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ASSISTANCE TO BELIZE ELECTRICITY LIMITED TO IDENTIFY AND ASSESS STRATEGIES TO CONTROL ELECTRICITY DEMAND AND PLAN THE SUPPLY

SI/BZE/92/803/11-51/J13317
BELIZE

Technical Report Vol. 3: Final Report including Hardware and Software Report, Commissioning Report, Second Mission of Consultant

Prepared by

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EXPLANATORY NOTES

Currency exchange rate (October 1994):

1 Belize Dollar BZ$	=	0.5 US$
1 US$	=	2 BZ$

BZ$ linked to the US$ since May 1976.

ABSTRACT

This is the final report of the UNIDO project "Assistance to Belize Electricity Limited to identify and assess strategies to control electricity demand and plan the supply", project no. SI/BZE/92/803, contract no. 93/265.

The report reflects the outcome of the second mission of Mr. Bernhard Bösl to Belize. The main objectives of this mission were to assist Belize Electricity Limited (BEL) to analyze the data retrieved from a nation wide household energy survey and to assess the influence of demand side strategies on the electricity demand of the household sector.

In addition, this report contains information about the purchase and commissioning of the computer hardware and software to Belize Electricity Limited.

For further information about the first phases of the project, please refer to the following reports:

Bernhard Bösl, "Technical Report Vol. 1: First Mission of Consultant", UNIDO Project No. SI/BZE/92/803, Institute for Energy Economics and the Rational Use of Energy (IER), University of Stuttgart, November 1993.

Bernhard Bösl, John Mencias, José Armando Moreno, "Technical Report Vol. 2: Training Program", UNIDO Project No. SI/BZE/92/803, Institute for Energy Economics and the Rational Use of Energy (IER), University of Stuttgart, April 1994.

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INTRODUCTION

This is the final report of the UNIDO project "Assistance to Belize Electricity Limited to identify and assess strategies to control electricity demand and plan the supply", project no. SI/BZE/92/803, covering the equipment purchase and commissioning, the second mission of Mr. Bösl, the performance of the household energy survey, and the household electricity demand analysis.

In the **hardware and software report** in Chapter I the computer hardware, commercial software and the energy planning software, delivered within this project, is described in detail.

The **commissioning report** in Chapter II summarizes the training and the installation procedure of the energy planning system MESAP.

Chapter III gives an overview on the objectives and tasks of the **second mission** of Mr. Bernhard Bösl to Belize. Mr. Bösl spent 6 weeks on site, from September 19 to November 1, 1994. Together with Mr. José Armando Moreno from the Planning Department of Belize Electricity Limited (BEL), Mr. Bösl carried out a household energy survey and a household electricity demand study, using the MESAP energy planning software.

The performance of the nation wide **energy survey** in the residential sector, from the sample design to the analysis of the electricity consumption in 1994, is described in Chapter IV.

The results obtained from the household energy survey were used for an **electricity demand study**, analyzing the impact of different scenarios on the trend of the residential electricity demand in Belize. The objective, the underlying assumptions and the results of this study are illustrated in Chapter V.

Further information, detailed tables, and graphics are attached to this report in the annexes.

I. HARDWARE AND SOFTWARE REPORT

A. Computer Hardware and Commercial Software

As recommended in the "Technical Report Vol. 1: First mission of consultant" the computer hardware and commercial software was purchased directly in Belize. The purchase and configuration of the computer equipment in Germany and the later shipment to Belize, as suggested in the UNIDO Project Document (12. April 1991), would have been a needless loss of money, since the counterpart has already broad experience with modern computer techniques.

Belize Electricity Limited ordered the computer equipment at Flamingo Export Company, United States, following the hardware and software specification in the Technical Report Vol. 1, Annex 7. The detailed specification and prices of the computer equipment delivered is given in the invoice, attached to this report in Annex 1. After receiving the original invoice, the University of Stuttgart reimbursed the expenses of Belize Electricity Limited up to the budget limit of US$ 30,000.

B. Energy Planning Software - MESAP

The energy planning software applied within this project, is the **M**icrocomputer based **E**nergy **S**ector **A**nalysis and **P**lanning System **MESAP**. MESAP was developed by the Institute for Energy Economics and the Rational Use of Energy (IER), University of Stuttgart. The MESAP System combines on one computer a set of energy analysis and planning tools. Actually two versions of the MESAP System were transferred to Belize Electricity Limited: MESAP Version II and MESAP Version III.

The **MESAP Version II** runs under the DOS operating system and contains the widely used energy planning models MADE, MESSAGE, INCA, WASP:

The **energy demand model MADE** (**M**odel for the **A**nalysis of the **D**emand for **E**nergy) provides in a flexible format several methodological options on how to calculate useful energy requirements and the final energy demand. A simulation algorithm calculates the secondary and primary energy consumption. In the demand part, econometric as well as engineering techniques are optionally available.

The **energy supply system model MESSAGE** is based on the LP (Linear Programming) approach. It is flexible in terms of the fuels considered, the sectors analyzed and with respect to the model size. It is a network oriented model. The objective function can be defined by the user.

INCA is an acronym for **In**vestment **Ca**lculation, a program which calculates the present value of alternative investments. Based on the present value method, the dynamic power generation costs, cash flow, amortisation time and other economic key parameters are determined.

The **power plant expansion module WASP** (**W**ien **A**utomatic **S**ystem **P**lanning) model uses the dynamic programming technique for the expansion planning of electricity generation units. The model has been applied in many case studies all over the world.

For a detailed description of MESAP Version II see Technical Report Vol. 1, Annex 3.

Further, the NETWORK-Database and the Energy Demand Analysis and Supply Simulation model PlaNet of the recently developed **MESAP Version III** were delivered to Belize Electricity Limited. MESAP III is developed for PC's with a "Windows" based graphical user interface.

NETWORK, the new central database of MESAP, is based on the relational database concept. This database fulfills two main functions: it is a case study information system which offers all retrieval features of current information management tools and it serves as a standardized database for process-engineering oriented energy and environmental planning models. Standardization of the data structure is achieved through the representation of any energy and environmental system as a network diagram the so called "Reference Energy System (RES)". The RES consists of different fuels and other material flows being converted in a chain of processes. The only restriction in the design of NETWORK is that the energy and environment system must be represented as a network of commodities, flows and processes. This approach allows the planner to specify the level of detail in the analysis and creates a model independent database structure which is no longer adapted to the algorithms. Since different models can use the same standardized NETWORK database format, data sharing and exchanging is improved. The planner is supported by a state of the art user interface and strong analysis tools, now being shared between the models.

The Energy Demand Analysis and Supply Simulation model **PlaNet** is the successor for the demand model MADE. PlaNet is fully integrated into the NETWORK database concept. PlaNet allows to model the demand side as well as the supply sector by using any form of the "Reference Energy System (RES)". PlaNet has similar features to his predecessor MADE, but offers more flexibility concerning the simulation equations. It allows any number of equations for processes with multiple inputs or outputs and thus simulates technologies such as co-generation better. PlaNet allows to define any flow of a process or any quantity of a commodity in the RES exogenously. It includes the possibility to use product shares for technology inputs in addition to market shares for technology outputs and it will check for violations of user defined bounds and constraints. Units can be transferred automatically and an online unit calculator is available.

Future versions of PlaNet will allow higher time resolution in order to integrate load aspects in the energy demand analysis and the simulation of the supply system. Based on the calculation of all energy flows within the network, a user defined energy balance will be calculated for any time period. According to these flows the needed capacities of the energy conversion technologies will be determined. A detailed cost analysis will be available not only to determine total costs of the energy supply system, but also to calculate levelized production costs (per unit costs) for each commodity. A detailed evaluation of the environmental impacts will help find major emission sources and their abatement costs.

II. COMMISSIONING REPORT

A. Computer Hardware and Commercial Software

After the delivery of the computer hardware and commercial software to Belize Electricity Limited (BEL), at the end of July 1994, the equipment (computer, printer, UPS) was installed at the planning department of BEL, at the main power plant in Belize City, Magazine Road. The installation of the hardware and commercial software was carried out by the Data Processing Department of BEL. The PC's were linked to the existing NOVELL-PC-Network to make data exchange and communication easier.

B. Energy Planning Software - MESAP

1. Training on MESAP II and MESAP III

During the training phase of the project, taking place at the University of Stuttgart, Germany, from February 28 to March 25, 1994, two employees of BEL (Mr. Moreno and Mr. Mencias) were trained on the installation and application of the MESAP II and MESAP III system (see Technical Report Vol. 2: Training Program). During the second mission of consultant one of these employees (Mr. Moreno) was trained again in depth on the PlaNet model. Starting with a simple example, finally a comprehensive case study was implemented, analyzing the electricity demand of the residential sector in Belize.

Installation diskettes, installation descriptions and user manuals were delivered by the IER. The MESAP manuals are listed in the bibliography attached to this report. In the case of the PlaNet model a user manual is not yet available, but due to the high user-friendliness of WINDOWS-applications PlaNet can be handled without manual after an introduction.

2. Installation of MESAP II - System

MESAP can only be installed on a hard disk. It requires about 10 MB of hard disk space. The execution of the module MESSAGE requires the DOS-EMM device driver to be installed. Your CONFIG-SYS should include the following command:

```
device = c:\dos\emm386.exe auto 2048 ram
```

Please modify the command, if your DOS-System files are in another directory then specified above [C:\DOS\].

The directory structure of the MESAP system looks as follows:

```
D:.                 MESAP-Drive, in this case drive D:
└───MESAP           MESAP main directory
    ├───INCA        Module INCA (Investment calculation)
    │   ├───DATA    INCA default data
    │   └───EXE     INCA programs
    ├───KERNEL      MESAP kernel system
    │   └───EXE     MESAP kernel executable program
    ├───LOTUS       Lotus 2.01
    │   └───WK1     Lotus default worksheet directory
    ├───MADE        Module MADE (Energy Demand Analysis)
    │   ├───DATA    MADE default data sets
    │   └───EXE     MADE programs
    ├───MAINMENU    MESAP main menu system
    │   └───EXE     MESAP mainmenu executable program
    ├───MESSAGE     Module MESSAGE (Energy system optimization)
    │   ├───DATA    MESSAGE default data
    │   ├───EXE     MESSAGE programs
    │   └───FTN77   DOS-extender
    ├───SYS         MESAP utilities
    └───USERS       Install user subdirectories here!
        ├───BEL     User directory BEL
        └───CS      User directory CS
```

User Management:

Every user that has a subdirectory in the USERS directory can use the MESAP system. His identification is identical to his directory name. When a new user starts

a module for the first time, the default data sets will be copied into his user directory so he can start working on the default examples.

3. Installation of MESAP III - System (NETWORK, PlaNet)

This installation description refers to the PlaNet Version of 16.9.1994. All directory names in this installation description are examples and may be modified to customize installation.

1) Select a drive and home directory for PlaNet, eg.

   drive c:
   directory planet

   In this installation procedure we will always refer to the c:\planet as the PlaNet home directory. If you select a different drive and directory please modify the commands with your drive and directory.

2) Insert the diskette in drive a:. Type the following command:
   a:\install c: planet

3) The files from three diskettes will be copied

   This should result in the following directory structure:

```
C:PLANET
├──DATA
│   ├──GB\pl_case.mdb (case study tables of NETWORK)
│
├──EXE\*.exe, *.dll, *.rpt, planet.ini, etc.
│
├──SYSTABLE\pl_sys.mdb (system tables of NETWORK)
│
├──USER
│   ├──xx
```

4) Edit the file c:\planet\exe\planet.ini as follows:

[Planet]
SysTablePath = C:\planet\systable
SysTableBackupPath = ... (make your selection)
NewCaseStudyPath = ... (make your selection)

Indicates, where the directories for the system table, the system backup and the new case studies is.

5) If this is not yet the case, issue the following command at the DOS-prompt and add it to your autoexec.bat:

SHARE /L:500 (DOS Share command)

6) Start Windows

7) Create a new program group "PlaNet 1.1" with Windows command "File-New".

8) In this group create a new program item with the command "File-New":

Description: PlaNet 1.1
Command line: C:\planet\exe\planet.exe
Working directory: C:\planet\exe

The installation is finished!

9) Click the Planet-Icon to start Planet

10) Login as Manager, the password is "kentucky". Since you start with our System Tables and the userlist from IER Stuttgart, you have to make some modifications.

11) In the File-Supervisor menu choose USERLIST and add your account, i.e. XX. The default access levels is used, when no explicit access rights are granted for a case study. Choose "none". As home directory select C:\planet\user\XX. Delete all other existing users from IER.

12) Now login as XX. The default is no password. Select File-Import to import a case study from disk 1. The case studies are stored in A:\data*.plt. Assign a home directory for the case study, preferably c:\planet\data\case_xy. In the Import-Form

click both "Find-by-ID" buttons. Then click ok.

13) Open the case study with File-Open.

Finished! You are already working with PlaNet.

If you want to clean up the case study list, login as supervisor. Select the File-Supervisor menu choose CS_LIST (Case study list) and delete all case studies except the ones you just imported.

Installation of the PlaNet Update from 18.9.1994:

1) Copy all files from the update diskette to the directory C:\PLANET\EXE.

2) You have to insert two new parameters in the parameter list. Therefore login as supervisor and in the File-Supervisor menue choose PARAMETER LIST.

3) Insert a new parameter:
   ID: MKT_SPLIT
   Name: Market Split (sum <> 1)
   Related Specifier: prod_alloc_2
   The other entries are similar to the parameter MKTA.

4) Insert an other parameter:
   ID: PKT_SPLIT
   Name: Product Split (sum <> 1)
   Related Specifier: cons_alloc_2
   The other entries are similar to the parameter PKTA.

III. SECOND MISSION OF CONSULTANT

A. Objectives

Originally, the objective of the second expert mission to Belize within the overall project was to refine the electricity demand calculations. Based on the data collected by BEL and on the model setup of the case study, different scenarios and strategies for the development of the activities and behavior of the economic sectors and their influence on the electricity demand should have been calculated. For more details on the original workplan see "Technical Report Vol. 1: First Mission of Consultant", Chapter III.D.4. The preliminary and the final time schedule of the overall project are attached in Annex 2 and 3. The UNIDO-Job Description for this mission is attached in Annex 4.

Due to serious personal bottlenecks in the Planning Department, BEL was not able to finish the data collection and the model setup before the second mission. Currently there are several major projects going on which are supervised and performed by the Planning Department of BEL: construction of Belize's first hydro power plant and it's connection to the main load centers Belmopan and Belize City, and the construction of a transmission grid connecting the five largest power systems of Belize ("Power 2 Project"). For more information on these projects see "Technical Report Vol. 1: First Mission of Consultant", Chapter II.F. Therefore, only one employee of BEL (Mr. Moreno) was able to continue working on this project.

Considering these constraints the consultant Mr. Bösl and Mr. Moreno agreed to concentrate during the second mission on the residential sector and to perform all steps of a electricity demand analysis for this sector, from the data collection to the graphical presentation of the results. Thus, the objective of this second mission was to assist BEL in the design, realization, and analysis of a nation wide household energy survey, and to estimate the electricity demand of the residential sector following different scenarios. The detailed tasks are described in the following chapter.

B. Tasks

Following, the working plan of the second mission, taking place from September 19 to November 1, 1994. For a more detailed description of the tasks and their results see Chapter IV an V in this report.

1) Current Energy Situation, Data Analysis

1.1) National Energy Survey - Household Sector
- 1.1.1) discussions on sample design, calculation of survey statistics
- 1.1.2) programming the database tables for the raw data, using PARADOX FOR WINDOWS
- 1.1.3) programming the forms for the data input
- 1.1.4) manual consistency checks of completed survey questionnaires
- 1.1.5) training of auxiliary employees for data input and supervision of data input
- 1.1.6) programming and running of automatic consistency check routines
- 1.1.7) programming and running of automatic data analysis routines
- 1.1.8) aggregation, presentation and discussion of survey results
- 1.1.9) technical assessment of end use technologies used by the residential sector
- 1.1.10) calculation of the electricity consumption in the baseyear 1994

1.2) National Energy Survey - Industrial and Services Sector
- 1.2.1) discussions about sectoral aggregation and sample design
- 1.2.2) setup of survey questionnaire

2) Modelling and Analysis of the future Electricity Demand

2.1) setup of the reference energy system (RES)

2.2) detailed definition of scenarios and strategies

2.3) Energy Demand and Supply Simulation Model PlaNet
- 2.3.1) installation and introduction
- 2.3.2) definition of the RES-structure
- 2.3.3) definition of equations
- 2.3.4) definition of regions and hypothesis (scenarios and strategies)

2.3.5) input of data
2.3.6) consistency checks
2.3.7) calculation of results

2.4) aggregation and graphical presentation of results

2.5) discussion of results with BEL.

IV. ANALYSIS OF THE CURRENT ENERGY SITUATION

A. National Energy Survey - Household Sector

1. Sample Design

The sample for the Household Energy Survey was selected by the Central Statistical Office (CSO), Ministry of Finance, Belmopan, Belize. Following, the description of the sample design delivered by CSO:

"The sample chosen for the National Energy Survey (NES) is a sub-sample of the grand sample from the Continuous Labour Force Survey (LFS). The LFS grand sample was a two-stage cluster sample, equally divided into 3 sub-samples. Each district was treated as an independent domain and divided into urban, rural divisions. Each district was assigned a number of clusters proportional to the number of households as at the 1991 Population Census. At the first stage was the selection of the primary units, the enumeration areas. The enumeration areas are chosen proportional to size, the size being the number of clusters assigned. Sizes of clusters are uniform within districts and vary slightly between districts. At the second stage, clusters of households within selected enumeration areas are chosen inversely proportional to the size of the enumeration area. This results in an equal sampling fraction in each domain. The grand sample is selected with a probability of 1 in 8. In the LFS, 2 of the 3 sub-samples are selected and interviewed per round. This yields approximately 3000 households to be interviewed per round. This fairly large household sample is necessary to ensure that an adequate number of persons aged 14 years or older are selected for interview. Since the unit of measurement for the NES is the household, a smaller sample of households would be adequate. It was decided that one of the three sub-samples be chosen. This yielded 1576 households or approximately 4 % of households to be interviewed."

This percentage is based on 39,832 households in the year 1991. The annual average growth rate in the number of households between the census 1980 and 1991 was about 3.2 % (see Annex 5 for more information on household statistics). Considering the same ongoing growth rate, the number of households was estimated on 43,937 in 1994. Out of the 1576 questionnaires 1283 were completed, the other households were vacant or refused to answer. Thus, the household survey covered 2.92 % of the total households of Belize in 1994.

In the statistics available from CSO the households are classified by 6 districts and by urban and rural (see Annex 5). For the electricity demand analysis a different classification is of interest. The households are divided into those areas that are closed to the proposed transmission grid (GRID) and those that will not be affected by the grid at least in the foreseeable future (NON GRID). The households living closed to the grid are further divided into urban (URBAN GRID) and rural (RURAL GRID), because of different consumption patterns. The NON GRID households are considered to have a more homogenous and rural consumption behavior and are not further subdivided. For more details on this classification see Report Vol.2 , Chapter X.C.3. For the analysis of the results of the survey it is required to know the number of households in each of the three categories (URBAN GRID, RURAL GRID, NON GRID) in the year 1994. Therefore, it was necessary to classify each of the approximately 260 enumeration areas and add up the number of households within the enumeration areas for each category and district. Again, the values for 1994 were calculated based on the growth rates observed between 1980 and 1991. The detailed survey statistics are given in Annex 6.

2. Questionnaire Design

The questionnaire used for the Household Energy Survey was designed by Mr. Moreno (BEL) with assistance from Mr. Bösl (IER) and CSO. It contains 70 questions in 7 sections. The questions cover all uses and forms of energy in the residential sector, though in the later case study the focus is on the use of electricity. Therefore, the results of this survey are not merely valuable for this analysis, but also for numerous other studies, e.g. the influence of the use of firewood on deforestation, the potential of solar water heating, or the LPG consumption of the households. The questionnaire was tested and improved in a small pilot survey. A copy of the questionnaire is attached to this report in Annex 7.

3. Survey Performance

The survey was conducted by the Central Statistical Office (CSO) of Belize. The data was collected by 67 interviewers from September 14 to September 30, 1994, and later checked by 7 editors and 7 supervisors of the CSO. Since quality of the gathered data mainly depends on the skill and empathy of the interviewer, all interviewers were prepared for the survey in an one-day training. Each interviewer was responsible for

at least on of the 84 enumeration areas selected in the sample. From each enumeration area about 20 households were interviewed. Out of the 1576 households selected for the survey, about 293 (19 %) questionnaires were not completed.

