Title
Electricity End Use Demand Study for Egypt

Authors
Turiel, I.
Lebot, B.
Nadel, S.
et al.

Publication Date
1990-12-01

LBL-29595
UC-350

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

APPLIED SCIENCE DIVISION

Electricity End Use Demand Study for Egypt

I. Turiel, B. Lebot, S. Nadel, J. Pietsch,
and L. Wethje

December 1990

APPLIED SCIENCE DIVISION

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.

LBL-29595

ELECTRICITY END USE DEMAND STUDY FOR EGYPT

Isaac Turiel, Benoit Lebot, Steven Nadel, Joseph Pietsch, and Larry Wethje

Lawrence Berkeley Laboratory

University of California

Berkeley California 94720

For Meta Systems, Inc., Cambridge, Massachusetts and
Organization for Energy Planning, Cairo, Egypt

December 1990

Isaac Turiel is Staff Scientist and Benoit Lebot is Senior Research Associate at Lawrence Berkeley Laboratory, University of California, Berkeley, California. Steve Nadel is a Senior Associate at the American Council for an Energy-Efficient Economy, Washington D.C., Joseph Pietsch is an engineering consultant, Dallas, Texas, and Larry Wethje is Manager of the Heating/Mechanical Division of ETL Testing Laboratories, Cortland New York.
This work was supported by the U.S. Agency for International Development under Subcontract No. 10-242-03 for Meta Systems, Inc., through the U.S. Department of Energy under Contract No. DE-AC03-7600098.

TABLE OF CONTENTS

Chapter	Page
Executive Summary	3
1: Introduction	5
2: Data Gathering and Analysis	6
3: Assessment of Appliance Manufacturing Plants	17
4: Demonstration of Computer Programs	18
5: Gathering of Data on Appliance Standards and Test Procedures	19
6: Energy Impact of Programs to Foster Energy Efficiency	25
References	39
List of Appendices	40
A: Efficiency and Price Data for Refrigerators and Air Conditioners	41
B: Appliance Ownership and Usage Survey	43
C: Residential Appliance Manufacturing Industry Evaluation	61
D: ETL Testing Laboratories Inc. Report	90
E: Lighting Energy Use and Conservation Opportunities in Egypt	117

EXECUTIVE SUMMARY

This report describes the results of a study undertaken by Lawrence Berkeley Laboratory (LBL) to develop an approach for reducing electricity demand in the residential sector in Egypt. A team with expertise in appliance energy usage, appliance manufacturing, appliance testing, and energy analysis was assembled to work on this project. The team visited Egypt during the month of March, 1990. They met with the Egyptian Organization for Energy Planning (OEP) and with many other parties. They also visited eleven appliance manufacturing facilities.

The project tasks are listed below:

- Data Gathering and Analysis
- Assessment of Appliance Manufacturing Plants
- Demonstration of Microcomputer Programs
- Gathering of Data on Appliance Standards and Test Procedures
- Impact of Programs to Foster Energy Efficiency of Electricity Use

Based upon data gathered and analyzed, visits to appliance manufacturing facilities and government facilities, and discussions with OEP staff and others, the project team made the following recommendations for government action.

- A consumer appliance testing center should be established at the Bureau of Egyptian Standards to carry out energy use and performance testing of products such as refrigerators, freezers, room air conditioners, lamps and ballasts (see Appendix D for details)
- Common appliance testing procedures should be established for each major appliance; in most cases an existing ISO or IEC test procedure can be used
- An energy use labeling program for major consumer appliances should be designed
- Energy efficiency standards for refrigerators, freezers, room air conditioners and lighting products (including ballasts) should be established as soon as the testing laboratory and labeling program are satisfactorily operating

- Government owned appliance manufacturing facilities should improve their production efficiency, enhance quality control, and improve safety practices; the private sector plants, which bring a strong infusion of manufacturing and product technology from the U.S., Europe, and Japan, should be emulated by the public sector plants (see Appendix C, pp. 86-89)
- An extensive household survey should be carried out to better understand end use energy consumption in Egyptian households. A careful survey design, to assure that the sample is representative of the whole population, should be performed before the survey is initiated.

The first three items can be accomplished in parallel as soon as funding is available. To administrate a certification program for refrigerators and room air conditioners in Egypt, one full time engineer and two technicians would be required. Additional products would require more personnel. The estimated cost of the appliance testing facilities is given for several options on pages 22 and 23. Efficiency standards can also be developed while experience is gained with testing and labeling of appliances. The standards could be promulgated after one or two years experience with testing and labeling of appliances. Consultants with manufacturing experience could assist Egyptian public sector appliance manufacturers in improving their production methods and facilities. The household survey would be used to refine the estimates of end-use energy consumption and also the potential energy savings from standards. This could lead to additional testing, labeling and standards programs for other products.

1. INTRODUCTION

This report describes the results of a study undertaken by Lawrence Berkeley Laboratory (LBL) to develop an approach for reducing electricity demand in the residential sector in Egypt. A team with expertise in appliance energy usage, appliance manufacturing, appliance testing, and energy analysis was assembled to work on this project. The team visited Egypt during the month of March, 1990. They met with the Egyptian Organization for Energy Planning (OEP) and with many other parties. They also visited eleven appliance manufacturing facilities.

The project tasks are listed below:

- Data Gathering and Analysis
- Assessment of Appliance Manufacturing Plants
- Demonstration of Microcomputer Programs
- Gathering of Data on Appliance Standards and Test Procedures
- Impact of Programs to Foster Energy Efficiency of Electricity Use

Some data were gathered on electricity generation and household energy use. These are presented below. Table 1 shows the sources of electricity generation in Egypt for 1988/89.

Table 1 Fuel Sources For Egyptian Electricity Generation 1988/89

Fuel Type	% of Total
Oil	39.2
Natural Gas	37.3
Hydroelectric	23.5

Source: Annual Report of Electric Statistics 1988/1989, Ministry of Electricity and Energy, Egyptian Electricity Authority

The installed electric generating capacity for 1988/1989 is about 10,000 MW. Electricity sales for the last 12 month period (1988/1989) for which there are data were 23,758 MkWh. Figure 1 shows the breakdown by sectors of the economy. The residential and commercial sectors are combined and are estimated to account for 48% of the total electricity sales in 1988/1989[1]. Total electricity sales of the Electricity Distribution Authority have increased at an annual rate of 5% from 1984 through 1988[2].

