87					6.17		8.66								
	B/C	Micro-hydro with Off-grid		-							-	-	-	-					-		-								
	B/C	PV with Off-grid		0.04							0.05	0.07	0.04	0.04					0.07		0.04								
	B/C	Diesel with Off-grid		1.00							1.00	1.00	1.00	1.00					1.00		1.00								
		Name of TC										Dzoole	Siyasiya	Mtema					Molipa		Ngwelero								
		Peak Demand (kW)										105	113	170					113		224								
		Energy Demand (MWh)										526	567	851					567		1,121								
		Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.					DL Ext.		DL Ext.								
		Electrification Cost (1,000US$)										193	88	239					88		137								
		Benefit/Cost										3.90	8.69	4.37					8.69		9.11								
	Investment Cost	D/L Extension (1,000US$)										193	88	239					88		137								
	Investment Cost	Micro-hydro with Off-grid (1,000US$)										-	-	-					-		-								
	Investment Cost	PV with Off-grid (1,000US$)										16,538	17,847	26,757					17,847		35,238								
	Investment Cost	Diesel with Off-grid (1,000US$)										143	147	171					147		199								
	Life cycle cost	D/L Extension (1,000US$)										190	90	237					90		141								
	Life cycle cost	Micro-hydro with Off-grid (1,000US$)										-	-	-					-		-								
	Life cycle cost	PV with Off-grid (1,000US$)										-	-	-					-		-								
	Life cycle cost	Diesel with Off-grid (1,000US$)										740	779	1,036					779		1,287								
	B/C	D/L Extension										3.90	8.69	4.37					8.69		9.11								
	B/C	Micro-hydro with Off-grid										-	-	-					-		-								
	B/C	PV with Off-grid										0.05	0.04	0.04					0.04		0.04								
	B/C	Diesel with Off-grid										1.00	1.00	1.00					1.00		1.00								

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern										
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase XI		Name of TC										Kalonga	Matenje	Bisai							Chisunzi								
		Peak Demand (kW)										48	38	112							113								
		Energy Demand (MWh)										239	190	562							567								
		Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.							DL Ext.								
		Electrification Cost (1,000US$)										71	115	208							103								
		Benefit/Cost										6.77	3.86	3.80							7.52								
	Investment Cost	D/L Extension (1,000US$)										71	115	208							103								
	Investment Cost	Micro-hydro with Off-grid (1,000US$)										-	-	-							-								
	Investment Cost	PV with Off-grid (1,000US$)										7,553	6,008	17,673							17,847								
	Investment Cost	Diesel with Off-grid (1,000US$)										115	110	147							147								
	Life cycle cost	D/L Extension (1,000US$)										70	112	204							104								
	Life cycle cost	Micro-hydro with Off-grid (1,000US$)										-	-	-							-								
	Life cycle cost	PV with Off-grid (1,000US$)										-	-	-							-								
	Life cycle cost	Diesel with Off-grid (1,000US$)										476	430	775							779								
	B/C	D/L Extension										6.77	3.86	3.80							7.52								
	B/C	Micro-hydro with Off-grid										-	-	-							-								
	B/C	PV with Off-grid										0.06	0.07	0.04							0.04								
	B/C	Diesel with Off-grid										1.00	1.00	1.00							1.00								
		Name of TC										Kalumbu	Chagunda	Mbng'ombe							Ngondole								
		Peak Demand (kW)										146	113	153							204								
		Energy Demand (MWh)										730	567	766							1,021								
		Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.							DL Ext.								
		Electrification Cost (1,000US$)										178	88	312							149								
		Benefit/Cost										5.24	8.69	3.14							7.86								
	Investment Cost	D/L Extension (1,000US$)										178	88	312							149								
	Investment Cost	Micro-hydro with Off-grid (1,000US$)										-	-	-							-								
	Investment Cost	PV with Off-grid (1,000US$)										22,967	17,847	24,081							32,094								
	Investment Cost	Diesel with Off-grid (1,000US$)										162	147	166							190								
	Life cycle cost	D/L Extension (1,000US$)										177	90	306							152								
	Life cycle cost	Micro-hydro with Off-grid (1,000US$)										-	-	-							-								
	Life cycle cost	PV with Off-grid (1,000US$)										-	-	-							-								
	Life cycle cost	Diesel with Off-grid (1,000US$)										927	779	962							1,195								
	B/C	D/L Extension										5.24	8.69	3.14							7.86								
	B/C	Micro-hydro with Off-grid										-	-	-							-								
	B/C	PV with Off-grid										0.04	0.04	0.04							0.04								
	B/C	Diesel with Off-grid										1.00	1.00	1.00							1.00								