4. Data Input and Consistency Checks

For the input, storage and analysis of the data from the Household Energy Survey the relational database system PARADOX FOR WINDOWS was selected. Modern database systems like PARADOX allow to define in an easy and user friendly way

- tables to store the data,
- forms to input and view the data,
- queries to analyze and modify the data, and
- reports to present the data.

For the storage of the input data three tables were defined, file *raw_hh1.db* for question 1 to question 20, *raw_hh2.db* for question 21 to 35, and *raw_hh3.db* for question 36 to 70. The tables contain automatic validity checks to avoid obviously absurd data entries. For the input of the data a user-friendly input-form was designed (file *hh_raw.fsl*). To simplify the data entry the design of this input-form is similar to the questionnaire design. The screen print of the input form is attached to this report in Annex 8. The 1283 questionnaires have been entered into the data base by three typists within two weeks from October 3 to October 14, 1994. Due to many inconsistencies, all questionnaires had to be checked again manually by Mr. Moreno and Mr. Bösl, before processing. For every enumeration area a separate set of database files was used, and named according to the code of the area (e.g. the files *r1_3102.db*, *r2_3102.db*, and *r3_3102.db* for the enumeration area no. 3102). After completion of the data entry all data files were joined to one data table, containing all questions and all households (file *tot_bel.db*).

To find further inconsistencies, not discovered by the previous manual checks, and to detect typing errors, a set of automatic consistency checks have been programmed using the "query by example"-tool of PARADOX (files *check1.qbe* to *check18.qbe*). All mistakes that have been noticed by these consistency queries have been checked with the original questionnaire and corrected in the *tot_bel.db*-table.

5. Data Analysis and Aggregated Results

To retrieve information out of the database a set of analysis routines were implemented, using "query by example" (files *ana_1.qbe* to *ana_18.qbe*). The results of these data queries have been transferred to a QUATTRO PRO FOR WINDOWS spreadsheet (file *surv_res.wb1*). The aggregated results of the Household Energy Survey for total Belize as well as for the three categories (urban grid, rural grid, non grid) are attached in the Annex 9 and Annex 10.

The result table in Annex 9 shows the fuel use of the residential sector. About 80 % of the households of Belize are using electricity for lighting. Kerosene is used by about 26 % and candles by about 23 % of the households as single light source or as backup for electric lighting in case of a brownout. The major fuel for cooking in Belize is butane gas, used by about 76 % of the households. Firewood is used by 37 % of the households, 13 % in the urban grid but about 60-65 % in the rural grid and non grid areas. The share of households using electricity for cooking is less than 1 % and can be neglected. To be able to compare this result with other fuels, only electric stoves but no microwave ovens, kettles, toasters, or rice cookers are considered. About 50 % of the households have electric refrigerators or freezers, while the number of gas or kerosene refrigerators is negligible. Water heating and room cooling are only of small importance in the residential sector.

In Annex 10 the detailed results of the survey are presented. For every fuel the total number of appliances and the average usage of the appliances are listed. The absolute figures were first retrieved from the sample size and then estimated for the total number of households. As far as possible, the figures were compared to other statistics, e.g. the results of the 1991 census and the sales statistics of BEL. These comparisons showed only small variations and therefore proved the quality and reliability of the survey results.

6. Electricity Consumption of Households in 1994

Based on the results of the household energy survey the electricity consumption for different end use purposes in the year 1994 was calculated. Therefore, the end use technologies used by the residential sector in Belize have been assessed, in order to find out their average efficiencies, power ratings, or specific consumptions. Most of these values have been retrieved from literature and from previous studies, but some were gathered in a market survey in Belize. In Annex 11 the results of this technical

assessment of household appliances are shown in detail. Further, Annex 11 lists the technical values that have been finally selected for the electricity demand study, for each appliance.

Using the results of the technical assessment and the total number of appliances with their average usage, as retrieved from the household survey, it is possible to calculate the total electricity consumption per year for each appliance. These calculations for each region (urban grid, rural grid, non grid) are attached in Annex 12. In the case of refrigeration, water heating and laundry a slightly different calculation procedure was chosen. Since refrigerators usually run day and night, their total number was directly multiplied by the average electricity consumption per unit. For water heating the energy content of the required amount of hot water was calculated based on the physical energy content of water, and then multiplied with the efficiency of the heating appliance In the case of laundry the number of loads per year were multiplied by the average electricity consumption per load.

The results in the summary sheet in Annex 13 show that based on these calculations the total electricity consumption in 1994 of the residential sector is estimated to be about 57 GWh. After deducting the households with private generation, an electricity demand from Belize Electricity Limited of about 54.8 GWh was estimated. Since the reference month of the survey was August 1994, this value was compared to the sales statistics of BEL from the same month. According to the sales statistics the electricity consumption of the residential sector has only slight seasonal fluctuations and the month August was close to the average monthly sales within the last few years. Therefore, the total electricity consumption in 1994, based on the sales in August, is estimated to be about 54.5 GWh. Thus, the results of the survey lay within an error margin of less than 1 %, which again indicates the high quality and reliability of the survey results.

The results show that about 18 % of the residential electricity consumption is used for lighting and almost 36 % for refrigeration. Again, cooking is only of low importance, with about 3 %. Among the other electrical appliances the fans (12.6 %) and the iron (9.8 %) play an important role for the residential electricity use. There are only moderate variations of these shares among regions.

Annex 14 shows a crosscountry comparison of the residential electricity end-use. This comparison demonstrates that the consumption pattern of Belize is considerably close to the values of other Central American countries, except for cooking. While in other Central American countries about 20 % of the residential electricity consumption is used for cooking, in Belize this share is negligible. This is mainly caused by the

comparatively high electricity prices in Belize. People prefer to cook with the cheaper butane gas, though it is less comfortable (handling of cylinders). The comparison with the electricity end-use in the United States and Germany shows a typical difference between industrial and developing countries. The share of electricity used for lighting and refrigeration is smaller in higher developed countries, while water heating, air conditioning, and in the case of Germany room heating (considered among "Others") is of higher importance.

B. National Energy Survey - Industry and Services Sector

During the second mission of consultant the sectoral aggregation, the sample and the questionnaire design for the industry and services sector were discussed. With the experiences gathered during the residential electricity demand study Mr. Moreno from BEL will continue the electricity demand analysis for these sectors.

The **industry sector** is divided into sugar, citrus, bananas, food processing and light industry. All industrial sectors, except the light industry, consist only of a very small number of companies. Therefore all companies of these sectors will be surveyed. In the case of light industry a survey sample has to be selected with the help of the Central Statistical Office. For the industry sector a separate questionnaire was designed.

The **service sector** is further disaggregated into tourism, commerce, Belize Defence Forces (BDF), WASA (Water and Sewage Authority) operations, and Government/ statutory bodies/ streetlighting. Again, in the case of BDF, WASA and the government a complete survey, and in the case of tourism and commerce a sample survey will be undertaken.

V. ANALYSIS OF THE FUTURE ELECTRICITY DEMAND

A. Objective

It must be pointed out again that the objective of an energy demand analysis is not to predict a detailed figure about the energy demand in a certain year in the future. Nobody knows what will happen in future and all we know we have only learned by observing the past. But since decisions that have to be taken today have long term effects it is necessary to analyze these intertemporal aspects, in order to find a basis for rational and robust decisions. Therefore, the objective of a demand study in general is not to forecast the electricity demand, but to evaluate different strategies with regard to their influence on the electricity demand. The underlying criterias for this evaluation depend on the objectives of the counterpart involved in the study. In case of a government this objective may be e.g. energy conservation in order to reduce the import of fossil fuels. In the case of a private utility the objective is to maximize profits, by reducing the costs and/or increasing the sales.

B. Modelling Framework

For the estimation of the influence of various scenarios and strategies on the future electricity demand of the residential sector in Belize, the energy demand and supply simulation model PlaNet of the MESAP III System was applied (see Chapter I.B). As baseyear for the calculations the year of the Household Energy Survey, 1994 was chosen. A 20 year estimation period divided into steps of 5 years was used to show the impact of the trend in the long run. Thus, the results were calculated for the years 1999, 2004, 2009, and 2014.

C. Reference Energy System (RES)

The **Reference Energy System (RES)** of the electricity demand study for the residential sector is attached to this report in Annex 15. The RES displays the structure of the analyzed system and thus the sequence of calculations from the activities (e.g. number of electrified households) on the right side to the final energy demand for electricity on the left side. A PlaNet-Report listing the processes and their input and output commodities is given in Annex 16. Further, a report listing the

commodities and their units is shown in Annex 17. The equations of the resulting linear equation system are presented in Annex 18. This equation system is solved by PlaNet for each region, for each hypothesis, and in each modelling year.

D. Regions

As described in Chapter IV.A.1 the residential sector is sub-divided into 3 categories, namely URBAN GRID, RURAL GRID, and NON GRID. PlaNet offers the possibility to define different regions. Regions are characterized to have the same RES structure, but it is possible to define different input values for each region. Since in our case the types of end use appliances are the same in every household category (same RES) and only the intensities, usages etc. vary from region to region (different input values), each category is modelled as one region in the PlaNet model. This reduces the modelling effort drastically. The RES as shown in Annex 15 was defined only once, but is used for all three regions. Common data for all regions are entered only once and automatically inherited to all regions, while the specific data for a region must be entered separately and is only valid for this region.

E. Scenarios and Strategies

To cover likely trends in the electricity consumption, resulting out of the overall demographic and economic development, that can't be influenced by BEL, three **scenarios** were considered. The scenarios for the residential sector are characterized by different growth rates in the number of households and in the number of appliances per household or per person (intensities). The light intensity (lumenhours per room), the usage of the appliances (hours) and the technical values of the end use technologies (efficiencies, power ratings, specific consumptions) are assumed to stay constant in all scenarios. They could be influenced by BEL and therefore are subject of the strategies.

- **Stagnation Scenario (STAG)**
  Low growth rate in the number of households of about 1 % per year in urban grid and of about 2 % per year in rural grid and non grid. The number of appliances per household or per person remain on their level of 1994.

- **Reference Scenario (REF)**
  The number of households grow with the same rate as between the census 1980 and 1991: 2.79 % per year in the case of urban grid and 3.7 % in the case of rural grid and non grid. The intensities are assumed to grow at 1 % per year.

- **Prosperity Scenario (PROS)**
  High growth rate in the number of households of 3 % in the urban grid and 4 % per year in the rural grid and non grid region. High growth rate of 2 % per year in the intensities.

Scenario Table, Residential Sector

Scenario Parameter	Stagnation	Reference	Prosperity
No. of Households			
urban grid	+ 1 % per year	+ 2.79 % per year	+ 3 % per year
rural grid, non grid	+ 2 % per year	+ 3.7 % per year	+ 4 % per year
Intensities	constant	+ 1 % per year	+ 2 % per year

To analyze and compare the impact of measures of BEL on the electricity demand of the residential sector, various **strategies** are considered:

- **Business as Usual Strategy (BAU)**
  No measures are taken. This "doing nothing" case is used to evaluate the other strategies.

- **Market Increase Strategy (INC)**
  This strategy analyzes the impact of various measures to increase the penetration of existing markets and the growth of new markets, thus finally the increase of the sales. Possible measures considered by this strategy are:
  - Extension of the grid into new areas (shift from non grid to grid).
  - Connection of more customers to existing grid (increase electrification rate).
  - Encouraging the use of electricity for end uses like e.g. cooking, water heating.

- **Load Management Strategy (LOAD)**
  This strategy contains measures that are supposed to flatten the load curve and thus finally reducing specific generation costs:
  - Promoting the use of more efficient appliances, especially in the case of lighting.
  - Encouraging the use of appliances with constant or equal distributed load during the day, like e.g. refrigerators.

A more general description of the scenarios and strategies for all economic sectors, is given in Report Vol. 2, Chapter X.D and Annex 3.

Every combination of a scenario and a strategy will be modelled as a so called **hypothesis** in the PlaNet model. The combination REF/BAU is considered as the reference hypothesis. In PlaNet, the input values of the reference hypothesis are automatically inherited to each hypothesis in case there is no other value specified for this hypothesis. So far, only the combinations with the business as usual strategy were calculated. The results of these calculations are presented in the following chapter.

F. Results

During the second mission of consultant for each of the three regions (urban grid, rural grid, non grid) three hypothesis have been calculated (STAG/BAU, REF/BAU, PROS/BAU). The detailed results of these 9 model calculations are presented in Annex 19 in tabular form and in Annex 20 in graphical form.

In case of the Stagnation / Business as Usual hypothesis the electricity demand of the residential sector in total Belize is estimated to increase from about 57 GWh per year in 1994 to about 75 GWh in 2014. This is equal to an average growth rate of approx. 1.4 % per year. In the REF/BAU hypothesis the electricity demand increases with about 4 % per year and is estimated to approx. 125 GWh in the year 2014. Finally, in the PROS/BAU hypothesis the residential demand for electricity reaches the level of about 155 GWh in 2014 with an annual average growth rate of 5.1 %.

VI. CONCLUSIONS

Concluding, the objectives of the second mission of consultant and of the project in general, have been reached.

The essential backbone and main objective of the overall project was to train and familiarize local staff with computer-based energy planning methods. Within the project two employees of Belize Electricity Limited (Mr. Moreno and Mr. Mencias) were trained on the basics and principles of energy planning in an intensive one month course, taking place at the University of Stuttgart, Germany, from February 28 to March 25, 1994. During the second mission of Mr. Bösl to Belize, taking place from September 19 to November 1, 1994, Mr. Moreno from Belize Electricity Limited (BEL) was further trained in depth in the field of survey analysis and electricity demand analysis. Thus, within the project the local capability to create and analyze energy planning models was built.

Beside the educational part, a comprehensive case study for Belize was set up. Though the personal bottlenecks on behalf of BEL during the final phase of the project, a detailed electricity demand analysis of the residential sector was done. The specifications, assumptions and results of the household electricity demand study are described in Chapter IV and V of this report. The results attained so far are very promising and from the extension of the study on the other economic sectors interesting outcomes may be expected.

VII. RECOMMENDATIONS

During the National Household Energy Survey a huge amount of data was gathered, covering all residential energy uses and all energy carriers. The results of this survey are not merely valuable for the actual electricity demand study by BEL, but also for numerous other studies and organizations.

Therefore, it is recommended that the results are made accessible for the Central Statistical Office (CSO) and the proposed "Energy Unit" of the Government of Belize.

Further, it is recommended to update this micro survey on a regular base every 3 to 5 years and to incorporate the main energy related questions into the census, carried out by the CSO every 10 years (last census: 1991). This would enable the planning department of BEL to build up a continuous energy data base and thus to improve the quality of future studies and decisions.

So far, a detailed electricity demand analysis of the residential sector, covering all steps from the data collection to the graphical presentation of the results, was performed. After the intensive training on energy planning methods of some BEL staff members, they should be in the position to carry on working in this field on their own and to extent the existing study.

As a first step, it is recommended to incorporate additional strategies into the residential electricity demand study and to analyze their impact on the electricity consumption, as described in Chapter V.E.

Further, it is recommended to extent the analysis on other economic sectors. In order to get a reliable data base it is recommended to conduct an energy survey for the industrial and services sector, as specified in Chapter IV.B.

ANNEX 1: SPECIFICATION OF DELIVERED COMPUTER EQUIPMENT

I hereby certify that this invoice is true and correct and that no other invoice exists

Flamingo Export Co. 009059 26 JUL 94

IMPORTS

FLAMINGO EXPORT COMPANY
9001 NW 97 TERR
MEDLEY, FLORIDA, 33178
TEL:305/887-5884/FAX:887-7605

INVOICE 673
DATE 7/12/94

Bill To:
BELIZE ELECTRICITY LIMITED
115 BARRACK ROAD
BELIZE CITY BELIZE
CENTRAL AMERICA

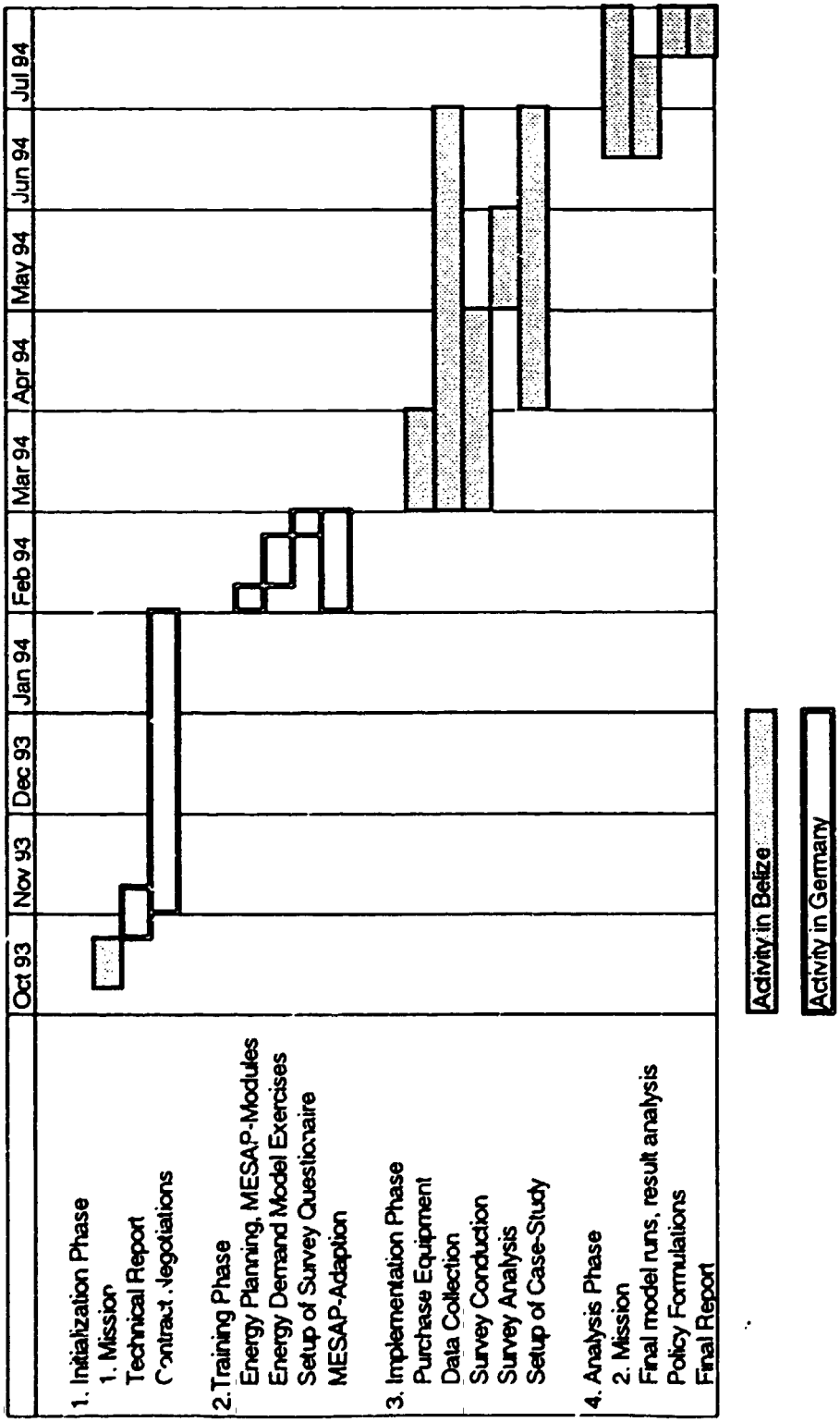
Ship To:
TEL:011-501-2-77141
FAX:011-501-2-75838 STORES
FAX:011-501-2-31905 COMPUTER

P.O Number: REG 279/0347DP
Terms: 30 DAYS
INVOICE: C.I.F. BELIZE/AIR & SEA 7/15/94 F-0