In Figure 2, residential energy use is disaggregated in two ways; by energy consumption and by number of customers[3]. We can see that the majority of customers use very little electricity but that, in total, they account for a large percentage of residential electricity use. The top pie chart shows that 24.5% of residential energy use is accounted for by customers that use less than 100 kWh per month. Customers that use less than 200 kWh per month account for almost 60% of residential energy use. Some customers are seen to use very large amounts of electricity (>500 kWh/month). It is possible that a small percentage of those customers are single meters connected to several households. It is important to note that a very large percentage (66%) of customers use less than 100 kWh per month.

2. DATA GATHERING AND ANALYSIS

As shown above, detailed data for electricity supply are available. For the demand side, there are much fewer data available. We have gathered limited data on appliance production, efficiency, and price. We have not been able to obtain appliance ownership (saturations) or usage data. However, a small sample of OEP staff were surveyed for appliance ownership and usage. In this section we will present those data that we were able to collect during our visit to Egypt, including some of the results of the OEP survey. The detailed results of the OEP survey will be presented in Appendix B to this report. Our data sources for this section were OEP, electric utilities and appliance manufacturers.

Production

Production figures were obtained from individual manufacturers and from the OEP. Table 2 shows annual appliance production obtained from OEP. Room air conditioner production is seen to be quite low, approximately 25,000 per year. They are a discretionary item for most Egyptians. Refrigerator production has steadily grown, and is now estimated to be greater than 700,000 per year. Clothes washer production has been very variable, ranging from 178,000 to 313,000 per year. Gas water heater (instantaneous type) production has steadily grown while electric storage-type water heater production has leveled off after earlier strong years. This may be due to greater penetration of piped gas in the residential sector. The production of lamps has grown, decreased and then grown again. We do not know if lamps includes fluorescents. Television production has decreased steadily and significantly. Actual shipments by year may be different than production due to changes in inventory levels.

Table 2 Egyptian Appliance Production

(Units Per Year)

	82/83	83/84	84/85	85/86	86/87	87/88
Room Air Cond.	21356	28164	32625	31788	23802	25221
Refrigerator	418,000	457,000	514,000	536,000	601,000	693,000
Washing machines	232,000	313,000	268,000	194,000	178,000	248,000
LPG Heater (Water Heater)	24,000	27,000	29,000	48,000	45,000	59,000
Elec. Water Heater	125,000	146,000	71,000	64,000	84,000	72,000
Electric Lamps(10^6)	47	58	70	65	56	77
Elec. Heater	260,000	285,000	N.A.	N.A.	N.A.	N.A.
TVs	819,000	900,000	895,000	443,000	333,000	315,000

Source: OEP

Some production estimates were also obtained from manufacturers. These are shown in Tables 3 and 4 for refrigerators and room air conditioners, respectively. These unofficial estimates do not match the OEP production estimates, especially for room air conditioners. For room air conditioners, the annual production estimate of 80,000 is much higher than the OEP estimate of only 25,000. Perhaps the OEP values did not include private sector companies. Miraco, a public sector company and Koldair, a public sector company, are seen to have roughly equal market shares. For refrigerators, there is a closer match between OEP and private sector estimates. Ideal (public sector) is seen to have the largest market share.

Table 3 Estimated Egyptian Refrigerator Production for 1989

Company	Shipments
Ideal	500,000
Phillips	30,000
Zanussi	30,000
Krizy	30,000
Alaska	25,000
Siltal	20,000
Iberna	20,000

Source: Zanussi

Table 4 Estimated Egyptian Room Air Conditioner Production for 1989

Company	Shipments
Miraco	40,000
Koldair	30,000
Power	6,000
Carrier	4,000
Philco	3,000

Source: Miraco

Efficiency and Prices

Data on efficiency and prices of appliances are not collected in any central repository. We did gather some data from manufacturers and retail stores. Retail prices for appliances manufactured by public sector companies are fixed by the Egyptian government, whereas, private companies set their own prices. Appliance efficiency data are difficult to obtain. At present, there are no mandated test procedures for measuring appliance energy efficiency. Additionally there are no efficiency labeling requirements. Some efficiency data were obtained directly from manufacturers. Table 5 shows some data on partial auto-defrost refrigerator prices. Appendix A contains more complete data sets for refrigerators and room air conditioners. Private sector prices are much higher than public sector (Ideal) prices. In general, we were not able to obtain efficiency data for all of the models shown in Table 5. However, for the two Ideal models, we were given values of 1.7 and 2.0 kWh/day, respectively. It is not known if the test conditions were according to the Tropical test (43C) or for a lower ambient (32C). For the first Ideal refrigerator listed, we had enough data to calculate a power factor of 0.65. This indicates that the compressor motor probably does not have a run capacitor. If that is the case, it should be possible to significantly improve the power factor with a low cost run capacitor.

Table 5 Retail Prices of Egyptian Partial Auto-Defrost Refrigerator-Freezers

Company	Volume (Liters)	Price (L.E.*)
Ideal	225	425
Ideal	280	530
Zanussi	320	960
Iberna	255	865
Siltal	290	895
Siltal	360	1320

* One L.E. is approximately equal to $0.38.

Table 6 Retail Prices and Efficiency of Egyptian Room Air Conditioners

Company	Capacity (Btu/hr)	EER (Btu/Wh)	Price (L.E.)	PF
Koldair	12,000	8.0	-	-
Koldair	16,000	6.7	-	-
Koldair	20,000	7.7	-	-
Koldair	24,000	8.6	-	-
Carrier	14,400	8.0	-	0.93
Carrier	17,900	8.9	-	0.96
Carrier	24,000	8.7	-	0.95
Philco	8,000	10.4	2100	-
Philco	20,000	6.9	3150	-
Power	18,000	8.0	-	-
Power	18,000	9.5	4550	-
Power	24,000	9.4	5900	-
Miraco	13,000	7.3	2465	0.92
Miraco	18,000	8.6	2865	0.87

The capacity of the room air conditioners shown in Table 6 range from 8,000 to 24,000 Btu/hr. The efficiencies range from an EER of 6.7 to 10.4. However, we do not know if all companies have used the same test conditions to measure efficiency. Although we do not have prices for the Koldair (public sector) models, private sector companies have indicated that Koldair products sell for about 30% less than comparable private sector models. The last column shows the power factor for those models for which we had enough data to perform the calculation. It can be seen that the power factors are generally around 0.90.