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase XII		Name of TC										Mkukula	Pemba	Sinumbe															
		Peak Demand (kW)										124	224	26															
		Energy Demand (MWh)										621	1,121	132															
		Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.															
		Electrification Cost (1,000US$)										103	166	176															
		Benefit/Cost										7.95	7.61	2.22															
	Investment Cost	D/L Extension (1,000US$)										103	166	176															
	Investment Cost	Micro-hydro with Off-grid (1,000US$)										-	-	-															
	Investment Cost	PV with Off-grid (1,000US$)										19,518	35,238	4,168															
	Investment Cost	Diesel with Off-grid (1,000US$)										152	199	105															
	Life cycle cost	D/L Extension (1,000US$)										104	169	170															
	Life cycle cost	Micro-hydro with Off-grid (1,000US$)										-	-	-															
	Life cycle cost	PV with Off-grid (1,000US$)										-	-	-															
	Life cycle cost	Diesel with Off-grid (1,000US$)										828	1,287	378															
	B/C	D/L Extension										7.95	7.61	2.22															
	B/C	Micro-hydro with Off-grid										-	-	-															
	B/C	PV with Off-grid										0.04	0.04	0.09															
	B/C	Diesel with Off-grid										1.00	1.00	1.00															
		Name of TC										Chakadza	Mphinzi	Kang'oma															
		Peak Demand (kW)										158	38	227															
		Energy Demand (MWh)										792	190	1,137															
		Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.															
		Electrification Cost (1,000US$)										120	235	210															
		Benefit/Cost										8.06	1.90	6.16															
	Investment Cost	D/L Extension (1,000US$)										120	235	210															
	Investment Cost	Micro-hydro with Off-grid (1,000US$)										-	-	-															
	Investment Cost	PV with Off-grid (1,000US$)										24,890	6,008	35,741															
	Investment Cost	Diesel with Off-grid (1,000US$)										166	110	199															
	Life cycle cost	D/L Extension (1,000US$)										122	226	211															
	Life cycle cost	Micro-hydro with Off-grid (1,000US$)										-	-	-															
	Life cycle cost	PV with Off-grid (1,000US$)										-	-	-															
	Life cycle cost	Diesel with Off-grid (1,000US$)										982	430	1,300															
	B/C	D/L Extension										8.06	1.90	6.16															
	B/C	Micro-hydro with Off-grid										-	-	-															
	B/C	PV with Off-grid										0.04	0.07	0.04															
	B/C	Diesel with Off-grid										1.00	1.00	1.00															

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern												
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase XIII		Name of TC										Chimungu		Chiwamba																
		Peak Demand (kW)										86		102																
		Energy Demand (MWh)										430		511																
		Appropriate Electrification Method										DL Ext.		DL Ext.																
		Electrification Cost (1,000US$)										176		88																
		Benefit/Cost										3.79		8.18																
	Investment Cost	D/L Extension (1,000US$)										176		88																
		Micro-hydro with Off-grid (1,000US$)										-		-																
		PV with Off-grid (1,000US$)										13,536		16,091																
		Diesel with Off-grid (1,000US$)										133		143																
	Life cycle cost	D/L Extension (1,000US$)										172		89																
		Micro-hydro with Off-grid (1,000US$)										-		-																
		PV with Off-grid (1,000US$)										-		-																
		Diesel with Off-grid (1,000US$)										652		729																
	B/C	D/L Extension										3.79		8.18																
		Micro-hydro with Off-grid										-		-																
		PV with Off-grid										0.05		0.05																
		Diesel with Off-grid										1.00		1.00																
		Name of TC										Thonje		Chadza																
		Peak Demand (kW)										86		224																
		Energy Demand (MWh)										430		1,122																
		Appropriate Electrification Method										DL Ext.		DL Ext.																
		Electrification Cost (1,000US$)										132		256																
		Benefit/Cost										5.01		5.04																
	Investment Cost	D/L Extension (1,000US$)										132		256																
		Micro-hydro with Off-grid (1,000US$)										-		-																
		PV with Off-grid (1,000US$)										13,536		35,273																
		Diesel with Off-grid (1,000US$)										133		199																
	Life cycle cost	D/L Extension (1,000US$)										130		256																
		Micro-hydro with Off-grid (1,000US$)										-		-																
		PV with Off-grid (1,000US$)										-		-																
		Diesel with Off-grid (1,000US$)										652		1,288																
	B/C	D/L Extension										5.01		5.04																
		Micro-hydro with Off-grid										-		-																
		PV with Off-grid										0.05		0.04																
		Diesel with Off-grid										1.00		1.00																