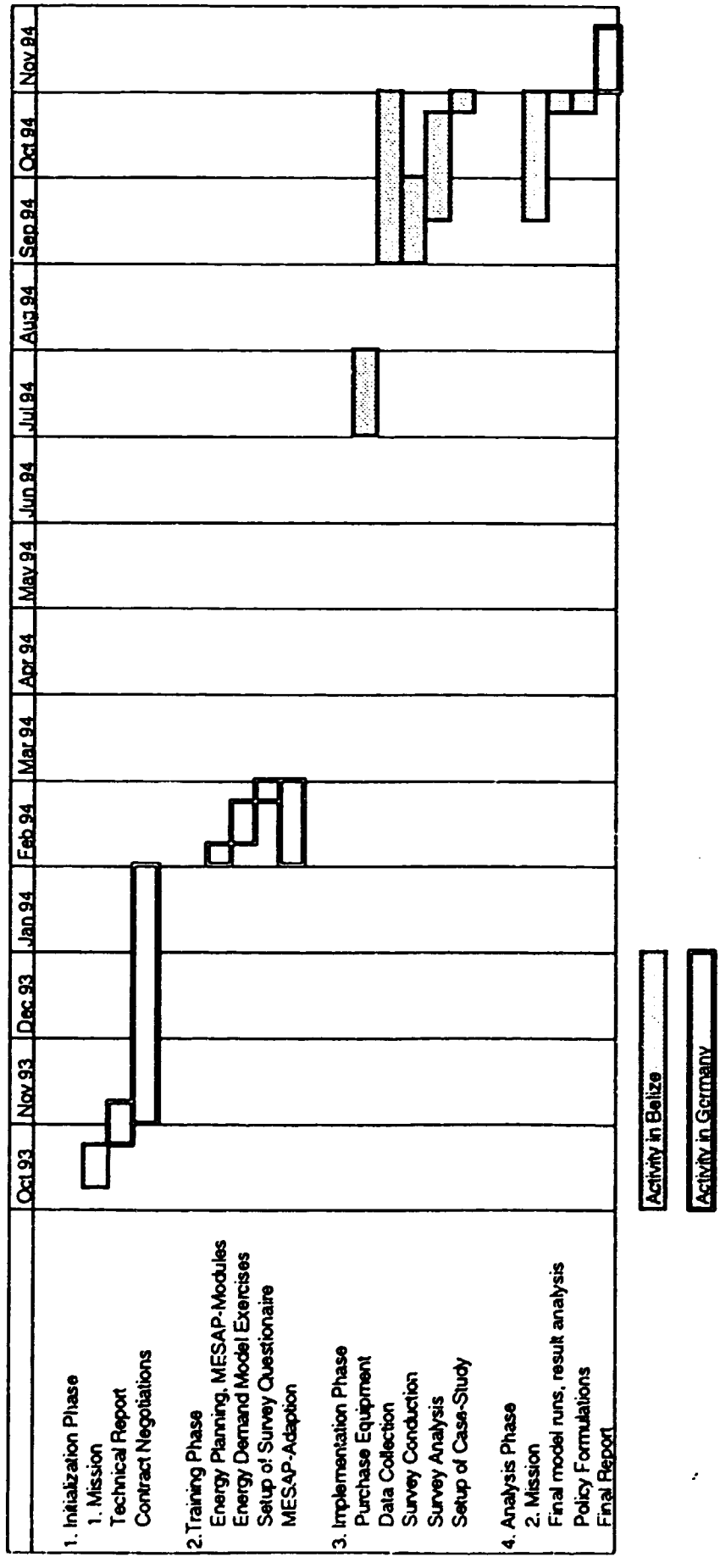
		Description			Amount
2	H74901	DOS VERSION 6.2	@	228.00	456.00
2	H7490-34	COMPAQ MINI COMPUTERS	@	3833.00	7,666.00
2	4127H2L	ACTON ETHERNET COMBOS	@	90.00	180.00
1	DT20C43	COLORADO JUMBO TAPE	@	250.00	250.00
1	2000VA	AMERICAN POWER(2000VA)	@	1335.00	1,335.00
2	C2539A	HEWLETT/PACKARD LAZERJET(4M+)	@	2423.00	4,846.00
2	11132	COMPAQ CONTURA NOTEBOOKS	@	3850.00	7,700.00
3	DC6250	DATA CARTRIDGES(DC6250)	@	33.00	99.00
2	HP92298A	TONERS H/P(4M+)	@	120.00	240.00
2	HP922	PRINTER CABLES	@	7.00	14.00
3	57346141	WINDOWS(V3.11)	@	102.00	306.00
2	4725H22	PARADOX(V4.5W)	@	150.00	300.00
1	51222	WORDPERFECT(V6.0)	@	318.00	318.00
2	4620H81	FREELANCE(V2.01/W)	@	326.00	652.00
1	109503	QUATTRO PRO(V5.0/W)	@	50.00	50.00
1	4939A42	COMPAQ SVGA MONITERS(17")	@	1625.00	3,250.00
2	4940	SYSTAT/WINDOWS	@	1050.00	2,100.00
				Subtot.	$ 29,762.00
				FREIGHT	300.00
				GRAND TOTAL:	$ 30,062.00

C/S. NO 59/94

ANNEX 2: PRELIMINARY PROJECT TIME SCHEDULE



ANNEX 3: FINAL PROJECT TIME SCHEDULE



ANNEX 4: JOB DESCRIPTION

UNIDO
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

Request from the Government of Belize

May 1994

SI/BZE/92/803/11-51

Post title : Consultant on computer-based energy system modeling and analysis

Duration : 9 weeks:

a) 3 weeks home-base
b) 6 weeks mission in Belize in September 1994

Date required : July 1994

Duty station : Belize and home base

Purpose of the project: To assist the Belize Electricity Board to identify and assess strategies to control electricity demand, and to provide reliable and low-cost supply.

Duties : The consultant will be expected to:

a) At the home-base: Revise the MESAP module PlaNet and prepare it for Belizean application. PlaNet is a combined energy demand analysis and supply simulation model, with menue-guide and GUI.

b) In Belize:

- Install and commission the complete computer system.
- Assist counterpart in building and solving the electric power system models.
- Based on the model solution results and their analysis, give advise to formulate alternative supply planning and demand management, strategies with optimization models, input/output routines and operating procedures.
- Train counterpart personnel.

Qualifications : A university degree, preferably in engineering or science; practical experience in computer applications and programming; specific experience in optimization software and modeling in connection with the utility operations, resource assessment, energy technologies, and energy planning/programming.

Language : English

Background information:

The dependence of Belize on imported equipment and fuel has placed an obvious burden on the entire economy. Moreover, this burden is likely to increase because of growth in electrical demand and inevitable increases in the prices of equipment, and possibly of fuel. Ultimately, this dependency reduces national income, increases unemployment, and slows the rate of social development.

The annual expenditure will grow as electricity demand rises due to economic expansion and social development. Until now, the potential for reducing these costs has not been systematically examined. Certainly there are some areas where generation practices or technologies may be changed with relatively little investment to produce substantial savings. This situation must be addressed in order to better allocate national resources and to prevent future economic hardship.

By identifying electricity demand management and supply planning opportunities suitable for Belize, the current energy situation can gradually be transformed into a more self-sufficient, cheaper energy future. Use of these different energy planning tools can minimize the economic problems associated with dependency on imported oil. This proposal outlines an immediate assistance to identify and adopt an integrated planning framework that can be used to assess the effectiveness of various policies and technologies which contribute to a sustainable energy future in the are of electricity generation for Belize.

ANNEX 5: NUMBER OF HOUSEHOLDS

Belize National Energy Survey - Household Sector

Number of Households

BEL / IER / CSO

October 1994

	TOTAL			URBAN			RURAL		
DISTRICT	1980	1991	Growth	1980	1991	Growth	1980	1991	Growth
COROZAL	4056	5518	2.84%	1322	1498	1.14%	2734	4020	3.57%
ORANGE WALK	4003	5750	3.35%	1485	2206	3.66%	2518	3544	3.16%
BELIZE	10659	13530	2.19%	8437	11094	2.52%	2222	2436	0.84%
CAYO	4196	7299	5.16%	2103	3429	4.54%	2093	3870	5.75%
STANN CREEK	2934	4140	3.18%	1371	1546	1.10%	1563	2594	4.71%
TOLEDO	2289	3595	4.19%	509	815	4.37%	1780	2780	4.14%
TOTAL	28137	39832	3.21%	15227	20588	2.78%	12910	19244	3.70%

Source: 1980 figures extracted from the 1980 census, Central Statistical Office (CSO)
1991 figures are based on the 1991 census, updated for the National Laborforce Survey 1993

Belize National Energy Survey - Household Sector

Survey Statistics

BEL / IER / CSO

October 1994

	Total				Grid Urban				Grid Rural				Non Grid			
District	# of HH 1991	# of HH 1994	# of HH surveyed	% of HH surveyed	# of HH 1991	# of HH 1994	# of HH surveyed	% of HH surveyed	# of HH 1991	# of HH 1994	# of HH surveyed	% of HH surveyed	# of HH 1991	# of HH 1994	# of HH surveyed	% of HH surveyed
1. Corozal	5518	6015.6	212	3.52	1498	1549.9	52	3.47	3520	3910.3	160	4.55	500	555.4	0	0.00
2. Orange Walk	5750	6347.7	215	3.39	2206	2457.4	110	4.99	2967	3256.9	105	3.54	577	633.4	0	0.00
3. Belize	13530	14451.9	390	2.70	11094	11954.1	341	3.07	1860	1907.2	39	2.10	576	590.6	10	1.74
4. Cayo	7239	8485.9	234	2.76	3642	4161.5	99	2.72	3433	4059.5	116	3.38	224	264.9	19	8.48
5. Stann Creek	4140	4575.8	109	2.38	1546	1597.5	48	3.10	1022	1173.4	10	0.98	1572	1804.9	51	3.24
6. Toledo	3595	4059.8	123	3.03	0	0.0	0	0.00	0	0.0	0	0.00	3595	4059.8	123	3.42
Total	39832	43936.7	1283	2.92	19986	21720.4	650	3.25	12802	14307.3	430	3.36	7044	7909.0	203	2.88

Values for 1994 are estimated based on the growth rates estimated from 1980 to 1991 census figures as shown on Table "Number of Households"

ANNEX 7: HOUSEHOLD ENERGY SURVEY - QUESTIONNAIRE

QUESTIONNAIRE NO: _____

BELIZE ELECTRICITY LIMITED

PLANNING DEPARTMENT

NATIONAL ENERGY SURVEY

HOUSEHOLD SECTOR

SEPTEMBER 1994

GENERAL

District Number ☐

Area ☐

ED Number ☐☐☐☐

Household Number ☐☐☐

1. Name of Head of Household: ....

2. District:.....

3. City/Town/Village:.....

4. Telephone No: .....

5. Classification: ☐

1 URBAN GRID
2 RURAL GRID
3 NON GRID

Major towns connected to the future BEL grid system are to be considered as **Urban Grid** together with communities that form part or are very close to the major population centers e.g. Ladyville in the case of Belize City; Santa Elena in the case of San Ignacio, etc. All other villages or communities that are to be connected to the future Bel grid system shall be considered **Rural Grid**. Systems to be left isolated and shall not make part of the grid system e.g. Punta Gorda, Maskall, Sarteneja shall be considered **Non Grid**.

6. Interview status: ☐

1. Complete
2. Partially complete
3. Refusal
4. Vacant
5. No contact

CONTROL

7. Date of Interview .....(DD/MM/YY)

8. Time of Interview from ..... to .....(AM/PM)

9. Total time of interview .....

10. Interviewer's Signature.....

11. Checked Supervisor's Signature .....

Date: .....(DD/MM/YY)

12. Punched and Verified: .....

Date: .....(DD/MM/YY)

SECTION I

General
Household Information

13. Total number or rooms (include outside kitchen and veranda with permanent fixtures; exclude toilets, stores and other outside buildings).....

14. Approximate size of house ... ft. X ... ft. X... levels.

15. For how many people - not necessarily living in household - are following meals prepared.

MEALS	WEEKDAYS	SATURDAYS	SUNDAYS
Breakfast			
Lunch			
Evening Meal			

16. Information on use of not water Bathing purposes:

DESCRIPTION	1 = YES 2 = NO	USERS PER WEEK	GALS. HOT WATER/USER
Bath (exclude shower)			
Shower			

17. Does the household undertake small scale farming (as a major activity) on the land on which their house is located? (Indicate with a √)

1. ☐ YES

2. ☐ NO

18. Is any carpentry, electronic repairs, garages or other such energy consuming activities undertaken on the premises of the household for commercial purposes? (Indicate with a √)

1. ☐ YES

2. ☐ NO

19. What fuel do you presently use for the following activities? Indicate with the following:

0 - Not in use
1 - Only fuel use
2 - About 1/4 in use
3 - About 1/2 in use
4 - More than 1/2 in use
5 - Rarely used
9 - Not applicable

		Electricity	Gas	Kerosene	Charcoal	Firewood	Candles	Solar Water Heater	Heating
1.	Lighting								
2.	Cooking								
3.	Water Heating *								
4.	Refrigeration								
5.	Room Cooling **								

* Exclude for cooking purposes
** Air Conditioning

20. FILL IN THE FOLLOWING TABLE WITH THE REQUIRED HOUSEHOLD INFORMATION.

LIST OF ALL PERSONS PERMANENTLY LIVING IN HOSEHOLD				APPLIES TO PERSONS AGED 14 YEARS AND OVER				
No.	Name	Sex (M/F)	Age (Years)	Occupations or Type of Work	SECTOR *	Type **	Net Income ($Bz/month)	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

Gross income of household ($Bz/month) ____

Total number of people permanently living in the household ____

OUTGOING PAYMENTS /MONTH

LOAN ____

RENT ____

OTHER LIVING EXPENSES ____

SAVINGS ____

TOTAL ____

* 1. Government
2. Semi-Government
3. Private

** 1. Fulltime
2. Partime/seasonal
3. Not employed

SECTION II
ELECTRICITY USE

21. Do you use electricity in this household? (Indicate with a ✓)

1. ☐ YES

2. ☐ NO

IF NO, DO 22 THEN GO TO 36

IF YES, SKIP TO 23

22. What is your reason for not using electricity? (Indicate with a ✓)

(i) Price of electricity too expensive 1. ☐

(ii) Connection and wiring is too expensive 1. ☐

(iii) Electrical appliances are too expensive 1. ☐

(iv) Electricity supply not available 1. ☐

(v) Electricity not suitable for our needs 1. ☐

(vi) Other (Specify) .....

23. Do you have your own generator(s)? (Indicate with a ✓)

1. ☐ YES

2. ☐ NO

IF NO, GO TO 30

24. What is the size of your generator? (add all units to get total generating cpacity in KW if more than one unit).....

25. What fuel do you use for this generator?(Indicate with a √)

    1. ☐ DIESEL

    2. ☐ GASOLINE

26. How many gallons of fuel per month do you use for this generator?.....

27. How much do you pay per gallon of this fuel? (BZ$).....

28. How many hours per week do you operate this generator?.....

29. What is your average monthly fuel bill(BZ$)?.....

30. Are you connected to BEL supply?(Indicate with a √)

    1. ☐ YES

    2. ☐ NO

IF NO, GO TO 33

31. What was your last electricity bill(From BEL in BZ$)?.....

32. What was your last month electricity consumption in kWh (From BEL)?.....

33. Are you using more or less electricity than a year ago (Indicate with a ✓)

    1 ☐ More

    2 ☐ Less

    3 ☐ Same

34. Inventory of household electrical appliances.

(i) **Lighting**

	APPLIANCE	UNITS IN USE	AVG. USAGE H/DAY PER UNIT *
1.	Incandescent Bulb (40 watts)		
2.	Incandescent Bulb (60 watts)		
3.	Incandescent Bulb (75 watts)		
4.	Incandescent Bulb (100 watts)		
5.	Flourescent Tube (20 watts)		
6.	Flourescent Tube (40 watts)		
7.	Other:.....		

* If usage/day less than an hour, state in minutes e.g.30 mins.

(ii) **Cooking**

	APPLIANCE	POWER RATING (W)	UNITS IN USE	AVG. USE PER DAY (H/DAY) PER UNIT
1.	Electric Stove with:		[redacted]	[redacted]
1.1	Plates	[redacted]		
1.2	Grill	[redacted]		
1.3	Oven	[redacted]		
2	Microwave Oven			
3	Kettle			
4	Toaster			
5	Rice Cooker			

(iii) **Refrigeration**

	APPLIANCE	UNITS IN USE	AGE IN YEARS	SIZE *
1.	Fridge with Freezer			
2.	Deep Freeze			

* Indicate as follows:

1 - small: refrigerators or freezers less than 3 feet in height

2 - medium: refrigerators or freezers 3 to 5 feet in height

3 - large: refrigerators or freezers with more than 5 feet in height or length

(iv) **Water Heating**

	APPLIANCE	UNITS IN USE	POWER RATING(W)	SIZE OF STORAGE TANK (GALS)
1.	Shower Head			
2.	Storage			

(v) **Laundry (by Washing machine)**

	TEMPERATURE	AVG. NO OF LOADS PER WEEK	GALS. HOT WATER/WASH
1.	Cold		
2.	Warm		
3.	Hot		

(vi) Other Electric Appliances

	APPLIANCE	UNITS USED	SIZE **	POWER RATING (W)	AVG. USAGE (H/DAY) PER UNIT*
1.	Air Conditioner				
2.	Fan				
3.	Television				
4.	Video				
5.	Hifi				
6.	Radio (electric)				
7.	Iron				

* If usage is less than an hour indicate length in minutes.
** Indicate the following:
s - small: screen smaller than 6"
m - medium: screen 7-20"
l - large: screen larger than 20"

35. What alternative energy form is used in the absence of electricity (Indicate with a ✓)

(i) Standby Generator 1. ☐

(ii) LPG (Butane) 1. ☐

(iii) Firewood 1. ☐

(iv) Kerosene 1. ☐

(v) Charcoal 1. ☐

(vi) Candles 1. ☐

(vii) Other (Specify).....

SECTION III

LPG (BUTANE GAS) USE

36. Do you use butane gas in this household? (Indicate with a √)

1. ☐ YES

2. ☐ NO

IF YES, SKIP TO 38

IF NO DO 37 THEN GO TO 44

37. If no, what is your reason for not using LPG (Butane Gas)? (Indicate with a ✓)

(i)	Fuel is too expensive	1. ☐
(ii)	Cylinders and regulators are too expensive	1. ☐
(iii)	Appliances (e.g. stoves) are too expensive	1. ☐
(iv)	Gas not easily available	1. ☐
(iv)	Unsuitable for our needs	1. ☐

38. Which of the following gas equipment do you have IN USE?

	APPLIANCE	UNITS IN USE	USAGE HRS/WEEK/UNIT
1.	Gas Stove with:		
1.1	Burners		
1.2	Oven		
1.3	Grill		
2	Gas Refrigerator		
3	Gas Water Heater		
4	Gas Lantern		

39. What size of gas cylinders do you buy? (Indicate with ✓)

    1. 25 lbs. (small) 1☐
    2. 50 lbs. (medium) 2☐
    3. 100 lbs. (large) 3☐
    4. Other (Specify).....

40. How much do you pay per cylinder including delivery (size as identified above in BZ$).....

41. What is the average duration of the size of cylinder you normally buy (weeks)?.....

42. What is your average monthly gas bill (BZ$)?.....

43. Are you consuming more or less LPG (Butane Gas) than a year ago? (Indicate with ✓)

    1 ☐ More
    2 ☐ Less
    3 ☐ Same

SECTION IV

KEROSENE USE

44. Do you regularly use kerosene as a main energy source in this household? (Indicate with a ✓)

    1. ☐ YES
    2. ☐ NO

IF YES, SKIP TO 46

IF NO, DO 45 THEN GO TO 51

45. What is your reason for not using kerosene in this household?(Indicate with ✓).

(i) Kerosene is too expensive 1☐

(ii) Apliances are too expensive 1☐

(iii) Poor availability of kerosene 1☐

(iv) Inappropriate for our needs 1☐

(iv) Other (Specify).....

46. How much do you pay for a gallon (1 gallon is equivalent to 4 quarts) of kerosene?(BZ$).....

47. What is your monthly kerosene bill(BZ$)?.....

48. How much kerosene do you buy per month (gallons).....

49. Are you using more or less kerosene than a year ago? (Indicate with a ✓).

1 ☐ More

2 ☐ Less

3 ☐ Same

50. Inventory of kerosene appliances in use

	APPLIANCES	UNITS IN USE	UNITS AVERAGE USAGE (HOURS/WEEK/UNIT
1.	Kerosene Stove		
2.	Kerosene Lamp		
3.	Coleman Pressure Lamp		
4.	Kerosene Refrigerator		
5.	Other: (specify)		

SECTION V

CHARCOAL USAGE

51. Do you use charcoal in this household? (Indicate with a ✓)

1. ☐ YES

2. ☐ NO

IF YES, SKIP TO 53

IF NO, DO 52 THEN GO TO 58

52. What is your reason for not using charcoal in this household? (Indicate with ✓).

(i) Charcoal is too expensive 1. ☐

(ii) Charcoal appliances are too expensive 1. ☐

(iii) Poor availability of charcoal 1. ☐

(iv) Not appropriate for our needs 1. ☐

(iv) Other (Specify).....