Appliance Household Survey

A questionnaire (see Appendix B) concerning household appliances ownership and usage was prepared by the LBL team (while in Cairo) with the aid of OEP staff. The purpose of the questionnaire was to obtain some limited data on appliances and to test the survey instrument itself. Since it was not known if any appliance ownership or usage data would be available through CAPMAS (a government agency), it was important to develop a questionnaire that could be tested on a small group of participants and be improved for potential use on a larger sample of the population. The questionnaires were filled out by 29 OEP staff members. We expect that these data are more representative of households of the upper economic class in Cairo.

We present a few of the survey results here and the complete analysis in Appendix B. Figure 3 shows the saturations for several product types. Almost all households have lighting, refrigerators (97%) and televisions. Some households have more than one refrigerator or television. Almost all have fans, water heaters, and clothes washers. Figure 4 shows the distribution of electricity consumption by percentage of households for the 23 households for which data are available. This figure can be compared to Figure 2 for all of Egypt. It can be seen that most of the households fall into the 100-200 kWh/month bin; nationwide the majority of households fall into the < 100 kWh/month bin. The OEP sample represents households with greater than average electricity use.

Figure 5 shows an attempt to disaggregate total electricity use into its end uses. The analysis was done for households with and without air conditioning. The sample size was very small (4 households) for households with room air conditioners. Where possible (lighting, air conditioning, space heating and fans) we calculated end-use energy consumption directly from the power and usage values found on the questionnaires. We did not have enough data to directly calculate refrigerator and water heater end use. For refrigerators, we chose to use a constant 1.95 kWh/day energy use. This was based on very limited data. We metered a few refrigerators while in Egypt and obtained a few energy use estimates from manufacturers. Water heating is placed in the miscellaneous category with toasters, vacuum cleaners, stereos, etc. Lighting and refrigeration are seen to be very important for both groups. We were able to calculate lighting directly from the responses to the survey. For televisions, we assumed 100W of power for an average color television and multiplied that value times the usage values supplied by the respondents. It should be kept in mind that these end use consumption estimates are based on a very small sample size and are very preliminary in nature. On the other hand, they are all the data that are available.