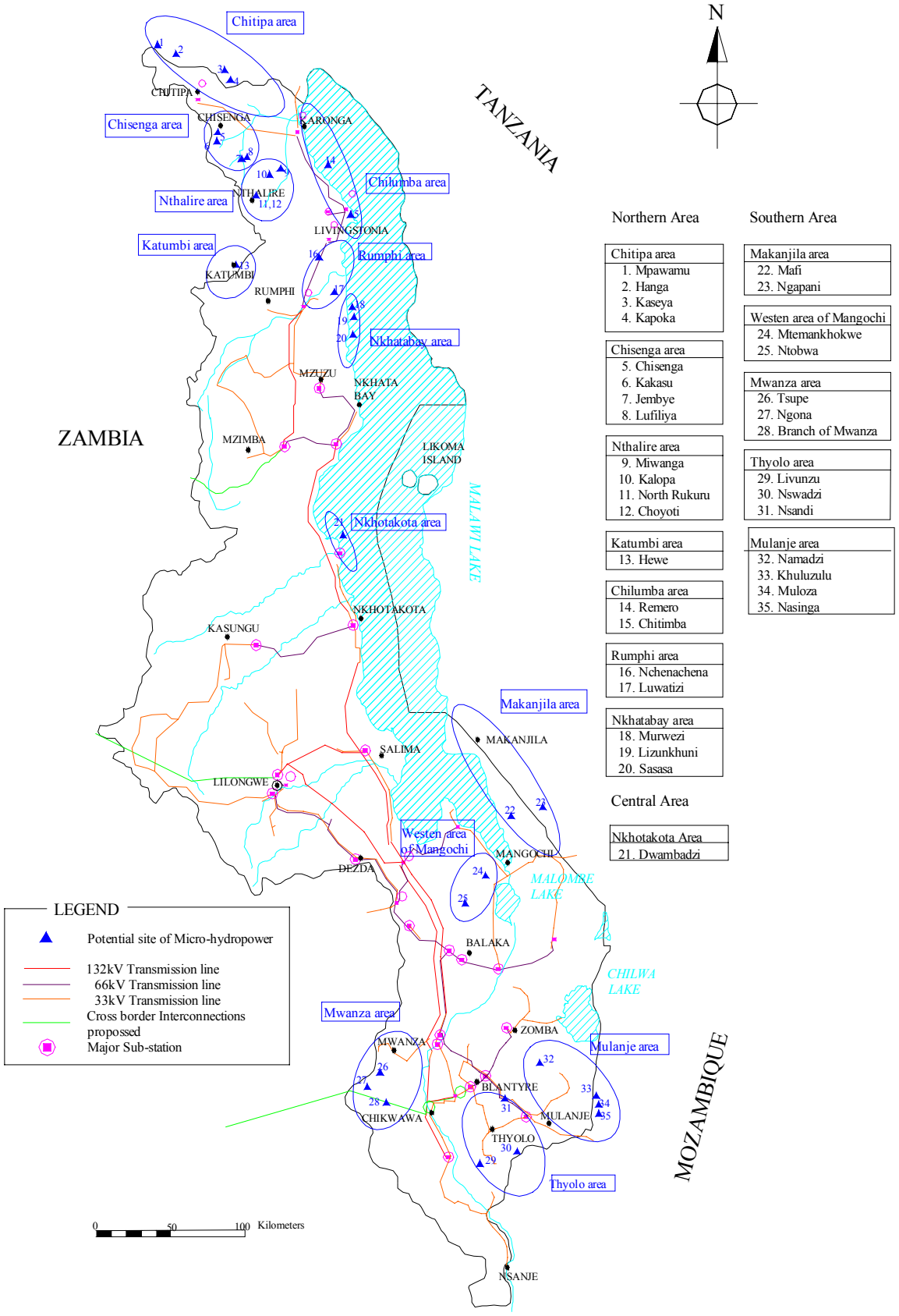
Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase			Region	Northern						Central									Southern											
			Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase XIV			Name of TC										Kayembe		Kalumbu															
			Peak Demand (kW)										115		189															
			Energy Demand (MWh)										575		946															
			Appropriate Electrification Method										DL Ext.		DL Ext.															
			Electrification Cost (1,000US$)										252		163															
			Benefit/Cost										3.19		6.80															
	Investment Cost		D/L Extension (1,000US$)										252		163															
			Micro-hydro with Off-grid (1,000US$)										-		-															
			PV with Off-grid (1,000US$)										18,099		29,737															
			Diesel with Off-grid (1,000US$)										147		180															
	Life cycle cost		D/L Extension (1,000US$)										246		165															
			Micro-hydro with Off-grid (1,000US$)										-		-															
			PV with Off-grid (1,000US$)										-		-															
			Diesel with Off-grid (1,000US$)										786		1,123															
	B/C		D/L Extension										3.19		6.80															
			Micro-hydro with Off-grid										-		-															
			PV with Off-grid										0.04		0.04															
			Diesel with Off-grid										1.00		1.00															
			Name of TC										Simbi		Kalima															
			Peak Demand (kW)										86		45															
			Energy Demand (MWh)										430		226															
			Appropriate Electrification Method										DL Ext.		DL Ext.															
			Electrification Cost (1,000US$)										146		100															
			Benefit/Cost										4.52		4.75															
	Investment Cost		D/L Extension (1,000US$)										146		100															
			Micro-hydro with Off-grid (1,000US$)										-		-															
			PV with Off-grid (1,000US$)										13,536		7,149															
			Diesel with Off-grid (1,000US$)										133		115															
	Life cycle cost		D/L Extension (1,000US$)										144		98															
			Micro-hydro with Off-grid (1,000US$)										-		-															
			PV with Off-grid (1,000US$)										-		-															
			Diesel with Off-grid (1,000US$)										652		465															
	B/C		D/L Extension										4.52		4.75															
			Micro-hydro with Off-grid										-		-															
			PV with Off-grid										0.05		0.07															
			Diesel with Off-grid										1.00		1.00															