53. What is the price of charcoal? ($/lb or equivalent).....

54. How much do you spend on charcoal? ($/month).....

55. What quantity of charcoal do you use per month? (lb/month or equivalent) .....

56. What percentage of charcoal do you use for the following:

    (i) Cooking .....%

    (ii) Ironing .....%

    (iii) Water Heating .....%

57. What type of charcoal do you mostly use in this household? (Indicate with ✓).

    1 ☐ Local

    2 ☐ Imported

SECTION VI

FIREWOOD USE

58. Do you use firewood in this household? (Indicate with a ✓)

    1. ☐ YES

    2. ☐ NO

IF NO, GO TO 65

59. What is your total weekly firewood consumption (pieces).....

60. Of your total firewood needs what percentage do you buy? (%) .....

IF 0% GO TO 63

61. How much do you pay per piece firewood(BZ$)?.....

62. What is your monthly bill for firewood(BZ$)?.....

63. Specify the times per week and the average hours each time the following members of the family spend collecting firewood.

FAMILY MEMBER	TIMES PER WEEK	AVERAGE HOURS EACH TIME
Father		
Mother		
Children (No.)		
Other		

64. What percentage of firewood do you use for the following:

(i) Cooking .....%.

(ii) Water Heating(for bathing & laundry purposes).....%.

SECTION VII

OTHER DOMESTIC FUEL USE

65. How many candles do you buy per month?.....

66. How much do you spend per month on candles?(BZ$).....

67. Indicate the number of the following dry batteries do you normally use per month?

BATTERY SIZE:	PIECES CONSUMED/MONTH	PRICE/PIECE (BZ$)
Small (AA 1.5 V)		
Medium (C 1.5V)		
Large (D 1.5 V)		
6 Volts		
9 Volts		
Other: (Specify)		

68. What uses do you have for dry batteries?
Tick (√) appropriate box.

(i) Flash light 1. ☐

(ii) Radio 1. ☐

(iii) Television 1. ☐

(iv) Emergency lighting 1. ☐

(v) Other (Specify).....

69. Do you use 12 volts car batteries in this household?
(Indicate with a √)

1. ☐ YES

2. ☐ NO

70. If yes:

(i) How many units do you have?.....

(ii) How many times per month do you charge them?.....

(iii) How much do you pay per charge? (BZ$).....

ANNEX 8: HOUSEHOLD ENERGY SURVEY - INPUT FORM

BELIZE ELECTRICITY LIMITED - PLANNING DEPARTMENT
NATIONAL ENERGY SURVEY - HOUSEHOLD SECTOR

Section I : General Household Information

District Number :

Area :

ED Number :

Household Number :

1. Head of Household :
2. District : (choose from list or type in)
3. City/Town/Village : (choose from list or type in)
4. Telephone No. :
5. Classification : Urban Grid / Rural Grid / Non Grid

13. Number of Rooms :
14. Size of house ft. X ft. X levels.
15. For how many people - not necessarily living in the household - are the following meals prepared ?

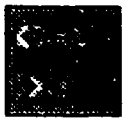
Meals	Weekdays	Saturdays	Sundays
Breakfast			
Lunch			
Evening Meal			

16. Information on use of hot water for bathing purposes:

Description	Users/Week	Total gals. hot water per Week
Bath		
Shower		

17. Small scale farming ? Yes / No

18. Small business ?



19. What fuel do you presently use for the following activities?

Use \ Fuel	Elect.	Gas	Keros.	Coal	Wood	Candle	Solar
1. Lighting							
2. Cooking							
3. Water Heating							
4. Refrigeration							
5. Room Cooling							

20. Household information on income, expenses, and number of people

Gross income :

Number of people living in household :

Loan :

Rent :

Other living expenses :

Savings :

Total :

Section II. Electricity Use

21. Do you use electricity ?

22. If NO, what is your reason for not using electricity ? (click none, one, or several)

(i) Price of electricity too expensive

(ii) Connection and wiring is too expensive

(iii) Electrical appliances are too expensive

(iv) Electricity supply not available

(v) Electricity not suitable for our needs

23. Do you have your own generators ?

YES

NO

24. Total generating capacity (KW) :

25. What fuel do you use for this generator?

Diesel

Gasoline

26. How many gallons of fuel per month do you use for this generator ?

27. How much do you pay per gallon ? (BZ$) :

28. How many hours per week do you operate this generator ?

29. What is your average monthly fuel bill (BZ$) ?

30. Are you connected to BEL supply ?

- YES
- NO

31. What was your last electricity bill from BEL (BZ$) ?

32. What was your last month's electricity consumption from BEL (kWh) ?

33. Are you using more or less electricity than a year ago ?

- More
- Less
- Same

34. Inventory of household electrical appliances.

(i) Lighting

APPLIANCE	Units in Use	Avg. Usage H/DAY
1. Incandescent Bulb 40 W		
2. Incandescent Bulb 60 W		
3. Incandescent Bulb 75 W		
4. Incandescent Bulb 100 W		
5. Flourescent Tube 20 W		
6. Flourescent Tube 40 W		

(ii) Cooking

APPLIANCE	Units in Use	Avg. Usage H/DAY
1.1 El. Stove / Plates		
1.2 El. Stove / Grill		
1.3 El. Stove / Oven		
2. Microwave Oven		
3. Kettle		
4. Toaster		
5. Rice Cooker.		

(iii) Refrigeration

APPLIANCE	Units in Use	Age in years	Size
1. Fridge with Freezer			
2. Deep Freezer			

(iv) Water Heating

APPLIANCE	Units in Use	Size of storage (gals)
1. Shower Head		
2. Storage		

(v) Laundry (by Washing Machine)

TEMPERATURE	AVG. NO. OF LOADS / WEEK	Gls hot water / wash
1. Cold		
2. Warm		
3. Hot		

(vi) Other Electric Appliances

APPLIANCE	Units Used	Avg. Usage H/DAY
1. Air Conditioners		
2. Fans		
3. Television		
4. Video		
5. Hifi		
6. Radio (electric)		
7. Iron		

35. What alternative energy form is used in the absence of electricity ? (click none, one, or several)

(i) Standby Generator
(ii) LPG (Butane)
(iii) Firewood
(iv) Kerosene
(v) Charcoal
(vi) Candles

[redacted]

36. Do you use LPG (Butane Gas) ?

37. If NO, what is your reason for not using LPG (Butane Gas) ? (click none, one, or several)

(i) Fuel is too expensive

(ii) Cylinders and regulators are expensive

(iii) Appliances (e.g. stoves) are too expensive

(iv) Gas not easily available

(v) Unsuitable for our needs

38. Which of the following gas equipment do you have in use ?

APPLIANCE	Units in Use	Avg. Usage H/WEEK
1.1 Gas Stove / Burners		
1.2 Gas Stove / Oven		
1.3 Gas Stove / Grill		
2. Gas Refrigerator		
3. Gas Water Heater		
4. Gas Lantern		

39. What size of gas cylinders do you buy (lbs.) ? (choose from list or type in)

40. How much do you pay per cylinder including delivery (BZ$) ?

41. What is the average duration of the size of cylinder (weeks) ?

42. What is your average monthly gas bill (BZ$) ?

43. Are you consuming more or less LPG (Butane Gas) than a year ago ?

More

Less

Same

[redacted]

44. Do you regularly use Kerosene ?

45. If NO, what is your reason for not using Kerosene ? (click none, one, or several)

(i) Kerosene is too expensive

(ii) Appliances are too expensive

(iii) Poor availability of Kerosene

(iv) Inappropriate for our needs

46. How much do you pay for one gallon of kerosene (BZ$) ?

47. What is your monthly kerosene bill (BZ$) ?

48. How much kerosene do you buy per month (gallons) ?

49. Are you using more or less Kerosene than a year ago ?

- More
- Less
- Same

50. Inventory of Kerosene appliances in use

APPLIANCE	Units in Use	Avg. Usage H/WEEK
1. Kerosene Stove		
2. Kerosene Lamp		
3. Coleman Pressure Lamp		
4. Kerosene Refrigerator		

Section V: Charcoal Use

51. Do you use Charcoal ?

52. If NO, what is your reason for not using Charcoal ? (click none, one, or several)

(i) Charcoal is too expensive

(ii) Charcoal appliances are too expensive

(iii) Poor availability of Charcoal

(iv) Not appropriate for our needs

53. What is the price of Charcoal (BZ$ / lb) ?

54. How much do you spend on Charcoal (BZ$ / month) ?

55. What quantity of Charcoal do you use (lb / month) ?

56. What percentage of Charcoal do you use for the following:

(i) Cooking (%)

(ii) Ironing (%)

(iii) Water Heating (%)

57. What type of Charcoal do you mostly use ?

Local

Imported

Section VI: Firewood Use

58. Do you use Firewood ? 

59. What is your total weekly firewood consumption (pieces) ? ☐

60. Of your total firewood needs what percentage do you buy (%) ? ☐

61. How much do you pay per piece firewood (BZ$) ? ☐

62. What is your monthly bill for firewood (BZ$) ? ☐

63. Specify the times spend for collecting firewood:

FAMILY MEMBER	Times / Week	Avg. Hours each time
Father		
Mother		
Children, No.:		
Other		

64. What percentage of firewood do you use for the following:

(i) Cooking (%) ☐

(ii) Water Heating (%) ☐

Section VII: OTHER DOMESTIC FUEL USES

65. How many candles do you buy per month ? ☐

66.How much do you spend per month on candles (BZ$) ? ☐

67. Indicate the number of the following dry batteries you normally use per month.

BATTERY SIZE	PCS. CONSUMED / MONTH	PRICE / PIECE
Small (AA 1.5 V)		
Medium (C 1.5 V)		
Large (D 1.5 V)		
6 Volts		
9 Volts		

68. What uses do you have for dry batteries ? (click none, one, or several)

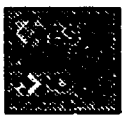
(i) Flash light ☐

(ii) Radio ☐

(iii) Television ☐

(iv) Emergency lighting ☐

69. Do you use 12 Volt car batteries in this household ?



70. If yes :

(i) How many units do you have ? ☐

(ii) How many times per month do you charge them ? ☐

(iii) How much do you pay per charge (BZ$) ? ☐

ANNEX 9: HOUSEHOLD ENERGY SURVEY - AGGREGATED RESULTS 1

Belize National Energy Survey - Household Sector

Aggregated Results

BEL \ IER \ CSO

October 1994

Number and percentage of Households using a certain Fuel for a certain Use

Total Belize

Fuel / Use	Electricity #	Electricity %	LPG #	LPG %	Kerosene #	Kerosene %	Coal #	Coal %	Wood #	Wood %	Candle #	Candle %	Solar #	Solar %
Lighting	1027	80.0	14	1.1	329	25.6					290	22.6		
Cooking	10	0.8	977	76.1	56	4.4	8	0.6	475	37.0				
Water Heat.	64	5.0	1	0.1									26	2.0
Refrigeration	632	49.3	2	0.2	8	0.6								
Room Cooling	16	1.2												
Wash. Mach.	419	32.7												

Urban Grid

Fuel / Use	Electricity #	Electricity %	LPG #	LPG %	Kerosene #	Kerosene %	Coal #	Coal %	Wood #	Wood %	Candle #	Candle %	Solar #	Solar %
Lighting	619	95.2	11	1.7	53	8.2					135	20.8		
Cooking	8	1.2	588	90.5	20	3.1	7	1.1	83	12.8				
Water Heat.	41	6.3	0	0.0									7	1.1
Refrigeration	423	65.1	0	0.0	0	0.0								
Room Cooling	14	2.2												
Wash. Mach.	263	40.5												

Rural Grid

Fuel / Use	Electricity #	Electricity %	LPG #	LPG %	Kerosene #	Kerosene %	Coal #	Coal %	Wood #	Wood %	Candle #	Candle %	Solar #	Solar %
Lighting	226	75.8	2	0.5	150	34.9					105	24.4		
Cooking	2	0.5	304	70.7	19	4.4	1.0	0.2	261	60.7				
Water Heat.	17	4.0	1	0.2									12	2.8
Refrigeration	159	37.0	0	0.0	1	0.2								
Room Cooling	0	0.0												
Wash. Mach.	142	33.0												

Non Grid

Fuel / Use	Electricity #	Electricity %	LPG #	LPG %	Kerosene #	Kerosene %	Coal #	Coal %	Wood #	Wood %	Candle #	Candle %	Solar #	Solar %
Lighting	82	40.4	1	0.5	126	62.1					50	24.6		
Cooking	0	0.0	85	41.9	17	8.4	0	0.0	131	64.5				
Water Heat.	6	3.0	0	0.0									7	3.4
Refrigeration	50	24.6	2	1.0	7	3.4								
Wash. Mach.	14	0.1												

ANNEX 10: HOUSEHOLD ENERGY SURVEY - AGGREGATED RESULTS 2

Belize National Energy Survey - Household Sector

Aggregated Results

BEL\IER\CSO

October 1994

	(absolute figures related to sample size)				(absolute figures related to total number of households)			
	Total Belize	Urban Grid	Rural Grid	Non Grid	Total Belize	Urban Grid	Rural Grid	Non Grid
1.1 General Survey Information								
# of HH	43936	21720	14307	7909	43936	21720	14307	7909
# of HH surveyed	1283	650	430	203	1283	650	430	203
% of HH surveyed	2.92%	2.99%	3.01%	2.57%	2.92%	2.99%	3.01%	2.57%
1.2 General Household Information								
# of rooms	5540	3154	1743	643	189715.85	105392.12	57993.26	25051.66
Avg. rooms/HH	4.32	4.85	4.05	3.17	4.32	4.85	4.05	3.17
Avg. size of HH (sq ft)	738.51	850.84	624.60	648.82	738.51	850.84	624.60	648.82
# of persons	6331	3020	2271	1040	216803.44	100914.46	75560.92	40519.01
Avg. persons/HH	4.93	4.65	5.28	5.12	4.93	4.65	5.28	5.12
Avg. income/HH	803.57	1021.20	664.64	538.45	803.57	1021.20	664.64	538.45
# of HH doing small scale farming	90	13	39	38	90.00	13.00	39.00	38.00
% of HH doing small scale farming	7.01%	2.00%	9.07%	18.72%	7.01%	2.00%	9.07%	18.72%
# of HH doing small scale business	70	34	28	8	70.00	34.00	28.00	8.00
% of HH doing small scale business	5.46%	5.23%	6.51%	3.94%	5.46%	5.23%	6.51%	3.94%
1.2.1 Electricity Use								
General characteristics								
# of HH using electricity	1029	620	327	82	35237.84	20717.54	10879.97	3194.77
% of HH using electricity	80.20%	95.38%	76.05%	40.39%	80.20%	95.38%	76.05%	40.39%
Reasons for not using electricity.					(in % of HH not using electricity)			
- price of electricity too expensive	61	14	41	6	24.02%	46.67%	39.81%	4.96%
- connection and wiring to expensive	65	11	45	9	25.59%	36.67%	43.69%	7.44%
- electrical appliances too expensive	43	8	34	1	16.93%	26.67%	33.01%	0.83%
- electricity supply not available	129	3	27	99	50.79%	10.00%	26.21%	81.82%
- not suitable for our needs	17	5	9	3	6.69%	16.67%	8.74%	2.48%
# of HH with private generation	75	6	44	25	2568.36	200.49	1463.97	974.01
% of HH with private generation	5.85%	0.92%	10.23%	12.32%	5.85%	0.92%	10.23%	12.32%
# of HH connected to BEL	962	618	286	58	32943.44	20650.71	9515.82	2259.71
% of HH connected to BEL	74.98%	95.08%	66.51%	28.57%	74.98%	95.08%	66.51%	28.57%
Avg. Electricity consumption/HH (kWh in 8/94)	134.78	165.78	57.76	110.40	134.78	165.78	57.76	110.40
Avg. Electricity bill (BZ$ in 8/94)	49.56	61.29	26.27	45.58	49.56	61.29	26.27	45.58
Avg. Electricity price (BZ$/kWh)	0.36	0.37	0.35	0.39	0.36	0.37	0.35	0.39
Lighting appliances								
# of 40 W incandescent bulbs	1396	945	277	174	47805.66	31577.54	9216.37	6779.14
Avg. usage of 40 W incandescent bulbs (h/d)	3.84	3.61	4.34	3.91	3.84	3.61	4.34	3.91
# of 60 W incandescent bulbs	896	626	211	59	30683.29	20918.03	7020.41	2298.67
Avg. usage of 60 W incandescent bulbs (h/d)	3.77	3.99	3.42	2.89	3.77	3.99	3.42	2.89
# of 75 W incandescent bulbs	102	51	42	9	3492.96	1704.18	1397.43	350.65
Avg. usage of 75 W incandescent bulbs (h/d)	3.91	3.78	4.01	4	3.91	3.78	4.01	4.00
# of 100 W incandescent bulbs	242	96	123	23	8287.23	3207.88	4092.47	896.09
Avg. usage of 100 W incandescent bulbs (h/d)	3.81	4.81	2.38	6.21	3.81	4.81	2.38	6.21
# of 20 W flourescent tubes	2571	1560	865	146	88043.22	52128.00	28780.36	5688.25
Avg. usage of 20 W flourescent tubes (h/d)	4.43	4.25	4.69	4.51	4.43	4.25	4.69	4.51
# of 40 W flourescent tubes	361	205	129	27	12362.35	6850.15	4292.10	1051.94
Avg. usage of 40 W flourescent tubes (h/d)	4.06	4.07	4.16	3.45	4.06	4.07	4.16	3.45
Cooking appliances								
# of electric plates	21	18	3	0	719.14	601.48	99.82	0.00
Avg. usage of electric plates (h/d)	1.65	1.32	2.5		1.65	1.32	2.50	0.00
# of electric grills	6	6	0	0	205.47	200.49	0.00	0.00
Avg. usage of electric grills (h/d)	0.33	0.33			0.33	0.33	0.00	0.00
# of electric ovens	4	3	1	0	136.98	100.25	33.27	0.00
Avg. usage of electric ovens (h/d)	0.13	0	0.5		0.13	0.00	0.50	0.00
# of microwave ovens	98	75	20	3	3355.98	2506.15	665.44	116.88
Avg. usage of microwave ovens (h/d)	0.23	0.2	0.32	0.32	0.23	0.20	0.32	0.32
# of kettles	22	17	3	2	753.38	568.06	99.82	77.92
Avg. usage of kettles (h/d)	0.71	0.71	0.54	1	0.71	0.71	0.54	1.00
# of toasters	162	124	34	4	5547.65	4143.51	1131.25	155.84
Avg. usage of toasters (h/d)	0.28	0.28	0.26	0.54	0.28	0.28	0.26	0.54
# of rice cookers	23	19	4	0	787.63	634.89	133.09	0.00
Avg. usage of rice cookers (h/d)	0.69	0.67	1		0.69	0.67	1.00	0.00