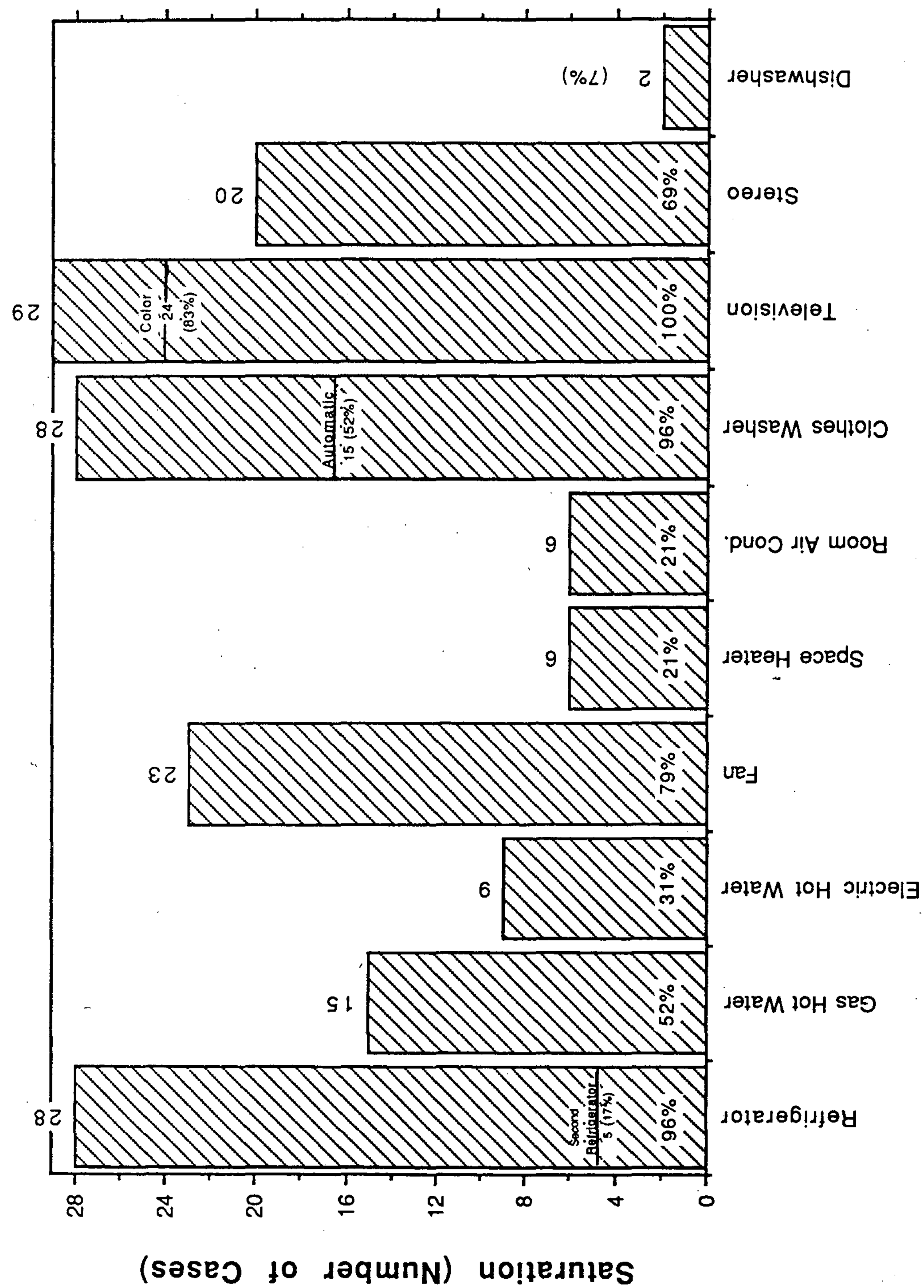


Figure 3: Saturation of Several Appliance Types

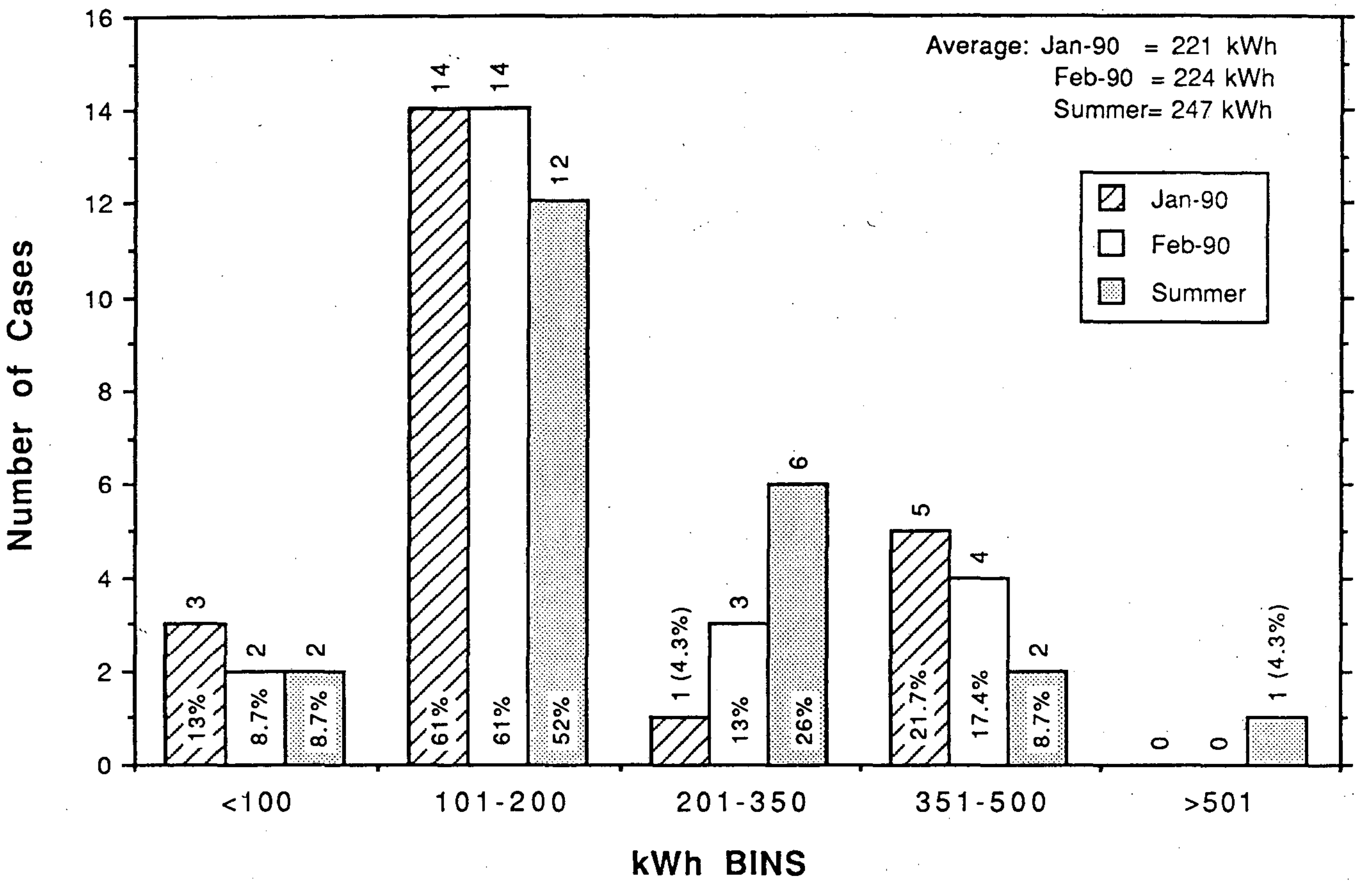
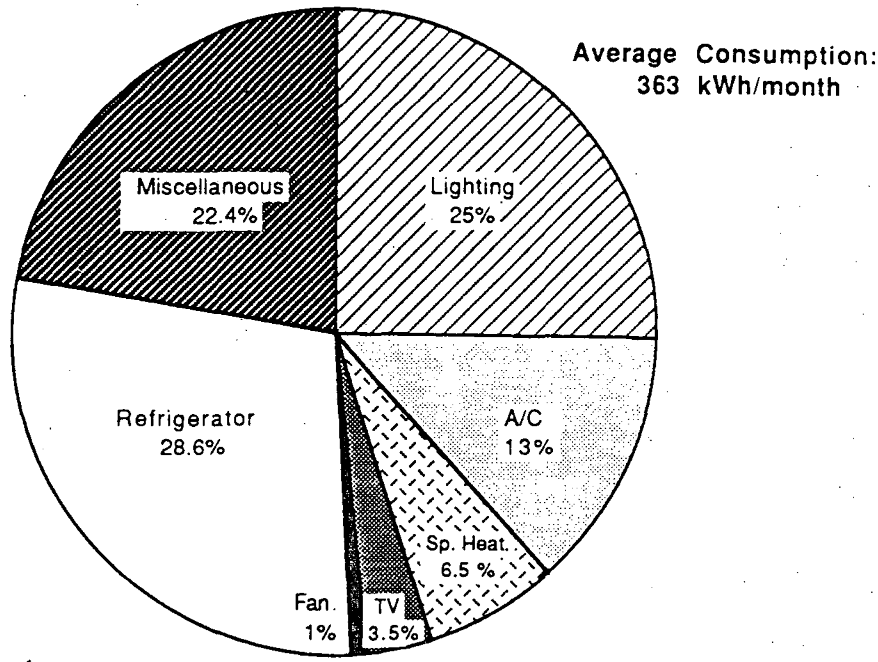


Figure 4: Distribution of Electricity Consumption for the 23 households for which data is available