Appendix Table 3 - 1 Electrification methods and construction costs in unelectrified trading centers

Electrification Phase		Region	Northern						Central									Southern											
		Name of District	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase XV		Name of TC										Bweya																	
		Peak Demand (kW)										81																	
		Energy Demand (MWh)										407																	
		Appropriate Electrification Method										DL Ext.																	
		Electrification Cost (1,000US$)										132																	
		Benefit/Cost										4.88																	
	Investment Cost	D/L Extension (1,000US$)										132																	
		Micro-hydro with Off-grid (1,000US$)										-																	
		PV with Off-grid (1,000US$)										12,826																	
		Diesel with Off-grid (1,000US$)										133																	
	Life cycle cost	D/L Extension (1,000US$)										130																	
		Micro-hydro with Off-grid (1,000US$)										-																	
		PV with Off-grid (1,000US$)										-																	
		Diesel with Off-grid (1,000US$)										634																	
	B/C	D/L Extension										4.88																	
		Micro-hydro with Off-grid										-																	
		PV with Off-grid										0.05																	
		Diesel with Off-grid										1.00																	
		Name of TC										Ntiti																	
		Peak Demand (kW)										115																	
		Energy Demand (MWh)										575																	
		Appropriate Electrification Method										DL Ext.																	
		Electrification Cost (1,000US$)										88																	
		Benefit/Cost										8.76																	
	Investment Cost	D/L Extension (1,000US$)										88																	
		Micro-hydro with Off-grid (1,000US$)										-																	
		PV with Off-grid (1,000US$)										18,099																	
		Diesel with Off-grid (1,000US$)										147																	
	Life cycle cost	D/L Extension (1,000US$)										90																	
		Micro-hydro with Off-grid (1,000US$)										-																	
		PV with Off-grid (1,000US$)										-																	
		Diesel with Off-grid (1,000US$)										786																	
	B/C	D/L Extension										8.76																	
		Micro-hydro with Off-grid										-																	
		PV with Off-grid										0.04																	
		Diesel with Off-grid										1.00																	

Source: Prepared by JICA MP ST



Source: Prepared by the JICA MP ST

Appendix Fig. 3 - 1 Map of locations covered by the study of micro-hydropower potential