Belize National Energy Survey - Household Sector

Aggregated Results

BEL\IER\CSO

October 1994

	(absolute figures related to sample size)				(absolute figures related to total number of households)			
	Total Belize	Urban Grid	Rural Grid	Non Grid	Total Belize	Urban Grid	Rural Grid	Non Grid
Refrigeration								
# of fridge with freezer	628	427	147	54	21505.70	14268.37	4891.00	2103.87
# of fridge with freezer < 5 years old	476	314	120	42	16300.50	10492.43	3992.65	1636.34
# of fridge with freezer >= 5 years old	152	113	27	12	5205.20	3775.94	898.35	467.53
Avg. age of fridge with freezer (years)	3.56	3.68	3.38	3.1	3.56	3.66	3.38	3.10
# of deep freeze	71	27	38	6	2431.38	902.22	1264.34	233.76
# of deep freeze < 5 years old	53	16	31	6	1814.97	534.65	1031.43	233.76
# of deep freeze >= 5 years old	18	11	7	0	616.41	367.57	232.90	0.00
Avg. age of deep freeze (years)	3.08	3.55	2.97	1.8	3.08	3.55	2.97	1.80
Water heating								
# of shower heads	44	28	11	5	1506.77	935.63	365.99	194.80
Hot water heated by shower heads (gal/week)	9720	6535	2065	1120	332858.86	218369.54	68706.87	43635.86
# of storage water heater	25	17	7	1	856.12	568.06	232.90	38.96
Hot water heated by storage (gal/week)	6210	3825	2205	180	212659.83	127813.85	73364.97	7012.91
Avg. storage size (gal)	22.21	20.14	28		22.21	20.14	28.00	0.00
Laundry by washing machine								
# of cold loads/week	2076	1164	857	55	71092.08	38895.51	28514.18	2142.83
# of warm loads/week	231		230	1	7910.53	0.00	7652.58	38.96
# of hot loads/week	174	18	154	2	5958.58	601.48	5123.90	77.92
Other electric appliances								
# of air conditioners	25	23	0	2	856.12	768.55	0.00	77.92
Avg. usage of air conditioners (h/d)	7.04	5.27		15	7.04	5.27	0.00	15.00
# of fans	1867	1291	486	90	63934.93	43139.26	16170.24	3506.45
Avg. usage of fans (h/d)	7.73	8.62	6.17	6.55	7.73	8.62	6.17	6.55
# of TVs	1020	721	247	52	34929.63	24092.49	8218.21	2025.95
Avg. usage of TVs (h/d)	4.84	4.95	4.73	4.07	4.84	4.95	4.73	4.07
# of Videos	193	135	42	16	6609.23	4511.08	1397.43	623.37
Avg. usage of videos (h/d)	1.33	1.17	1.4	2.55	1.33	1.17	1.40	2.55
# of Hifis	238	192	35	11	8150.25	6415.75	1164.52	428.57
Avg. usage of Hifis (h/d)	3.38	3.14	4.29	3.94	3.38	3.14	4.29	3.94
# of radios	800	471	264	65	27395.79	15738.65	8783.83	2532.44
Avg. usage of radios (h/d)	4.5	4.64	4.14	5.05	4.50	4.64	4.14	5.05
# of irons	915	589	276	50	31333.94	19681.66	9183.10	1948.03
Avg. usage of irons (h/d)	0.5	0.5	0.51	0.45	0.50	0.50	0.51	0.45
1.2.2 LPG Use								
General characteristics								
# of HH using LPG	979	589	304	86	33525.50	19681.66	10114.72	3350.61
% of HH using LPG	76.31%	90.62%	70.70%	42.36%	76.31%	90.62%	70.70%	42.36%
Reasons for not using LPG:								
- fuel is too expensive	105	16	57	32	34.54%	26.23%	45.24%	27.35%
- cylinders and regulators to expensive	107	17	63	27	35.20%	27.87%	50.00%	23.08%
- appliances too expensive	160	14	83	63	52.63%	22.95%	65.87%	53.85%
- not easily available	36	1	6	29	11.84%	1.64%	4.76%	24.79%
- not suitable for our needs	73	38	23	12	24.01%	62.30%	18.25%	10.26%
Avg. LPG consumption/HH (lbs/month)	34.56	34.63	34.4	34.96	34.58	34.63	34.4	34.96
Avg. LPG bill (BZ$/month)	17.33	16.98	16.56	22.28	17.33	16.98	16.56	22.28
Appliances								
# of gas burners	3508	2063	1133	312	120130.54	68935.94	37097.28	12155.70
Avg. usage of gas burners (h/week)	16.67	16.23	17.31	17.49	16.67	16.23	17.31	17.49
# of gas ovens	784	468	242	74	26847.88	15638.40	8051.85	2883.08
Avg. usage of gas ovens (h/week)	2.08	1.64	2.2	2.09	2.08	1.64	2.20	2.09
# of gas grills	532	312	157	63	18218.20	10425.60	5223.72	2454.52
Avg. usage of gas grills (h/week)	0.48	0.46	0.52	0.46	0.48	0.46	0.52	0.46
# of gas refrigerators	2	0	0	2	68.49	0.00	0.00	77.92
# of gas water heaters	1	0	1	0	34.24	0.00	33.27	0.00
# of gas lanterns	14	11	2	1	479.43	367.57	66.54	38.96
Avg. usage of gas lanterns (h/week)	17.34	12.68	50	0	17.34	12.68	50.00	0.00

Belize National Energy Survey - Household Sector

Aggregated Results

BEL \ IER \ CSO

October 1994

	(absolute figures related to sample size)				(absolute figures related to total number of households)			
	Total Belize	Urban Grid	Rural Grid	Non Grid	Total Belize	Urban Grid	Rural Grid	Non Grid
1.2.3 Kerosene Use								
General characteristics								
# of HH using Kerosene	359	62	156	141	12293.86	2071.75	5190.45	5493.44
% of HH using Kerosene	27.98%	9.54%	36.28%	69.46%	27.98%	9.54%	36.28%	69.46%
Reasons for not using Kerosene:								
- fuel is too expensive	2	0	2	0	0.22%	0.00%	0.73%	0.00%
- appliances too expensive	2	0	1	1	0.22%	0.00%	0.36%	1.61%
- poor availability	8	4	3	1	0.87%	0.68%	1.09%	1.61%
- not suitable for our needs	844	552	234	5	91.34%	93.88%	85.40%	8.06%
Avg. Kerosene consumption/HH (gal/month)	2.54	3.03	2.13	2.77	2.54	3.03	2.13	2.77
Avg. Kerosene bill (BZ$/month)	7.99	7.72	6.52	9.71	7.99	7.72	6.52	9.71
Avg. Kerosene Price (BZ$/gal)	3.21	2.61	3.19	3.5	3.21	2.61	3.19	3.5
Appliances								
# of kerosene stoves	64	21	20	23	2191.66	701.72	665.44	896.09
Avg. usage of kerosene stoves (h/week)	18.26	13.11	19.42	24.58	18.26	13.11	19.42	24.58
# of kerosene lamps	493	59	231	203	16882.66	1971.51	7685.85	7909.00
Avg. usage of kerosene lamps (h/week)	23.81	19.93	22.91	26.53	23.81	19.93	22.91	26.53
# of coleman pressure lamps	6	0	1	5	205.47	0.00	33.27	194.80
Avg. usage of coleman press. lamps (h/week)	16.5		28	12.67	16.50	0.00	28.00	12.67
# of kerosene refrigerators	9	0	2	7	308.20	0.00	66.54	272.72
1.2.4 Charcoal Use								
# of HH using Charcoal	8	7	1	0	273.96	233.91	33.27	0.00
% of HH using Charcoal	0.62%	1.08%	0.23%	0.00%	0.62%	1.08%	0.23%	0.00%
Reasons for not using Charcoal:								
- Charcoal is too expensive	17	0	7	10	1.33%	0.00%	1.63%	4.93%
- appliances too expensive	4	0	3	1	0.31%	0.00%	0.70%	0.49%
- poor availability	46	2	27	17	3.61%	0.31%	6.29%	8.37%
- not suitable for our needs	1206	620	405	181	94.59%	96.42%	94.41%	89.16%
Avg. Charcoal consumption/HH (lbs/month)	7.22	6.88	10	0	7.22	6.88	10.00	0.00
Avg. Charcoal bill (BZ$/month)	5.92	6.04	5	0	5.92	6.04	5.00	0.00
Avg. Charcoal price (BZ$/lbs)	0.96	1.02	0.5		0.96	1.02	0.50	0.00
1.2.5 Firewood Use								
# of HH using Firewood	475	83	261	131	16266.25	2773.48	8684.02	5103.84
% of HH using Firewood	37.02%	12.77%	60.70%	64.53%	37.02%	12.77%	60.70%	64.53%
Avg. firewood consumption/HH (pieces/week)	97.21	59.06	96.11	123.90	97.21	59.06	96.11	123.90
Avg. firewood price (BZ$/piece)	0.12	0.14	0.1	0.07	0.12	0.14	0.10	0.07
1.2.6 Other Domestic Fuel Use								
Candles								
# of HH using candles	290	135	105	50	9930.97	4511.08	3493.57	1948.03
% of HH using candles	22.60%	20.77%	24.42%	24.63%	22.60%	20.77%	24.42%	24.63%
Avg. consumption of candles/HH/month	5.58	3.76	1.85	12.04	5.58	3.76	4.85	12.04
Car batteries								
# of HH using car batteries	55	12	21	22	1883.46	400.98	698.71	857.13
% of HH using car batteries	4.29%	1.85%	4.88%	10.84%	4.29%	1.85%	4.88%	10.84%

ANNEX 11: ASSESSMENT OF END USE TECHNOLOGIES

Belize Electricity Demand Study, BEL/IER, October 1994

Assessment of End Use Technologies

Efficiencies, Power ratings, and specific consumption of applainces

Appliance	Unit	Literature	Survey in Belize	Applied for study
0 W bulb	lm/W	11 - 12		11
60 W bulb	lm/W	12 - 14.3		12
75 W bulb	lm/W	13 - 15.7		13
00 W bulb	lm/W	14.5 - 17.5		15
20 W flou.	lm/W	43 - 55.6	43	43
40 W flou.	lm/W	48 - 70	57	57
Plate	W	600 - 2000		1000
Grill	W	1200 - 1650		1400
Oven	W	1230 - 8000		1500
Microwave	W	975 - 1575		1400
Kettle	W	1000 - 1080	1500	1500
Toaster	W	300 - 1600		1000
Rice cooker	W	-		1500
Fridge w/ Freezer	kWh/y	356 - 1450		900
Deep Freeze	kWh/y	140 - 1500		600
Showerhead	Efficiency			0.95
Storage	Efficiency			0.8
Washing Machine	kWh/load	0.3 - 0.8		0.4
Air conditioner	W	800-2500		1000
Fan	W	40 - 200		40
Television	W	50 - 300		50
VCR	W	30 - 54		30
Hifi	W	25 - 109		30
Radio	W	5 - 100		10
Iron	W	938 - 1100		1000

Source:

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ANNEX 12: ELECTRICITY CONSUMPTION OF HOUSEHOLDS IN 1994 - BY REGION

Belize Electricity Demand Study, BEL/IER, October 1994

Electricity Consumption of Households in 1994

based on the Belize National Energy Survey

Region: Urban Grid

Lighting

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)	Efficiency (Mlmh/MWh)	Useful Energy (Mlmh/y)	Market Shar (%)
40 W bulb	31578	3.61	40	52.71	1664.35	11	18307.85	12.74%
60 W bulb	20918	3.99	60	87.36	1827.84	12	21934.03	15.26%
75 W bulb	1704	3.78	75	103.48	176.32	13	2292.23	1.59
100 W bulb	3208	4.81	100	175.57	563.21	15	8448.19	5.88
20 W flou.	52128	4.25	20	31.03	1617.27	43	69542.66	48.39
40 W flou.	6850	4.07	40	59.42	407.04	57	23201.32	16.14%
TOTAL					6256.04		143726.28	100.00%

Cooking

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)
Plate	602	1.32	1000	481.80	290.04
Grill	201	0.33	1490	168.63	33.89
Oven	100	0	1500	0.00	0.00
Microwave	2506	0.2	1400	102.20	256.11
Kettle	568	0.71	1500	388.75	220.80
Toaster	4144	0.28	1000	102.20	423.52
Rice cooker	635	0.67	1500	366.83	232.93
TOTAL					1457.30

Refrigeration

Appliance	# of Appliances	El. Cons. per unit (kWh/y)	Electricity Cons. (MWh/y)
Fridge w/ Freezer	14268	900	12841.2
Deep Freeze	902	600	541.2
TOTAL			13382.4

Water Heating

Appliance	Hot water (gals/week)	Hot water (gals./y)	Energy conten (kWh/y)	Efficiency (kWh/kWh)	Total El. Cons. (MWh/y)
Showerhead	218370	11355240	14995/2.99	0.95	1578.00
Storage	127814	6646328	8777/4.08	0.8	1097.14
TOTAL		18001568			2675.64

Hot water may be defined as water which is heated up by 30 K.

The specific energy content of water is equivalent to 4.402 Wh/(gal*K). For 30 K it is 0.13206 kWh/gal.

Laundry

Appliance	Loads/week	Loads/year	El. Cons. per load (kWh/load)	Total El. Cons. (MWh/y)
Washing Machine	39497	2053844	0.4	821.54

Other Electrical Appliances

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)
Air conditioner	769	5.27	1000	1923.55	1479.21
Fan	43139	8.62	40	125.85	5429.13
Television	24093	4.95	50	90.34	2176.50
VCR	4511	1.17	30	12.81	57.79
Hifi	6416	3.14	30	34.38	220.60
Radio	15739	4.64	10	16.94	266.56
Iron	19682	0.5	1000	182.50	3591.97
TOTAL					13221.76

Summary

Use	Electricity Consumption (MWh/y)	%
Lighting	6256.04	16.54%
Cooking	1457.30	3.85%
Refrigeration	13382.40	35.39%
Water Heating	2675.64	7.08%
Laundry	821.54	2.17%
Other electric appliances	13221.76	34.96%
TOTAL	37814.67	100.00%
% of HH w/ private generation	0.92%	
Estimated demand from BEL	37465.60	

Belize Electricity Demand Study, BEL/IER, October 1994

Electricity Consumption of Households in 1994

based on the Belize National Energy Survey

Rural Grid

Lighting

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)	Efficiency (Mlmh/MWh)	Useful Energy (Mlmh/y)	Market Share (%)
40 W bulb	9216	4.34	40	63.36	583.96	11	6423.59	8.31%
60 W bulb	7020	3.42	60	74.90	525.78	12	6309.41	8.16%
75 W bulb	139	4.01	75	109.77	153.35	13	1993.60	2.58%
100 W bulb	4093	2.38	100	86.87	355.56	15	5333.38	6.90%
20 W flou.	28780	4.69	20	34.24	985.34	43	42369.66	54.82%
40 W flou.	4292	4.16	40	60.74	260.68	57	14858.70	19.23%
TOTAL					2864.68		77288.34	100.00%

Cooking

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)
Plate	100	2.5	1000	912.50	91.25
Grill	0	0	1400	0.00	0.00
Oven	33	0.5	1500	273.75	9.03
Microwave	665	0.32	1400	163.52	108.74
Kettle	100	0.54	1500	295.65	29.57
Toaster	1131	0.26	1000	94.90	107.33
Rice cooker	133	1	1500	547.50	72.82
TOTAL					418.74

Refrigeration

Appliance	# of Appliances	El. Cons. per unit (kWh/y)	Electricity Cons. (MWh/y)
Fridge w/ Freezer	4891	900	4401.9
Deep Freeze	1264	600	758.4
TOTAL			5160.3

Water Heating

Appliance	Hot water (gals/week)	Hot water (gals./y)	Energy content (kWh/y)	Efficiency (kWh/kWh)	Total El. Cons. (MWh/y)
Showerhead	68707	3572764	471819.21	0.95	496.65
Storage	73365	3814980	503806.26	0.8	629.76
TOTAL		7387744			1126.41

Hot water may be defined as water which is heated up by 30 K.

The specific energy content of water is equivalent to 4.402 Wh/(gal*K). For 30 K it is 0.13206 kWh/gal.

Laundry

Appliance	Loads/week	Loads/year	El. Cons. per load (kWh/load)	Total El. Cons. (MWh/y)
Washing Machine	41291	2147132	0.4	858.85

Other Electrical Appliances

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)
Air conditioner	0	0	1000	0.00	0.00
Fan	16170	6.17	40	90.08	1456.63
Television	8218	4.73	50	86.32	709.40
VCR	1397	1.4	30	15.33	21.42
Hifi	1165	4.29	30	46.98	54.73
Radio	8784	4.14	10	15.11	132.74
Iron	9183	0.51	1000	186.15	1709.42
TOTAL					4084.32

Summary

Use	Electricity Consumption (MWh/y)	%
Lighting	2864.68	19.74%
Cooking	418.74	2.89%
Refrigeration	5160.30	35.56%
Water Heating	1126.41	7.76%
Laundry	858.85	5.92%
Other electric appliances	4084.32	28.14%
TOTAL	14513.30	100.00%
% of HH w/ private generation	10.23%	
Estimated demand from BEL	13028.21	

Belize Electricity Demand Study, BEL/IER, October 1994

Electricity Consumption of Households in 1994

based on the Belize National Energy Survey

Region: Non Grid

Lighting

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)	Efficiency (Mlmh/MWh)	Useful Energy (Mlmh/y)	Market Sha (%)
40 W bulb	6779	3.91	40	57.09	386.99	11	4256.85	20.64%
60 W bulb	2299	2.89	60	63.29	145.51	12	1746.07	8.4
75 W bulb	351	4	75	109.50	38.43	13	499.65	2.4
100 W bulb	896	6.21	100	226.67	203.09	15	3046.38	14.7
20 W flou.	5688	4.51	20	32.92	187.27	43	8052.44	39.05%
40 W flou.	1052	3.45	40	50.37	52.99	57	3020.39	14.65%
TOTAL					1014.27		20621.77	100.0

Cooking

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)
Plate	0	0	1000	0.00	0.00
Grill	0	0	1400	0.00	0.00
Oven	0	0	1500	0.00	0.00
Microwave	117	0.32	1400	163.52	19.13
Kettle	78	1	1500	547.50	42.71
Toaster	156	0.54	1000	197.10	30.75
Rice cooker	0	0	1500	0.00	0.00
TOTAL					92.58

Refrigeration

Appliance	# of Appliances	El. Cons. per unit (kWh/y)	Electricity Cons. (MWh/y)
Fridge w/ Freezer	2104	900	1893.6
Deep Freeze	234	600	140.4
TOTAL			2034

Water Heating

Appliance	Hot water (gals/week)	Hot water (gals /y)	Energy content (kWh/y)	Efficiency (kWh/kWh)	Total El. Cons. (MWh/y)
Showerhead	43636	2269072	299653.65	0.95	315.42
Storage	7013	364676	48159.11	0.8	60.20
TOTAL		2633748			375.62

Hot water may be defined as water which is heated up by 30 K.

The specific energy content of water is equivalent to 4.402 Wh/(gal*K). For 30 K it is 0.13206 kWh/gal.