4 Cases with Air Conditioning



16 Cases without Air Conditioning

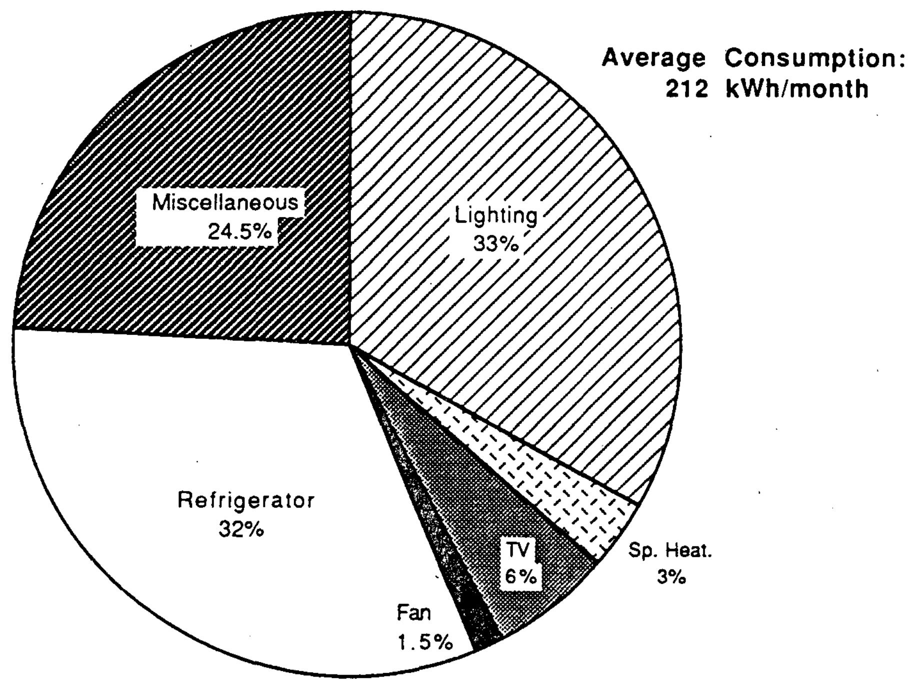


Figure 5: Electricity End Use Breakdown from the LBL-OEP Survey Data

3. ASSESSMENT OF APPLIANCE MANUFACTURING PLANTS

The LBL team visited eleven appliance manufacturing plants in Egypt. They are listed below along with the products manufactured. We observed manufacturing processes, spoke with engineers and managers, and obtained any data that were available. The results of investigations are described in detail in Appendix C to this report.

Table 7 Manufacturing Plants Visited in Egypt

Company	Products
Ideal	Refrigerators, Clothes Washers
Zanussi	Refrigerators
Koldair	Room Air Conditioners
Power	Room Air Conditioners
Miraco	Room Air Conditioners
Olympic	Electric Water Heaters
Mostafa Ali	Lamps and Ballasts
Alex Metal Products	Ranges/Ovens, Gas Water Heaters, Clothes Washers
Al Sharit	Lamps and Ballasts
Philips	Lamps

Four of the companies listed above (Ideal, Koldair, Philips, and Alex Metal) are public sector. The rest are private sector companies that manufacture or assemble particular models under license to foreign companies. For example, Miraco has an agreement with York (U.S.) and Power has an agreement with Daikin (Japan). In addition to these companies, the LBL team also visited with many appliance manufacturers at the Cairo Trade Fair and spoke to representatives of a new compressor manufacturer, MISR. MISR is a new private sector company that will produce refrigerator compressors starting in 1991. It is anticipated that compressors from this plant will be used by all Egyptian refrigerator manufacturers, replacing imported compressors.

A brief summary of some conclusions from Appendix C follows. For the most part, the private manufacturing operations have more up-to-date manufacturing facilities which produce a higher quality product with fewer workers and less overhead structure. The private sector also brings a strong infusion of manufacturing and product technology from the U.S., Europe, and Japan. Labor rates are higher in private sector plants. On the other hand, in both private and public sector plants, labor costs are relatively insignificant compared to purchased material costs.

In contrast, the older public sector plants are less efficient from direct labor and material flow considerations, have a larger overhead structure, pay less attention to quality, and exhibit poorer housekeeping practices. They produce products which are often behind the private sector in both feature and technology standpoints. In spite of some of their shortcomings, the public sector plants enjoy major shares of the market, primarily due to government price subsidies which make their products more affordable to consumers. The Egyptian manufacturing infrastructure, with its close ties to U.S., European, and Japanese technology, is capable of producing energy-efficient state-of-the-art consumer products, but needs some incentive to do so. That incentive could be labeling of energy efficiency with standard test procedures, rebate programs, standards, etc.

4. DEMONSTRATION OF COMPUTER PROGRAMS

The Energy Analysis Program at LBL has much experience in the use of computer programs for analysis of energy use of buildings and appliances. Three computer programs of significance are:

(1) PEAR, a program for energy analysis of residential buildings

(2) COMPACT, a program for energy analysis of commercial buildings

(3) a program for energy use calculations of refrigerators.

OEP staff were instructed in the use of these programs. The main purpose of presenting these computer analysis tools to OEP staff was to inform them of the types of computer simulation programs that could be developed for their use in future projects. The methodologies to create such programs could just as well be applied to Egyptian buildings. The first two programs were developed from a data base on characteristics of U.S. residential and commercial buildings and could not presently be used for Egypt. Considerable work would be required to collect the necessary data on Egyptian residential and commercial buildings to generate algorithms to run the first two programs. OEP would need to gather building specific data from surveys, audits, and metering and then perform statistical analyses on these data. The refrigerator simulation program could more easily be used for Egypt. It would require conversion from IP to metric units and the acquisition of large amounts of detailed input data on refrigerator characteristics. Additionally, the test procedure conditions would have to be altered from U.S. to Egyptian conditions (test conditions to be decided).

5. GATHERING OF DATA ON APPLIANCE STANDARDS AND TEST PROCEDURES

At this time, the U.S. appears to be the only nation with comprehensive energy efficiency standards for appliances. Several nations (e.g., Brazil, Canada, and France) do have appliance efficiency labeling programs. A copy of U.S. energy efficiency standards has been provided to OEP. These standards are mostly in the form of minimum efficiency requirements or maximum allowable energy use and they cover most major gas and electric residential appliances. The U.S. Department of Energy has established test procedures by which the energy efficiency and energy consumption of these appliances are measured. A copy of these test procedures has also been provided to OEP. The test procedures and energy standards were established over a period of many years. Both are periodically updated with much interaction between government, industry and environmental groups.

The main focus of this task was to develop estimates on the cost of setting up a facility in Egypt for appliance energy performance testing. These estimates are given in Appendix D which contains the report from ETL Laboratories. In Appendix C, proposed test procedures for each major appliance are discussed. We will summarize below the findings concerning test procedures and facilities.

Test Procedures and Labeling

In order to initiate an appliance labeling program, it will be necessary to establish uniform test procedures for each affected appliance. In some cases, some manufacturers are using International Standards Organization (ISO) procedures to measure appliance energy consumption. For example, for refrigerators, it appears that the ISO test procedure was being used at Ideal. In this procedure, consumption in kWh/day is measured at several ambient temperatures and at three interior cabinet temperature settings. Procedures for determining fresh food and freezer compartment volumes would bring uniformity for that variable. There are such procedures established in the U.S. and also by the ISO. Finally, a sweat test could be used to assure adequacy of the cabinet insulation and door seals and the effectiveness of anti-sweat heaters or condensation loops. All of these topics are covered in the ISO refrigerator standard.

An energy use label would assist consumers in making informed purchasing decisions. An example of a potential label follows:

Example of Proposed Energy Efficiency Label

Partial Defrost Refrigerator-Freezer

Fresh Food Volume	230 liters
Freezer Volume	70 liters
Total Volume	300 liters

Ambient Temperature (32^{o}C) Annual Energy Consumption (700 kWh/yr)
Annual Operating Cost (2.0 pt./kWh) 14 LE/yr

Annual Operating Cost (4.0 pt./kWh) 28 LE/yr

Figure 6 shows an example of a label used on refrigerators in the U.S.

For room air conditioners and other appliances suggestions for test procedures and labeling are given in Appendix C. In order to implement a testing and labeling program for residential appliances an agency such as the Egyptian Organization for Standardization and Quality Control would have to be involved. Test standards, as discussed above, would have to be implemented. When available, ISO test procedures are recommended. Modifications of U.S. Department of Energy test procedures should be considered for appliances not covered by ISO. In order to monitor compliance with prescribed test procedures, improved testing facilities will be required, especially for products influenced by climate, such as air conditioners, heat pumps and refrigerators. Even though manufacturers may wish to install their own test facilities, the Egyptian Organization for Standardization and Quality Control, or some equivalent agency, should have adequate facilities at their disposal for compliance testing. Competent technical support in the design, installation, and qualification of improved testing facilities and the training of personnel could be obtained from the professional staff at the engineering departments at the University of Cairo.

(Name of Corporation)
Model(s) AH503, AH504, AH507
Type of Defrost: Full Automatic

Refrigerator-Freezer
Capacity: 23 Cubic Feet

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 4.97¢ per kilowatt hour.

Only models with 22.5 to 24.4 cubic feet are compared in the scale.

Model with lowest energy cost
$68

$91

THIS ▼ MODEL

Model with highest energy cost
$132

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests.

How much will this model cost you to run yearly?

		Yearly cost Estimated yearly $ cost shown below
Cost per kilowatt hour	**2¢**	$44
	4¢	$88
	6¢	$132
	8¢	$176
	10¢	$220
	12¢	$264

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

Figure 6. Energy cost label used on U.S. refrigerators.

Recommended Certification Program

It is recommended that a third party certification program be established to verify the performance of residential appliances. Such a program typically allows the manufacturers to determine their own ratings by testing at least two samples per model, using either their own test facilities or those of others. The administrator of the testing program then publishes the model listings of all participants in a directory, with their respective ratings, updated once or twice a year. The models listed in the directory are subject to follow-up verification tests by the administrator; models are selected at random from the manufacturers production stock. Typically, one sample of between 1/3 and 1/2 of the models listed in the directory are tested each year.

Based on approximately 40 room air conditioner models and about 50 refrigerator models produced within Egypt, one facility could be designed to test both refrigerators and room air conditioners. One such facility would adequately handle the test load of a certification program. There would still be ample facility time available for research and development testing.

Recommended Test Facility

It is recommended that the testing be conducted in a balanced ambient room-type calorimeter. A simplified schematic of a test facility is shown in Figure 7, as taken from the ISO 5151 standard entitled ''Room Air Conditioners and Heat Pumps - Testing and Rating". Cost estimates for implementation of such an air conditioner and refrigerator testing laboratory have been prepared. Three different scenarios are given below.

1. *Turn-Key Facility* - This would provide a completely assembled and fully debugged test facility, inclusive of all hardware, software, and travel, necessary to get the facility operational. The facility would be erected and operated in the U.S. first, then disassembled, shipped and reassembled in Egypt. The budgetary cost for a turn-key balanced ambient room-type calorimeter, designed to test refrigerators and room air conditioners is about $875,000. This fee includes expenses for two personnel from Egypt to visit ETL for one week of training.

2. *Facility Design, Including Electronics and Software* - This would provide the complete engineering design prints and mechanical equipment specifications. Also included would be all electronic hardware (computers, transducers, controls, etc.). The data acquisition system would be assembled and debugged in the U.S., then shipped to Egypt. The cost for this option is about $375,000. This figure includes expenses for two personnel from Egypt to visit the designer of the test facility for one week of training. It also includes the necessary travel to Egypt to get the data acquisition system on-line.

3. *Facility Paper Design Only* - This would provide the complete engineering design prints, with all mechanical and electronic equipment specifications. No hardware, software, or electronics would be provided. The cost for this paper design is about $95,000. The only travel included in this figure is for the designer to visit the site of the facility in Egypt at the start of the project.

The above costs are estimates only; several specific design requirements would need to be discussed before firm prices could be quoted. To administrate a certification program for refrigerators and room air conditioners in Egypt, one full-time engineer and two technicians would be required. It is recommended that these personnel visit ETL Testing Laboratories in the U.S. for one week to experience certification program activities first hand.