Laundry

Appliance	Loads/week	Loads/year	El. Cons. per load (kWh/load)	Total El. Cons. (MWh/y)
Washing Machine	2260	117520	0.4	47.01

Other Electrical Appliances

Appliance	# of Appliances	Avg. use (h/d)	Power Rating (W)	El. Cons. per unit (kWh/y)	Total El. Cons. (MWh/y)
Air conditioner	78	15	1000	5475.00	427.05
Fan	3506	6.55	40	95.63	335.28
Television	2026	4.07	50	74.28	150.49
VCR	623	2.55	30	27.92	17.40
Hifi	429	3.94	30	43.14	18.51
Radio	2532	5.05	10	18.43	46.67
Iron	1948	0.45	1000	164.25	319.96
TOTAL					1315.35

Summary

Use	Electricity Consumption (MWh/y)	%
Lighting	1014.27	20.79%
Cooking	92.58	1.90%
Refrigeration	2034.00	41.69%
Water Heating	375.62	7.70%
Laundry	47.01	0.96%
Other electric appliances	1315.35	26.96%
TOTAL	4878.84	100.00%
% of HH w/ private generation	12.32%	
Estimated demand from BEL	4277.77	

ANNEX 13: ELECTRICITY CONSUMPTION OF HOUSEHOLDS IN 1994 - SUMMARY

Belize Electricity Demand Study, BEL/IER, October 1994

Electricity Consumption of Households in 1994

based on the Belize National Energy Survey

Summary

Region / Use	Total Belize (MWh/y)	%	Urban Grid (MWh/y)	%	Rural Grid (MWh/y)	%	Non Grid (MWh/y)	%
Lighting	10134.99	17.72%	6256.04	16.54%	2864.68	19.74%	1014.27	20.79%
Cooking	1968.62	3.44%	1457.30	3.85%	418.74	2.89%	92.58	1.90%
Refrigeration	20576.70	35.97%	13382.40	35.39%	5160.30	35.56%	2034.00	41.69%
Water Heating	4177.67	7.30%	2675.64	7.08%	1126.41	7.76%	375.62	7.70%
Laundry	1727.40	3.02%	821.54	2.17%	858.85	5.92%	47.01	0.96%
Other electric appliances	18621.42	32.55%	13221.76	34.96%	4084.32	28.14%	1315.35	26.96%
TOTAL	57206.80	100.00%	37814.67	100.00%	14513.30	100.00%	4878.84	100.00%
% of HH w/ private generation			0.92%		10.23%		12.32%	
Estimated demand from BEL	54771.58		37465.60		13028.21		4277.77	

Total Sales of BEL 1994 54466.85 (Estimated, based on the sales in August 1994 * 12)

ANNEX 14: CROSSCOUNTRY COMPARISON OF HOUSEHOLD ELECTRICITY END-USES

Belize Electricity Demand Study, BEL/IER, October 1994

Crosscountry Comparison of Household Electricity End-Uses

Country / Use	Belize 1994 (%)	Central America 1992 (%)	United States 1989 (%)	Germany 1989 (%)
Lighting	17.72	15.6	11.7	7
Cooking	3.44	19.69	6.3	8.8
Refrigeration	35.97	31.2	20.7	18.8
Water Heating	7.3	5.63	15	19.2
Air conditioning	3.33	3.84	11.8	0
Other electric appliances	32.24	24.04	34.5	46.2
Total	100	100	100	100

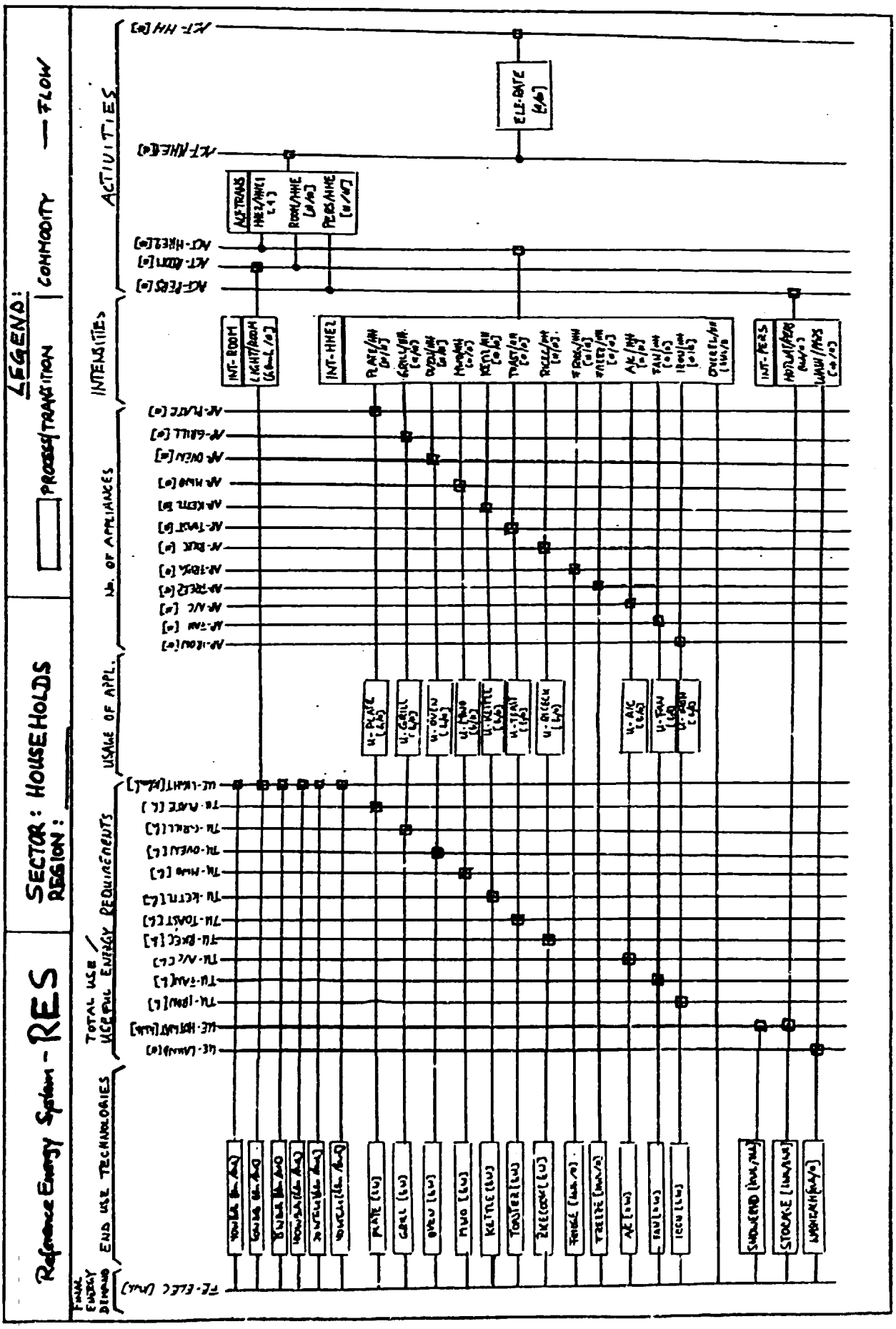
Sources:

Belize:
Belize National Energy Survey - Household Sector, BEL/IER/CSO, October 1994

Central America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama):
Aguinaga-Diaz J., Vieira de Carvalho A., Poveda M.: "OLADE's Central American DSM Project: A Model for International Cooperation", Proceedings of the Second International Energy Efficiency & DSM Conference, September 1993, Stockholm, Sweden

United States, Germany:
OECD/IEA: "Electricity End-Use Efficiency", Paris, 1989

ANNEX 15: REFERENCE ENERGY SYSTEM (RES)



ANNEX 16: RES-STRUCTURE

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RES Structure of Casestudy BEL_HH

Process			Commodity	
ELE-RATE	Electrification Rate	*Output:*	ACT-HH	Activity, No. of households
		Input:	ACT-HHE1	Activity, 1. No. of electrified HH
ACT-TRAN	Activity Transformation	*Output:*	ACT-HHE1	Activity, 1. No. of electrified HH
		Input:	ACT-HHE2	Activity, 2. No. of electrified HH
			ACT-ROOM	Activity, rooms in electrified HH
			ACT-PERS	Activity, persons in electrified HH
INT-ROOM	Intensities rel. to rooms in el. HH	*Output:*	ACT-ROOM	Activity, rooms in electrified HH
		Input:	UE-LIGHT	Useful energy, lighting
INT-HHE2	Intensities rel. to elec. HH	*Output:*	ACT-HHE2	Activity, 2. No. of electrified HH
		Input:	AP-PLATE	No. of electric plates
			APP-GRIL	No. of electric grills
			AP-OVEN	No. of electric ovens
			AP-MWO	No. of microwave ovens
			AP-KETTL	No. of electric kettles
			AP-TOAST	No. of electric toasters
			AP-RICE	No. of electric rice cookers
			AP-FRIDG	No. of electric refrigerators
			AP-FREEZ	No. of electric freezers
			AP-A/C	No. of air conditioners
			AP-FAN	No. of electric fans
			AP-IRON	No. of electric irons
			FE-ELEC	Final Energy, Electricity
INT-PERS	Intensities rel. to persons in el. HH	*Input:*	TU-LAUNT	Total loads, washing machine
		Output:	ACT-PERS	Activity, persons in electrified HH
		Input:	UE-HOTWA	Useful energy, hot water
U-PLATE	Avg. use of plates	*Output:*	AP-PLATE	No. of electric plates
		Input:	TU-PLATE	Total use, plates
U-GRILL	Avg. use of grills	*Output:*	APP-GRIL	No. of electric grills
		Input:	TU-GRILL	Total use, grill
U-OVEN	Avg. use of ovens	*Output:*	AP-OVEN	No. of electric ovens
		Input:	TU-OVEN	Total use, oven
U-MWO	Avg. use of microwave ovens	*Output:*	AP-MWO	No. of microwave ovens
		Input:	TU-MWO	Total use, microwave oven
U-KETTLE	Avg. use of kettles	*Output:*	AP-KETTL	No. of electric kettles
		Input:	TU-KETTL	Total use, kettle
U-TOAST	Avg. use of toasters	*Output:*	AP-TOAST	No. of electric toasters
		Input:	TU-TOAST	Total use, toaster
U-RICEC	Avg. use of rice cookers	*Output:*	AP-RICE	No. of electric rice cookers
		Input:	TU-RICEC	Total use, rice cooker
U-A/C	Avg. use of air conditioners	*Output:*	AP-A/C	No. of air conditioners
		Input:	TU-A/C	Total use, air conditioner
U-FANS	Avg. use of fans	*Output:*	AP-FAN	No. of electric fans
		Input:	TU-FAN	Total use, fan
U-IRON	Avg. use of irons	*Output:*	AP-IRON	No. of electric irons
		Input:	TU-IRON	Total use, iron
BULB-40W	40W Incandescent bulb	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-LIGHT	Useful energy, lighting

Process			Commodity	
BULB-60W	60W Incandescent bulb	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-LIGHT	Useful energy, lighting
BULB-75W	75W Incandescent bulb	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-LIGHT	Useful energy, lighting
BULB-100	100W Incandescent bulb	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-LIGHT	Useful energy, lighting
FLOU-20W	20W flourescent lamp	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-LIGHT	Useful energy, lighting
FLOU-40W	40W Flourescent lamp	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-LIGHT	Useful energy, lighting
PLATE	Electric plate	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-PLATE	Total use, plates
GRILL	Electric grill	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-GRILL	Total use, grill
MWO	Microwave oven	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-MWO	Total use, microwave oven
OVEN	Electric oven	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU OVEN	Total use, oven
KETTLE	Electric kettle	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-KETTL	Total use, kettle
TOASTER	Electric toaster	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-TOAST	Total use, toaster
RICEC	Electric rice cooker	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-RICEC	Total use, rice cooker
FRIDGE	Electric refrigerator	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	AP-FRIDG	No. of electric refrigerators
FREEZE	Electric freezer	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	AP-FREEZ	No. of electric freezers
A/C	Air conditioner	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-A/C	Total use, air conditioner
FAN	Electric fan	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-FAN	Total use, fan
IRON	Electric iron	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-IRON	Total use, iron
SHOWERH	Electric showerhead	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-HOTWA	Useful energy, hot water
STORAGE	Electric storage water heater	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	UE-HOTWA	Useful energy, hot water
WASHM	Washing machine	*Input:*	FE-ELEC	Final Energy, Electricity
		Output:	TU-LAUND	Total loads, washing machine

ANNEX 17: LIST OF COMMODITIES

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Commodities of Casestudy BEL_HH

Sort	ID	Name	Unit-ID	Unit-Name
1	ACT-HH	Activity, No. of households	No	Number
2	ACT-HHE1	Activity, 1. No. of electrified HH	No	Number
3	ACT-HHE2	Activity, 2. No. of electrified HH	No	Number
4	ACT-ROO	Activity, rooms in electrified HH	No	Number
5	ACT-PERS	Activity, persons in electrified HH	No	Number
6	AP-PLATE	No. of electric plates	No	Number
7	APP-GRIL	No. of electric grills	No	Number
8	AP-OVEN	No. of electric ovens	No	Number
9	AP-MWO	No. of microwave ovens	No	Number
10	AP-KETTL	No. of electric kettles	No	Number
11	AP-TOAST	No. of electric toasters	No	Number
12	AP-RICE	No. of electric rice cookers	No	Number
13	AP-FRIDG	No. of electric refrigerators	No	Number
14	AP-FREEZ	No. of electric freezers	No	Number
15	AP-A/C	No. of air conditioners	No	Number
16	AP-FAN	No. of electric fans	No	Number
17	AP-IRON	No. of electric irons	No	Number
18	UE-LIGHT	Useful energy, lighting	klmh	Kilolumenhour
19	TU-PLATE	Total use, plates	h	Hours
20	TU-GRILL	Total use, grill	h	Hours
21	TU-OVEN	Total use, oven	h	Hours
22	TU-MWO	Total use, microwave oven	h	Hours
23	TU-KETTL	Total use, kettle	h	Hours
24	TU-TOAST	Total use, toaster	h	Hours
25	TU-RICEC	Total use, rice cooker	h	Hours
26	TU-A/C	Total use, air conditioner	h	Hours

Sort	ID	Name	Unit-ID	Unit-Name
27	TU-FAN	Total use, fan	h	Hours
28	TU-IRON	Total use, iron	h	Hours
29	UE-HOTW	Useful energy, hot water	kWh	Kilowatthour
30	TU-LAUND	Total loads, washing machine	No	Number
31	FE-ELEC	Final Energy, Electricity	kWh	Kilowatthour

ANNEX 18: LIST OF EQUATIONS

Equations of Casestudy BEL_HH

Seq-#	Eq-#	Type	Equation
3	(1)	TR	*I_ELE-RATE_ACT-HHE1 = Electrification rate * O_ELE-RATE_ACT-HH*
6	(2)	TR	*I_ACT-TRAN_ACT-ROOM = Rooms per HH * O_ACT-TRAN_ACT-HHE1*
7	(3)	TR	*I_ACT-TRAN_ACT-PERS = Persons per HH * O_ACT-TRAN_ACT-HHE1*
8	(4)	TR	*I_ACT-TRAN_ACT-HHE2 = Dummy (1) * O_ACT-TRAN_ACT-HHE1*
15	(5)	TR	*I_INT-HHE2_AP-PLATE = Intensity * O_INT-HHE2_ACT-HHE2*
16	(6)	TR	*I_INT-HHE2_APP-GRIL = Intensity * O_INT-HHE2_ACT-HHE2*
17	(7)	TR	*I_INT-HHE2_AP-OVEN = Intensity * O_INT-HHE2_ACT-HHE2*
18	(8)	TR	*I_INT-HHE2_AP-MWO = Intensity * O_INT-HHE2_ACT-HHE2*
19	(9)	TR	*I_INT-HHE2_AP-KETTL = Intensity * O_INT-HHE2_ACT-HHE2*
20	(10)	TR	*I_INT-HHE2_AP-TOAST = Intensity * O_INT-HHE2_ACT-HHE2*
21	(11)	TR	*I_INT-HHE2_AP-RICE = Intensity * O_INT-HHE2_ACT-HHE2*
22	(12)	TR	*I_INT-HHE2_AP-FRIDG = Intensity * O_INT-HHE2_ACT-HHE2*
23	(13)	TR	*I_INT-HHE2_AP-FREEZ = Intensity * O_INT-HHE2_ACT-HHE2*
24	(14)	TR	*I_INT-HHE2_AP-A/C = Intensity * O_INT-HHE2_ACT-HHE2*
25	(15)	TR	*I_INT-HHE2_AP-FAN = Intensity * O_INT-HHE2_ACT-HHE2*
26	(16)	TR	*I_INT-HHE2_AP-IRON = Intensity * O_INT-HHE2_ACT-HHE2*
27	(17)	TR	*I_INT-HHE2_FE-ELEC = Intensity * O_INT-HHE2_ACT-HHE2*
65	(18)	TR	*I_U-PLATE_TU-PLATE = Avg. Use * O_U-PLATE_AP-PLATE*
66	(19)	TR	*I_U-GRILL_TU-GRILL = Avg. Use * O_U-GRILL_APP-GRIL*
67	(20)	TR	*I_U-OVEN_TU-OVEN = Avg. Use * O_U-OVEN_AP-OVEN*
68	(21)	TR	*I_U-MWO_TU-MWO = Avg. Use * O_U-MWO_AP-MWO*
69	(22)	TR	*I_U-KETTLE_TU-KETTL = Avg. Use * O_U-KETTLE_AP-KETTL*
70	(23)	TR	*I_U-TOAST_TU-TOAST = Avg. Use * O_U-TOAST_AP-TOAST*
71	(24)	TR	*I_U-RICEC_TU-RICEC = Avg. Use * O_U-RICEC_AP-RICE*
72	(25)	TR	*I_U-A/C_TU-A/C = Avg. Use * O_U-A/C_AP-A/C*
73	(26)	TR	*I_U-FANS_TU-FAN = Avg. Use * O_U-FANS_AP-FAN*
74	(27)	TR	*I_U-IRON_TU-IRON = Avg. Use * O_U-IRON_AP-IRON*
28	(28)	TR	*I_INT-ROOM_UE-LIGHT = Intensity * O_INT-ROOM_ACT-ROOM*
75	(29)	TR	*O_BULB-40W_UE-LIGHT = Luminous efficacy * I_BULB-40W_FE-ELEC*
76	(30)	TR	*O_BULB-60W_UE-LIGHT = Luminous efficacy * I_BULB-60W_FE-ELEC*
77	(31)	TR	*O_BULB-75W_UE-LIGHT = Luminous efficacy * I_BULB-75W_FE-ELEC*
78	(32)	TR	*O_BULB-100_UE-LIGHT = Luminous efficacy * I_BULB-100_FE-ELEC*
79	(33)	TR	*O_FLOU-20W_UE-LIGHT = Luminous efficacy * I_FLOU-20W_FE-ELEC*
106	(34)	TR	*O_FLOU-40W_UE-LIGHT = Luminous efficacy * I_FLOU-40W_FE-ELEC*
107	(35)	TR	*I_PLATE_FE-ELEC = Power rating * O_PLATE_TU-PLATE*
108	(36)	TR	*I_GRILL_FE-ELEC = Power rating * O_GRILL_TU-GRILL*
109	(37)	TR	*I_OVEN_FE-ELEC = Power rating * O_OVEN_TU-OVEN*
110	(38)	TR	*I_MWO_FE-ELEC = Power rating * O_MWO_TU-MWO*
111	(39)	TR	*I_KETTLE_FE-ELEC = Power rating * O_KETTLE_TU-KETTL*
112	(40)	TR	*I_TOASTER_FE-ELEC = Power rating * O_TOASTER_TU-TOAST*
113	(41)	TR	*I_RICEC_FE-ELEC = Power rating * O_RICEC_TU-RICEC*
80	(42)	TR	*I_FRIDGE_FE-ELEC = Consumption * O_FRIDGE_AP-FRIDG*
81	(43)	TR	*I_FREEZE_FE-ELEC = Consumption * O_FREEZE_AP-FREEZ*

Seq-#	Eq-#	Type	Equation	
114	(44)	TR	I_A/C_FE-ELEC	= Power rating * O_A/C_TU-A/C
115	(45)	TR	I_FAN_FE-ELEC	= Power rating * O_FAN_TU-FAN
116	(46)	TR	I_IRON_FE-ELEC	= Power rating * O_IRON_TU-IRON
82	(47)	TR	I_WASHM_FE-ELEC	= Consumption * O_WASHM_TU-LAUND
29	(48)	TR	I_INT-PERS_TU-LAUND	= Intensity * O_INT-PERS_ACT-PERS
30	(49)	TR	I_INT-PERS_UE-HOTWA	= Intensity * O_INT-PERS_ACT-PERS
83	(50)	TR	O_SHOWERH_UE-HOTWA	= Efficiency * I_SHOWERH_FE-ELEC
117	(51)	TR	O_STORAGE_UE-HOTWA	= Efficiency * I_STORAGE_FE-ELEC
1	(52)	EX	Q_ACT-HH	= quantity * 1
4	(53)	CC	Q_ACT-HHE1	= I_ELE-RATE_ACT-HHE1
9	(54)	CC	Q_ACT-ROOM	= I_ACT-TRAN_ACT-ROOM
10	(55)	CC	Q_ACT-PERS	= I_ACT-TRAN_ACT-PERS
11	(56)	CC	Q_ACT-HHE2	= I_ACT-TRAN_ACT-HHE2
31	(57)	CC	Q_AP-PLATE	= I_INT-HHE2_AP-PLATE
32	(58)	CC	Q_APP-GRIL	= I_INT-HHE2_APP-GRIL
33	(59)	CC	Q_AP-OVEN	= I_INT-HHE2_AP-OVEN
34	(60)	CC	Q_AP-MWO	= I_INT-HHE2_AP-MWO
35	(61)	CC	Q_AP-KETTL	= I_INT-HHE2_AP-KETTL
36	(62)	CC	Q_AP-TOAST	= I_INT-HHE2_AP-TOAST
37	(63)	CC	Q_AP-RICE	= I_INT-HHE2_AP-RICE
38	(64)	CC	Q_AP-FRIDG	= I_INT-HHE2_AP-FRIDG
39	(65)	CC	Q_AP-FREEZ	= I_INT-HHE2_AP-FREEZ
40	(66)	CC	Q_AP-A/C	= I_INT-HHE2_AP-A/C
41	(67)	CC	Q_AP-FAN	= I_INT-HHE2_AP-FAN
42	(68)	CC	Q_AP-IRON	= I_INT-HHE2_AP-IRON
43	(69)	CC	Q_UE-LIGHT	= I_INT-ROOM_UE-LIGHT
84	(70)	CC	Q_TU-PLATE	= I_U-PLATE_TU-PLATE
85	(71)	CC	Q_TU-GRILL	= I_U-GRILL_TU-GRILL
86	(72)	CC	Q_TU-OVEN	= I_U-OVEN_TU-OVEN
87	(73)	CC	Q_TU-MWO	= I_U-MWO_TU-MWO
88	(74)	CC	Q_TU-KETTL	= I_U-KETTLE_TU-KETTL
89	(75)	CC	Q_TU-TOAST	= I_U-TOAST_TU-TOAST
90	(76)	CC	Q_TU-RICEC	= I_U-RICEC_TU-RICEC
91	(77)	CC	Q_TU-A/C	= I_U-A/C_TU-A/C
92	(78)	CC	Q_TU-FAN	= I_U-FANS_TU-FAN
93	(79)	CC	Q_TU-IRON	= I_U-IRON_TU-IRON
118	(80)	CC	Q_FE-ELEC	= I_INT-HHE2_FE-ELEC + I_BULB-40W_FE-ELEC + I_BULB-60W_FE-ELEC + I_BULB-75W_FE-ELEC + I_BULB-100_FE-ELEC + I_FLOU-20W_FE-ELEC + I_FLOU-40W_FE-ELEC + I_PLATE_FE-ELEC + I_GRILL_FE-ELEC + I_OVEN_FE-ELEC + I_MWO_FE-ELEC + I_KETTLE_FE-ELEC + I_TOASTER_FE-ELEC + I_RICEC_FE-ELEC + I_FRIDGE_FE-ELEC + I_FREEZE_FE-ELEC + I_A/C_FE-ELEC + I_FAN_FE-ELEC + I_IRON_FE-ELEC + I_WASHM_FE-ELEC + I_SHOWERH_FE-ELEC + I_STORAGE_FE-ELEC