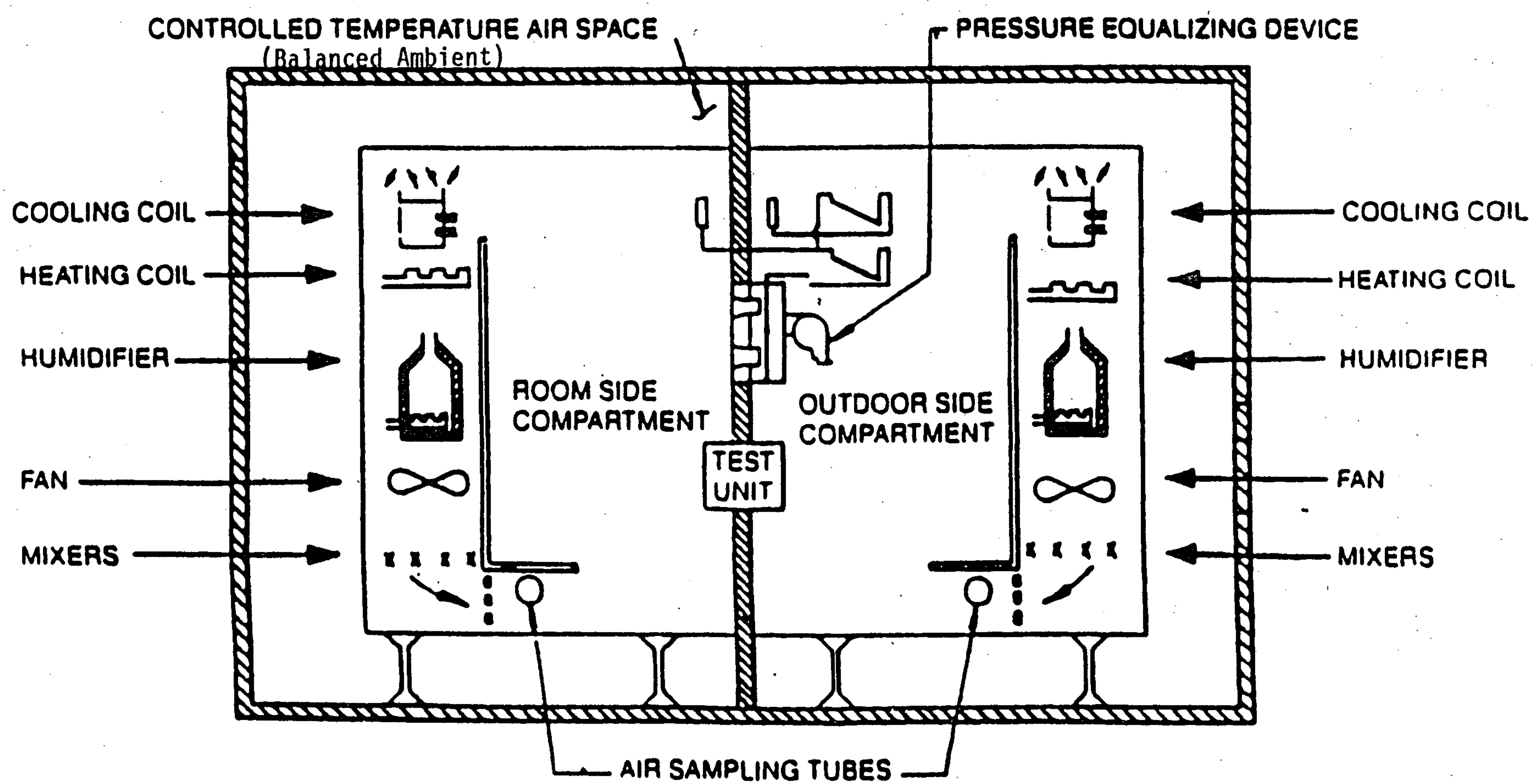


Figure 7. **Typical Balanced Ambient Room-Type Calorimeter**

6. ENERGY IMPACT OF PROGRAMS TO FOSTER ENERGY EFFICIENCY

The main objective of this task was to examine the potential for energy savings in residential electricity use. First we will look at the technical potential for electricity savings and then at potential strategies for implementing demand reductions. We gathered all the available data on residential sector energy use. When we discovered that saturation and usage data would not be available for the residential sector, we performed a small survey of OEP staff, as discussed earlier. From that survey, we were able to estimate end use consumption for several appliances (see Figure 5). It should be noted again that these are very rough estimates. We found that lighting and refrigeration are the two biggest end uses for this sample of upper economic class residents of Cairo.

Technical Potential for End Use Demand Reduction

A recent report estimated that 1987/1988 residential electricity consumption was equal to 8800 MkWh, that is 39.2% of total electricity sales that year[4]. Using that same percentage for 1988/1989, residential electricity use would be 9300 MkWh. If the above estimates are correct, 81% of the sum of residential and commercial electricity use is for the residential sector. We are choosing to modify this estimate to 75% residential and 25% commercial.* Therefore, we estimate residential consumption at 8,600 MkWh. In any case, the commercial sector, which is not addressed here, presently appears to comprise a relatively small fraction of total electricity demand. However, as commercial sector growth increases for hotels, office buildings, retail shops, etc., there will be concomitant growth in the demand for electricity in that sector.

In this section of the report, we discuss the technical potential for electricity end use reduction. We will apply the conservation potentials for each end use (ΔE_i) to the fraction of electricity use accounted for by that end use (E_i) to obtain total potential electricity savings in MkWh/yr.

$$PotentialElectricitySavings\,(MkWh/yr) = 8600MkWh/yr * \sum_{i=1}^{n} \Delta E_i * E_i$$

where 8600 MkWh/yr is total residential electricity use and n is the number of end uses. We can estimate percentage energy savings per end use from knowledge of what is available in the Egyptian and World marketplaces. We will estimate E_i for each end use as

* In 1975, the U.S.-Egypt Cooperative Energy Assessment estimated 60% of the sum of residential and commercial electricity use is for residential. Additionally, the source of the 81% estimate is not given in the O'Farrell report.

follows.

We assume that the saturations from the OEP survey are representative of the 30% of the population with electricity use between 100 and 350 kWh per month. For those households with less than 100 kWh per month electricity use, we assume that they all have lighting and that many have fans and/or televisions. A low percentage may have small refrigerators. A typical scenario for the 65% of households that use less than 100 kWh per month, is that they consume about 30-35 kWh for lighting, 3 kWh for fans, and 12 kWh for televisions. A small percentage of these households, those with monthly electricity use between 50 and 100 kWh, may have small refrigerators that use about 40 kWh per month.

Using the above assumptions and data collected from the OEP survey, we can estimate appliance saturations and annual energy consumption. Table 8 shows our estimates of these parameters. We have adjusted our original estimates of these parameters so that the total annual residential electricity consumption is 8600 MkWh. It should be noted, that these are preliminary estimates that would have to be adjusted as more extensive surveys are carried out for the residential sector. For these calculations, the number of households with electricity has been taken to be equal to 8,680,000*.

Refrigerator energy use is estimated by lowering the OEP survey value somewhat to account for smaller refrigerators in those households using less than 100 kWh/month. We assume that almost all of the 35% of the population consuming more than 100 kWh/month have refrigerators and that about 10% of the other 65% have refrigerators, for a total saturation of 41%. We assume that all households with electric service have lighting. We have lowered the average annual lighting energy consumption of 840 kWh, obtained from the survey, to 400 kWh/yr in order to account for less lighting in those 65% of households with less than 100 kWh/month of total electricity consumption. We know that the average energy use for such households is about 40 kWh per month, and that most of it is for lighting. Electric water heaters are assumed to use 900 kWh per year. This consumption value is derived from normalizing total residential consumption to 8600 MkWh/yr. The saturation of 10% is obtained by multiplying the 30% survey saturation by the estimated 35% of the population that are represented by the survey.