Seq-#	Eq-#	Type	Equation	
44	(81)	CC	Q_TU-LAUND	= I_INT-PERS_TU-LAUND
45	(82)	CC	Q_UE-HOTWA	= I_INT-PERS_UE-HOTWA
2	(83)	CP	Q_ACT-HH	= O_ELE-RATE_ACT-HH
5	(84)	CP	Q_ACT-HHE1	= O_ACT-TRAN_ACT-HHE1
12	(85)	CP	Q_ACT-ROOM	= O_INT-ROOM_ACT-ROOM
13	(86)	CP	Q_ACT-PERS	= O_INT-PERS_ACT-PERS
14	(87)	CP	Q_ACT-HHE2	= O_INT-HHE2_ACT-HHE2
46	(88)	CP	Q_AP-PLATE	= O_U-PLATE_AP-PLATE
47	(89)	CP	Q_APP-GRIL	= O_U-GRILL_APP-GRIL
48	(90)	CP	Q_AP-OVEN	= O_U-OVEN_AP-OVEN
49	(91)	CP	Q_AP-MWO	= O_U-MWO_AP-MWO
50	(92)	CP	Q_AP-KETTL	= O_U-KETTLE_AP-KETTL
51	(93)	CP	Q_AP-TOAST	= O_U-TOAST_AP-TOAST
52	(94)	CP	Q_AP-RICE	= O_U-RICEC_AP-RICE
53	(95)	CP	Q_AP-FRIDG	= O_FRIDGE_AP-FRIDG
54	(96)	CP	Q_AP-FREEZ	= O_FREEZE_AP-FREEZ
55	(97)	CP	Q_AP-A/C	= O_U-A/C_AP-A/C
56	(98)	CP	Q_AP-FAN	= O_U-FANS_AP-FAN
57	(99)	CP	Q_AP-IRON	= O_U-IRON_AP-IRON
94	(100)	CP	Q_UE-LIGHT	= O_BULB-40W_UE-LIGHT + O_BULB-60W_UE-LIGHT + O_BULB-75W_UE-LIGHT + O_BULB-100_UE-LIGHT + O_FLOU-20W_UE-LIGHT + O_FLOU-40W_UE-LIGHT
95	(101)	CP	Q_TU-PLATE	= O_PLATE_TU-PLATE
96	(102)	CP	Q_TU-GRILL	= O_GRILL_TU-GRILL
97	(103)	CP	Q_TU-OVEN	= O_OVEN_TU-OVEN
98	(104)	CP	Q_TU-MWO	= O_MWO_TU-MWO
99	(105)	CP	Q_TU-KETTL	= O_KETTLE_TU-KETTL
100	(106)	CP	Q_TU-TOAST	= O_TOASTER_TU-TOAST
101	(107)	CP	Q_TU-RICEC	= O_RICEC_TU-RICEC
102	(108)	CP	Q_TU-A/C	= O_A/C_TU-A/C
103	(109)	CP	Q_TU-FAN	= O_FAN_TU-FAN
104	(110)	CP	Q_TU-IRON	= O_IRON_TU-IRON
58	(111)	CP	Q_TU-LAUND	= O_WASHM_TU-LAUND
105	(112)	CP	Q_UE-HOTWA	= O_SHOWERH_UE-HOTWA + O_STORAGE_UE-HOTWA
59	(113)	AL	O_BULB-40W_UE-LIGHT	= mkta * Q_UE-LIGHT
60	(114)	AL	O_BULB-60W_UE-LIGHT	= mkta * Q_UE-LIGHT
61	(115)	AL	O_BULB-75W_UE-LIGHT	= mkta * Q_UE-LIGHT
62	(116)	AL	O_BULB-100_UE-LIGHT	= mkta * Q_UE-LIGHT
63	(117)	AL	O_FLOU-20W_UE-LIGHT	= mkta * Q_UE-LIGHT
64	(118)	AL	O_SHOWERH_UE-HOTWA	= mkta * Q_UE-HOTWA

ANNEX 19: RESULT TABLES

Belize Electricity Demand Study, BELMER, October 1994

Household Electricity Demand Forecast 1994-2014

Scenario: Stagnation - Business as Usual

Region	End Uses	1994 (MWh/y)	1999 (MWh/y)	2004 (MWh/y)	2014 (MWh/y)	growth rate (% per year)
Total Belize	Lighting	10134.60	10857.41	11638.51	13396.92	1.41%
	Cooking	1968.11	2095.63	2232.48	2537.31	1.28%
	Refrigeration	20577.14	22008.58	23552.79	27019.95	1.37%
	Water Heating	4177.70	4470.52	4786.58	5496.77	1.38%
	Laundry	1727.40	1863.59	2011.73	2348.50	1.55%
	Other	18620.32	19856.69	21185.95	24155.24	1.31%
	Total	**57205.27**	**61152.43**	**65408.04**	**74954.69**	**1.36%**
Grid Urban	Lighting	6255.93	6575.04	6910.44	7633.42	1.00%
	Cooking	1456.94	1531.26	1609.37	1777.75	1.00%
	Refrigeration	13382.89	14065.55	14783.03	16329.66	1.00%
	Water Heating	2675.66	2812.15	2955.60	3264.82	1.00%
	Laundry	821.54	863.45	907.49	1002.44	1.00%
	Other	13221.00	13895.41	14604.21	16132.14	1.00%
	Total	**37813.97**	**39742.86**	**41770.15**	**46148.23**	**1.00%**
Grid Rural	Lighting	2864.45	3162.58	3491.75	4256.42	2.00%
	Cooking	418.67	462.25	510.36	622.12	2.00%
	Refrigeration	5160.50	5697.61	6290.62	7668.23	2.00%
	Water Heating	1126.41	1243.65	1373.09	1673.79	2.00%
	Laundry	858.85	948.24	1046.94	1276.21	2.00%
	Other	4084.36	4509.46	4978.81	6069.14	2.00%
	Total	**14513.25**	**16023.80**	**17691.57**	**21565.92**	**2.00%**
Non Grid	Lighting	1014.22	1119.78	1236.33	1507.08	2.00%
	Cooking	92.49	102.12	112.75	137.44	2.00%
	Refrigeration	2033.75	2245.43	2479.13	3022.05	2.00%
	Water Heating	375.63	414.72	457.89	558.16	2.00%
	Laundry	47.01	51.90	57.30	69.85	2.00%
	Other	1314.96	1451.82	1602.93	1953.96	2.00%
	Total	**4878.06**	**5385.77**	**5946.33**	**7248.54**	**2.00%**

Belize Electricity Demand Study, BELMER, October 1994

Household Electricity Demand Forecast 1994-2014

Scenario: Reference - Business as Usual

Region	End Uses	1994 (MWh/y)	1999 (MWh/y)	2004 (MWh/y)	2014 (MWh/y)	growth rate (% per year)
Total Belize	Lighting	10134.60	11826.54	13807.48	18847.44	3.15%
	Cooking	1968.11	2400.53	2929.12	4366.32	4.06%
	Refrigeration	20577.14	25199.90	30875.31	46413.20	4.15%
	Water Heating	4177.70	5118.52	6274.11	9440.17	4.16%
	Laundry	1727.40	2132.06	2632.80	4020.66	4.31%
	Other	18620.32	22742.47	27788.73	41541.87	4.09%
	Total	**57205.27**	**69420.02**	**84307.55**	**124629.64**	**3.97%**
Grid Urban	Lighting	6255.93	7175.21	8229.58	10825.90	2.78%
	Cooking	1456.94	1756.28	2117.11	3076.40	3.81%
	Refrigeration	13382.89	16132.43	19446.87	28258.53	3.81%
	Water Heating	2675.66	3225.39	3888.05	5649.78	3.81%
	Laundry	821.54	990.33	1193.79	1734.72	3.81%
	Other	13221.00	15937.29	19211.64	27916.71	3.81%
	Total	**37813.97**	**45216.92**	**54087.03**	**77462.03**	**3.65%**
Grid Rural	Lighting	2864.45	3435.06	4119.35	5924.02	3.70%
	Cooking	418.67	527.68	665.08	1056.52	4.74%
	Refrigeration	5160.50	6504.18	8197.72	13022.50	4.74%
	Water Heating	1126.41	1419.70	1789.36	2842.49	4.74%
	Laundry	858.85	1082.48	1364.33	2167.31	4.74%
	Other	4084.36	5147.83	6488.21	10306.86	4.74%
	Total	**14513.25**	**18116.95**	**22624.06**	**35319.71**	**4.55%**
Non Grid	Lighting	1014.22	1216.26	1458.55	2097.53	3.70%
	Cooking	92.49	116.58	146.93	233.40	4.74%
	Refrigeration	2033.75	2563.30	3230.72	5132.16	4.74%
	Water Heating	375.63	473.43	596.70	947.89	4.74%
	Laundry	47.01	59.25	74.67	118.62	4.74%
	Other	1314.96	1657.35	2088.88	3318.30	4.74%
	Total	**4878.06**	**6086.16**	**7596.45**	**11847.91**	**4.54%**

Belize Electricity Demand Study, BELMER, October 1994

Household Electricity Demand Forecast 1994-2014

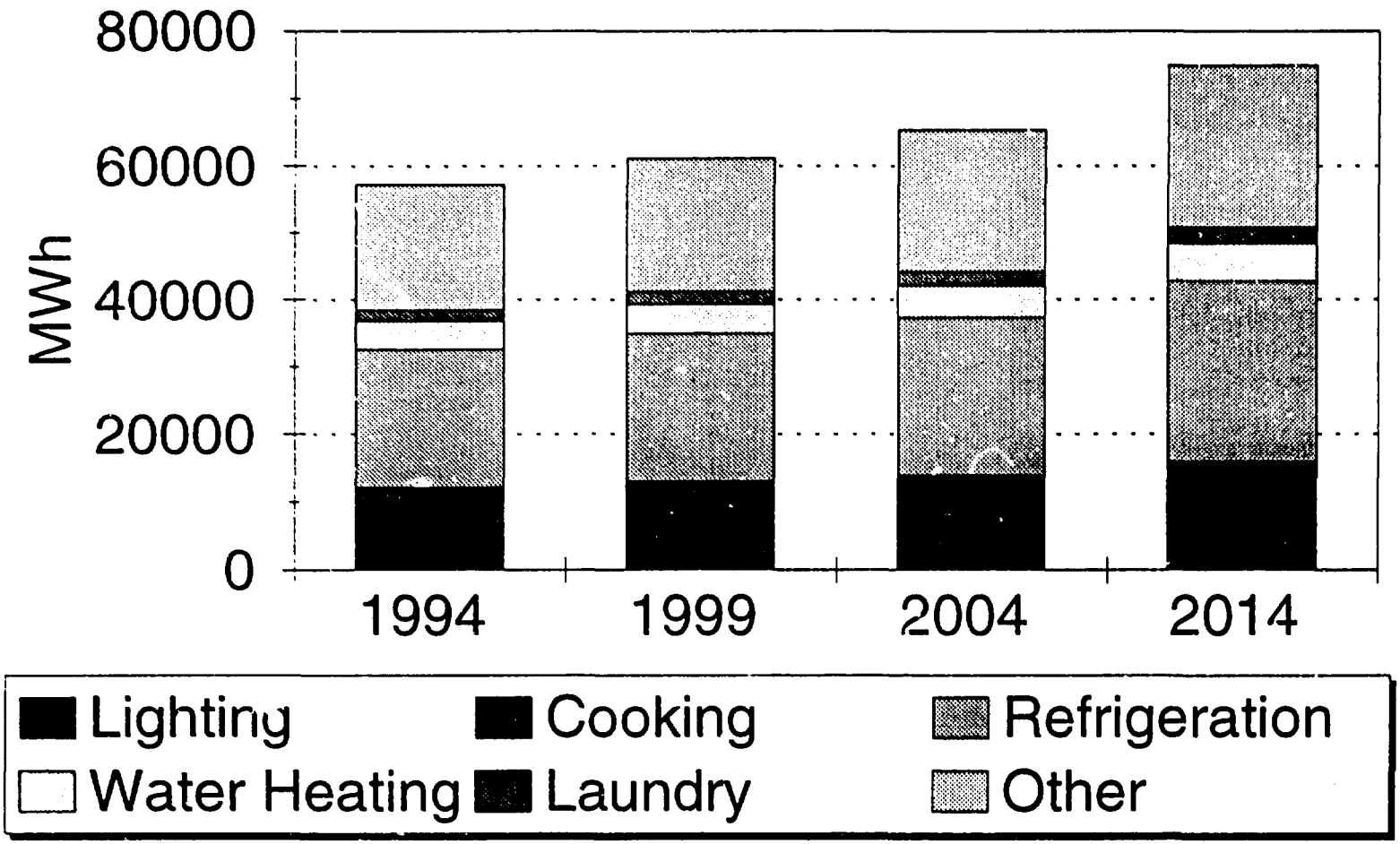
Scenario: Prosperity - Business as Usual

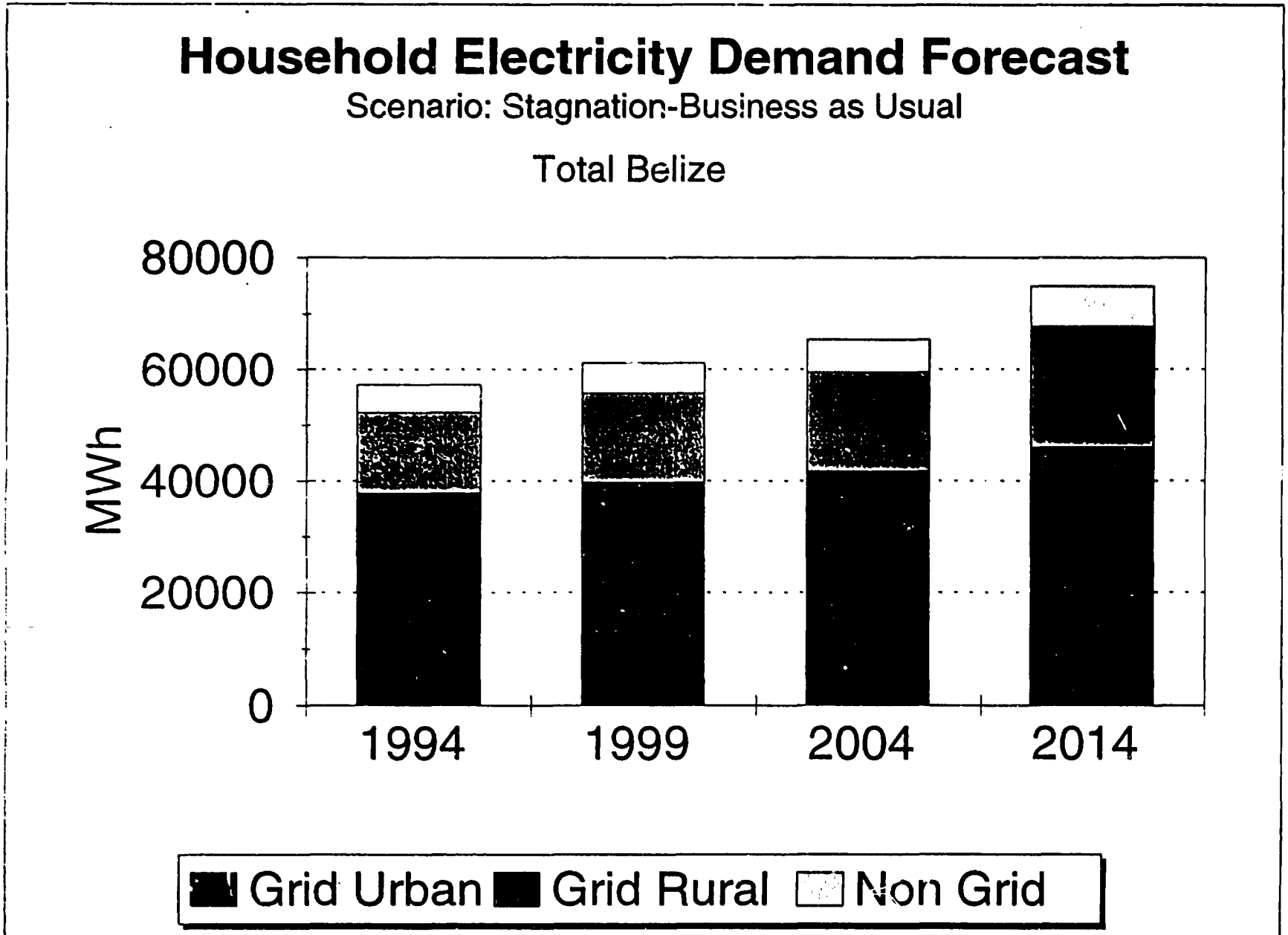
Region	End Uses	1994 (MWh/y)	1999 (MWh/y)	2004 (MWh/y)	2014 (MWh/y)	growth rate (% per year)
Total Belize	Lighting	10134.60	11971.33	14148.82	19797.54	3.40%
	Cooking	1968.11	2551.43	3309.15	5574.42	5.34%
	Refrigeration	20577.14	26793.11	34905.58	59340.53	5.44%
	Water Heating	4177.70	5442.33	7093.64	12071.39	5.45%
	Laundry	1727.40	2268.35	2980.42	5154.23	5.62%
	Other	18620.32	24174.80	31401.58	53061.96	5.38%
	Total	**57205.27**	**73201.34**	**93839.19**	**155000.07**	**5.11%**
Grid Urban	Lighting	6255.93	7252.34	8407.44	11298.90	3.00%
	Cooking	1456.94	1864.79	2386.80	3910.12	5.06%
	Refrigeration	13382.89	17129.19	21924.20	35916.80	5.06%
	Water Heating	2675.66	3424.67	4383.35	7180.91	5.06%
	Laundry	821.54	1051.52	1345.87	2204.84	5.06%
	Other	13221.00	16921.99	21659.00	35482.35	5.06%
	Total	**37813.97**	**47644.49**	**60106.66**	**95993.94**	**4.77%**
Grid Rural	Lighting	2864.45	3485.04	4240.08	6276.36	4.00%
	Cooking	418.67	562.39	755.45	1363.15	6.08%
	Refrigeration	5160.50	6932.01	9311.56	16802.04	6.08%
	Water Heating	1126.41	1513.09	2032.51	3667.47	6.08%
	Laundry	858.85	1153.68	1549.72	2796.34	6.08%
	Other	4034.36	5486.45	7369.85	13298.24	6.08%
	Total	**14513.25**	**19132.57**	**25259.28**	**44203.60**	**5.73%**
Non Grid	Lighting	1014.22	1233.95	1501.29	2222.28	4.00%
	Cooking	92.49	124.24	166.89	301.15	6.08%
	Refrigeration	2033.75	2731.90	3669.72	6621.68	6.08%
	Water Heating	375.63	504.57	677.79	1223.00	6.08%
	Laundry	47.01	63.14	84.82	153.05	6.08%
	Other	1314.96	1766.36	2372.73	4281.37	6.08%
	Total	**4878.06**	**6424.18**	**8473.24**	**14802.53**	**5.71%**

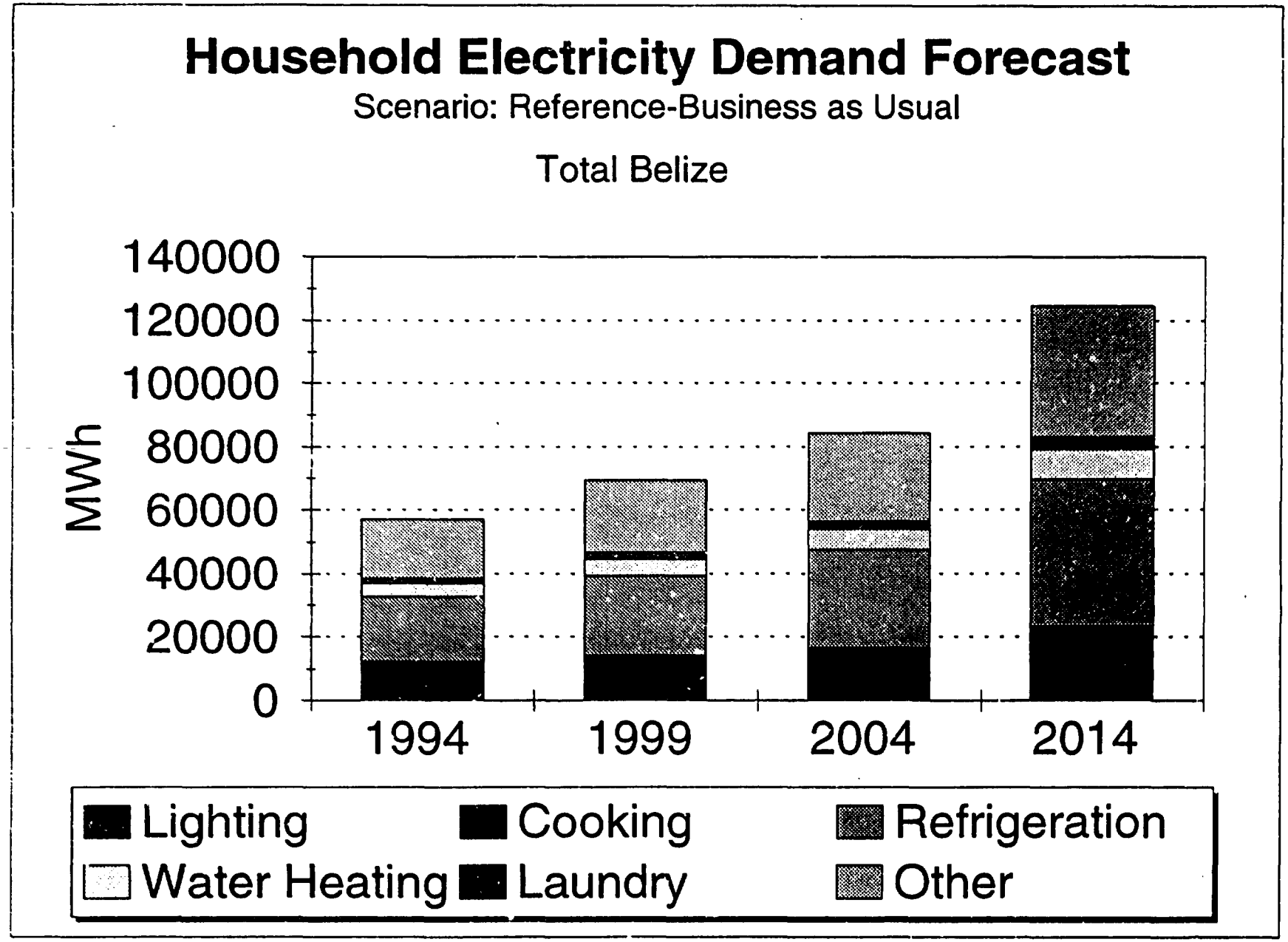
Household Electricity Demand Forecast

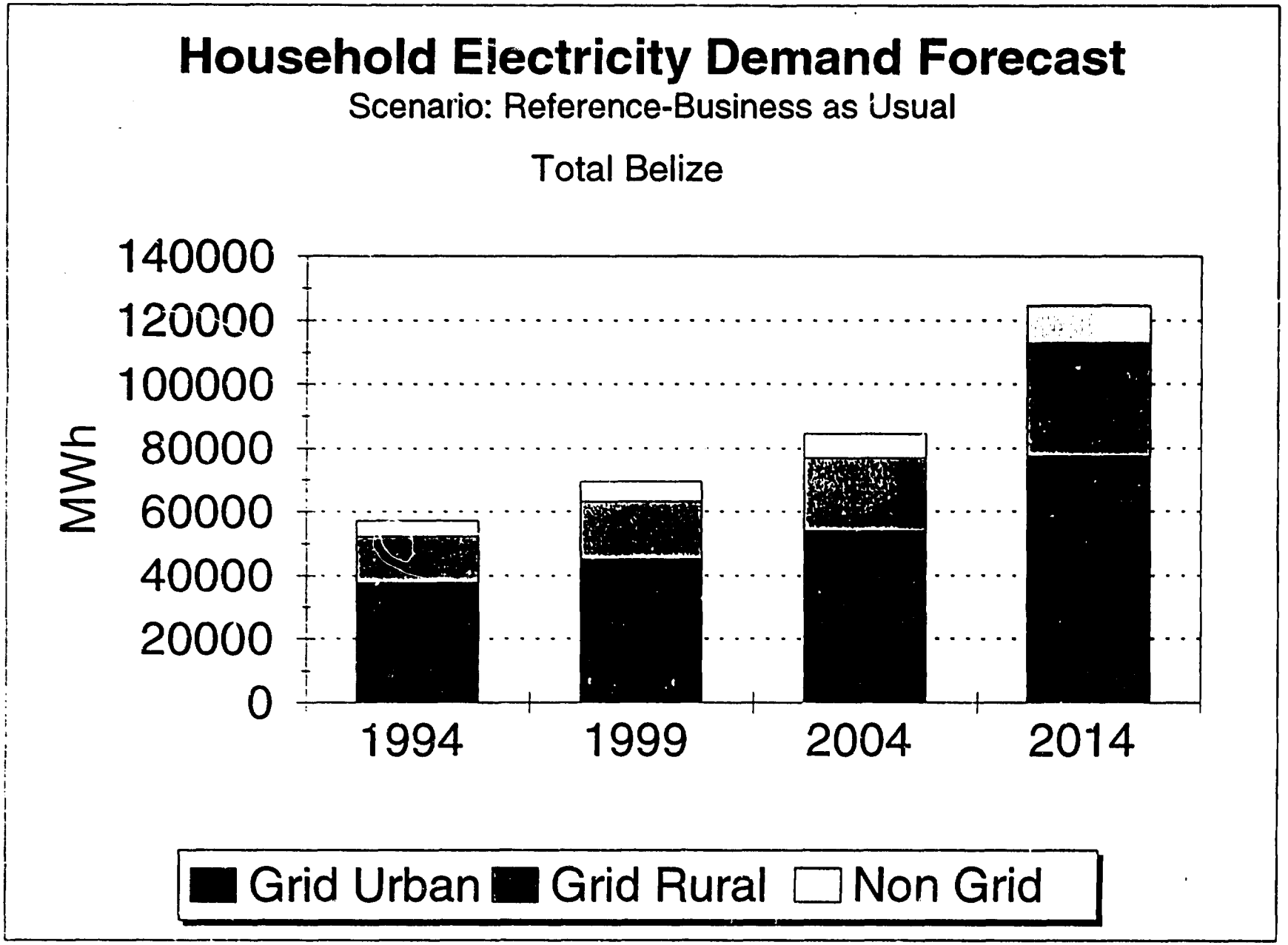
Scenario: Stagnation-Business as Usual

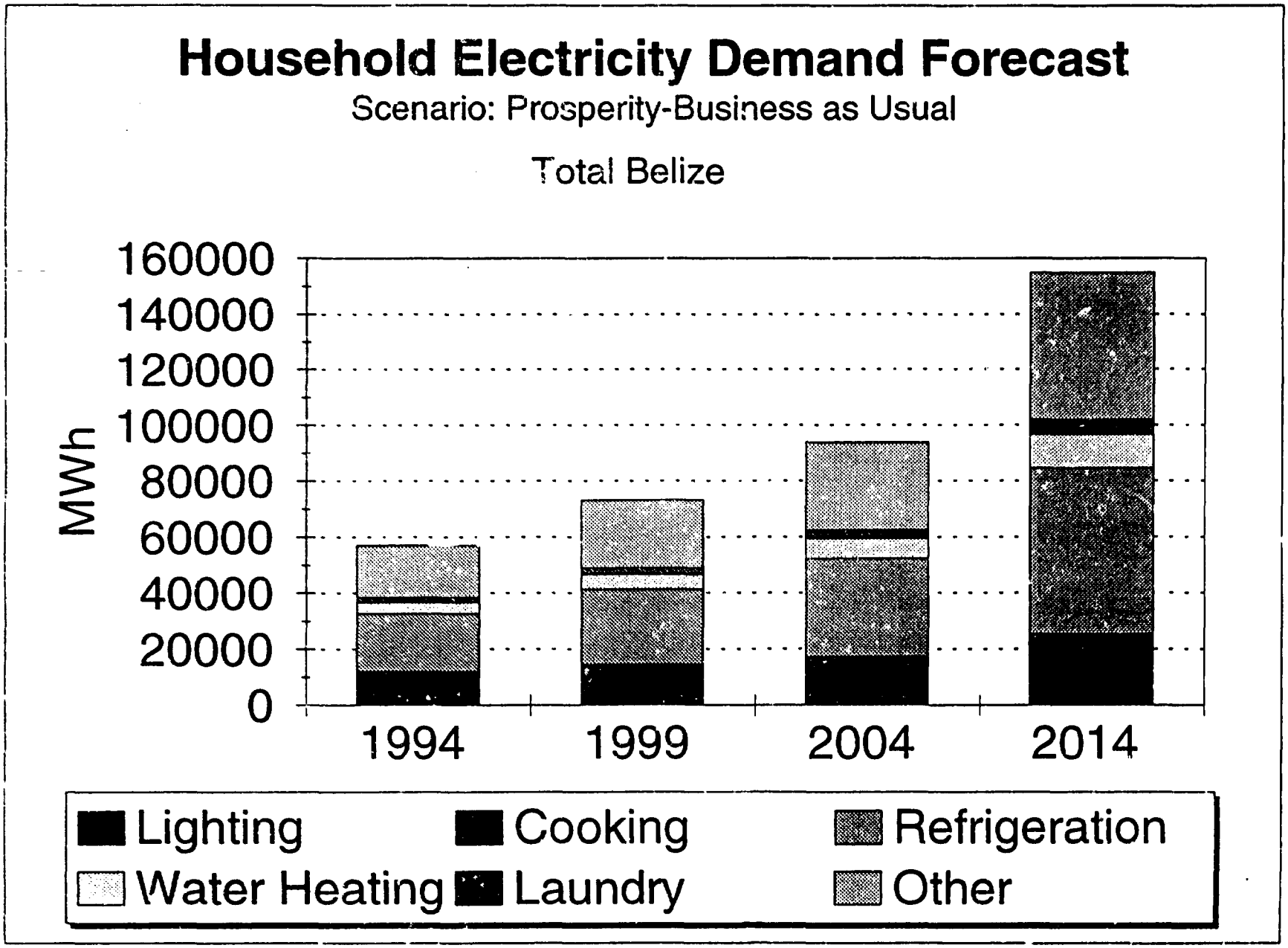
Total Belize

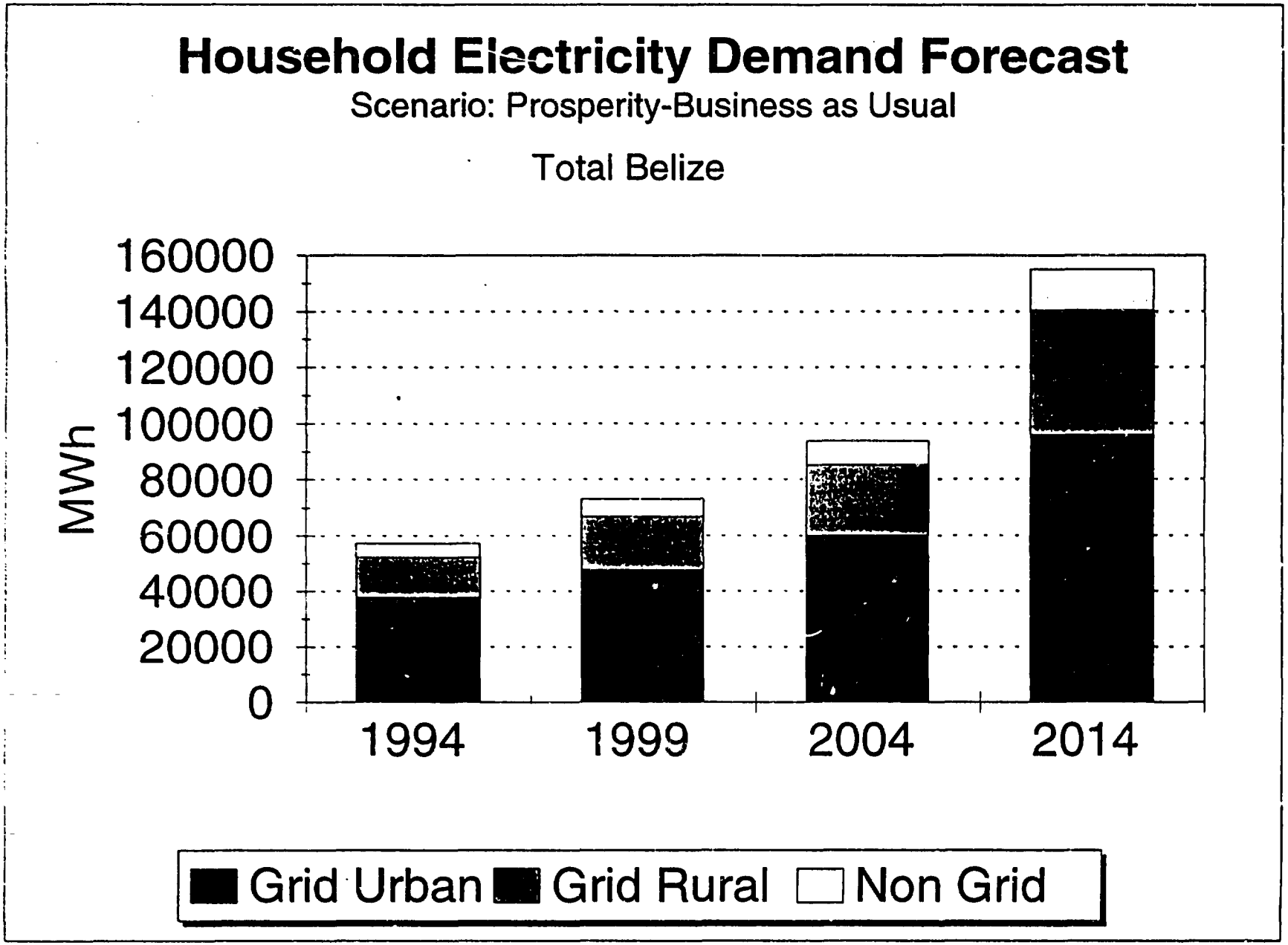


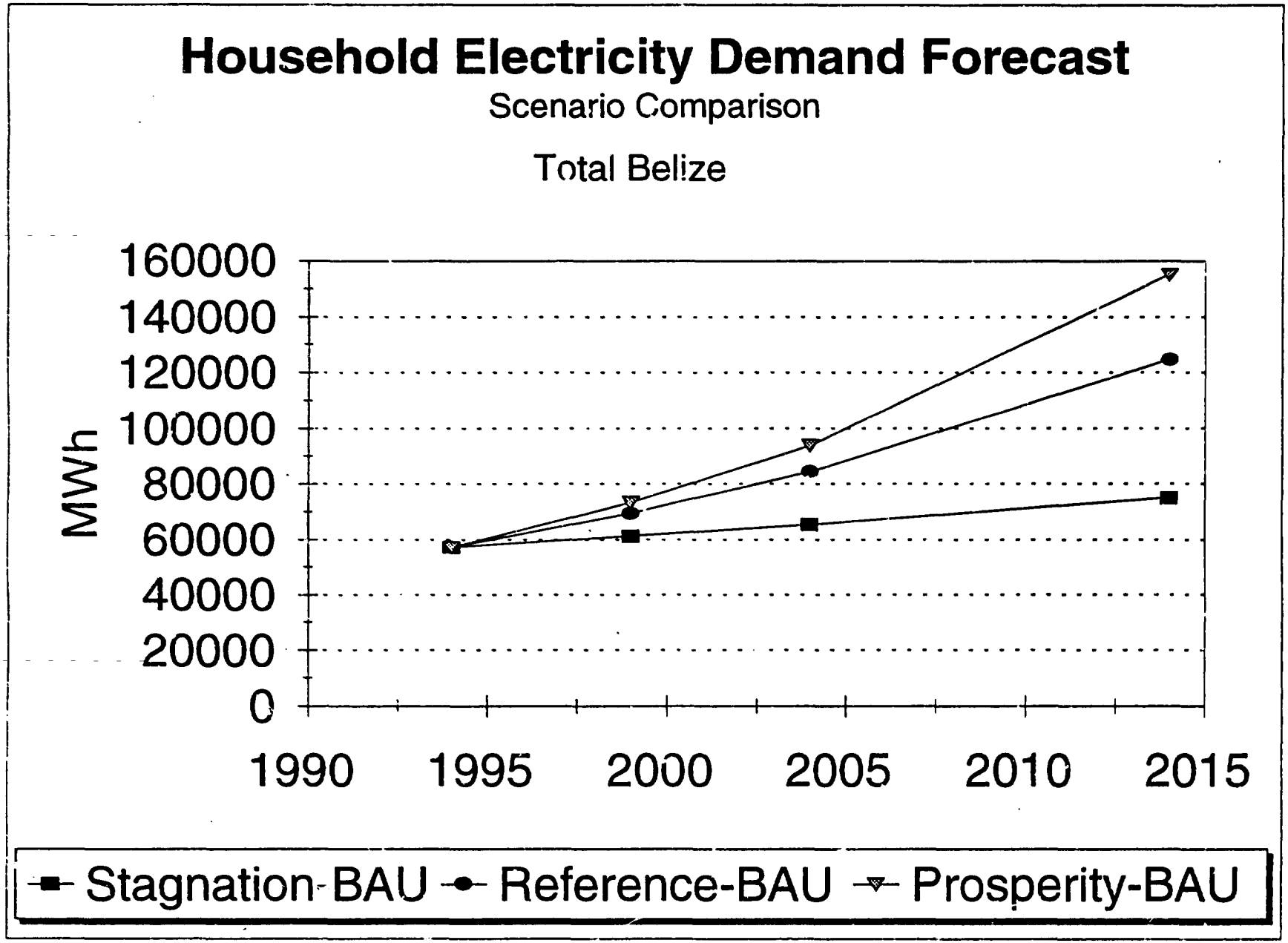

Household Electricity Demand Forecast
Scenario: Stagnation-Business as Usual
Total Belize
80000
60000
40000
20000
0
MWh
1994
1999
2004
2014
Grid Urban
Grid Rural
Non Grid


Household Electricity Demand Forecast
Scenario: Reference-Business as Usual
Total Belize
MWh
140000
120000
100000
80000
60000
40000
20000
0
1994
1999
2004
2014
Lighting
Cooking
Refrigeration
Water Heating
Laundry
Other


Household Electricity Demand Forecast
Scenario: Reference-Business as Usual
Total Belize
MWh
140000
120000
100000
80000
60000
40000
20000
0
1994
1999
2004
2014
Grid Urban
Grid Rural
Non Grid


Household Electricity Demand Forecast
Scenario: Prosperity-Business as Usual
Total Belize
MWh
160000
140000
120000
100000
80000
60000
40000
20000
0
1994
1999
2004
2014
Lighting
Cooking
Refrigeration
Water Heating
Laundry
Other


Household Electricity Demand Forecast
Scenario: Prosperity-Business as Usual
Total Belize
MWh
160000
140000
120000
100000
80000
60000
40000
20000
0
1994
1999
2004
2014
Grid Urban
Grid Rural
Non Grid


Household Electricity Demand Forecast
Scenario Comparison
Total Belize
MWh
160000
140000
120000
100000
80000
60000
40000
20000
0
1990
1995
2000
2005
2010
2015
Stagnation-BAU
Reference-BAU
Prosperity-BAU

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