The annual energy consumption of electric space heaters, room air conditioners, televisions, and fans are taken directly from the OEP survey. The data shown in Figure 5 are used to estimate consumption for these four end-uses. The television consumption

* Household data obtained from OEP.

was lowered from 144 to 100 kWh/yr to account for less consumption by smaller and black and white televisions in households using <100 kWh/month. The national saturations of these products are obtained by using the OEP values for 35% of the population and making estimates for the other 65% (those households with less than 100 kWh per month electricity consumption) of the population. We assume that none of these 65% of households have electric space heaters or room air conditioners. The miscellaneous consumption is also obtained from the survey. It is assumed that households with less than 100 kWh/month consumption have negligible miscellaneous electricity use. For other households, we estimate (from the survey) 52 kWh/month of miscellaneous energy use, including electric water heaters. From Table 8, we estimate 23 kWh/month for electric water heaters (0.31x950 kWh/yr/12), where 31% is the saturation level of electric water heaters for the survey households. Therefore, the remaining miscellaneous consumption is 30 kWh/month or 360 kWh/yr. Assuming that 35% of the population has this amount of miscellaneous energy use, the average miscellaneous consumption for the country as a whole is 125 kWh/yr.

Table 8 Preliminary Estimates of Residential Electric Appliance Saturation Rates and Energy Consumption

Appliance	Saturation*	Average Consumption/Household (kWh/yr)
Lighting	100%	400
Refrigerator	41%	600
Water Heater	10%	950
Space Heater	10%	75
Room A/C	5%	560
Television	65%	100
Fan	65%	38
Miscellaneous	35%	360

* Among households with electricity.

We now turn to conservation potential. For each end use, a potential reduction in unit energy consumption will be estimated. These are short-term estimates; they would be achievable in about a 3-5 year period. Additional energy savings could be obtained by the year 2000. For refrigerator-freezers, efficiency can be improved through the use of foamed in-place polyurethane foam insulation. Where only one inch of insulation has been used in the sides of the fresh food compartment of refrigerator-freezers, an increase to at least two inches will be cost-effective to the consumer. Non-CFC foams will soon be available for this use. More efficient compressors, reduced defroster energy use, and improved door gaskets will all increase energy efficiency. Based on experience in other nations an energy use reduction of 20% should be easily accomplished by improved insulation and more efficient compressors.

Table 9 shows the results of an engineering analysis performed at Lawrence Berkeley Laboratory for refrigerator-freezers[5]. The manufacturer cost and energy use of improved designs are shown for a typical model. These manufacturer cost estimates are applicable to a U.S. model which is almost twice as large as a typical Egyptian model. It was estimated that a 28% reduction in energy use from the baseline would cost $30 (a 13% increase in manufacturer cost). The 1993 U.S. energy efficiency standards were set at that level of energy use reduction. The consumer payback period for that level of conservation at U.S. conditions was estimated to be 4.2 years. A new analysis would have to be performed for smaller refrigerator-freezers, using compressors and fans (if present) that are appropriate for such models. However, one can see that thicker insulation is very effective in increasing energy efficiency. The impact of increased insulation on energy use would be even greater (% wise) for models without auto-defrost and evaporator or condenser fans.

Table 9 Manufacturer Cost and Unit Energy Consumption
Top-Mount Auto-Defrost Refrigerator-Freezer
(No CFCs)

Design	Design Option	Energy Use (kWh/yr)	Manufacturer Cost ($1987)
0	Baseline	955	224
1	0 + Enhanced Evapor Heat Transfer	936	224.1
2	1 + Foam Refrigerator Door	878	225.55
3	2 + 5.05 Compressor	787	228.95
4	3 + 2 inch Doors	763	232.65
5	4 + Efficient Fans	732	241.65
6	5 + 2.6"/2.3" Side and 2.6" Back Insul	706	249.10
7	5 + 3.0"/2.7" Side and 3.0" Back Insul	690	253.95
8	5 + Evacuated Panels	577	287.65
9	8 + Two-Compressor System	508	337.65
10	9 + Adaptive Defrost	490	353.65

Volume = 18.0 ft^3, AV=20.8 ft^3. Baseline includes: 4.5 EER compressor,
side wall insulation: 2.2" foam in freezer and 1.9" foam in refrigerator.
door insulation: 1.5" foam in freezer and 1.5" fiberglass in refrigerator.

For room air conditioners, the present average efficiency appears to be approximately an EER of 7.8. This estimate is derived from models presently sold by Miraco and Koldair, which range from 6.7 to 8.6 EER. Higher efficiency models (up to 10.4 EER) are also available on the Egyptian market. An improvement to an EER of 12 could easily be accomplished by using designs on the U.S. market. Efficiency can be increased through more efficient compressors and improved heat exchangers. An initial minimum efficiency standard of 9.0 EER would result in an energy use reduction of at least 13% (compared to the assumed baseline of 7.8 EER). Efficiency standards for room air conditioners could be made more stringent in future years.

Lighting technologies are discussed in detail in Appendix E. Residences use both incandescent and fluorescent lamps. A 15% energy use reduction for reduced wattage incandescent lamps with similar lumen output is possible (see Appendix E). Lamp lifetime will be reduced by about 25% although the value of energy savings (at 3pt. per kWh) approximately equals the extra lamp cost, resulting in no extra cost to the consumer. Thin-tube fluorescent lamps can be used to reduce energy use by about 10%. Incandescent lamps comprise about two-thirds of all residential lamps.

The efficiency of electric water heaters can be improved by thicker foam insulation and reduced thermostat setpoints. An energy use savings of at least 15% should be possible.

Using the above estimates of energy savings, an average household should save about 127 kWh/yr or 13% of their annual energy use (990 kWh/yr). If the full technical potential of 127 kWh/yr is achieved, the national energy savings will be 1210 MkWh/yr. This is almost 5% of present total electricity use. As the saturations of the above appliances increase, the potential annual savings will also increase. Therefore, the value of these savings increases each year. In the next section, we discuss several strategies for achieving this technical potential.

End Use Conservation Strategies

There are a number of strategies for reducing electricity demand in the residential sector. Some of these are listed below:

- Labeling
- Information Programs
- Energy Audits

- Cash Rebates
- Increased Electricity Prices
- Fuel Switching
- Energy Efficiency Standards

Energy consumption labeling of appliances has been discussed earlier. It is essential for implementation of information programs, energy audits, cash rebates, and efficiency standards. Studies have shown that labeling, without information programs, is not very effective. As stated earlier, labels require a system for uniform testing of appliances. Labeling, when combined with an information program, can promote the purchase of more efficient appliances. Consumers must be educated as to the advantages of purchasing a more expensive appliance that has lower operating costs. Table 10 shows some estimates of the electricity demand impact of various strategies (based on experience in the U.S.)[6]. It can be seen that information alone (energy savings goals and factual) has little impact on energy demand. Additionally, the range of savings is quite wide for all of these programs. An elaborate type of information program involves energy audits of households. Energy audits include visits to individual homes by trained energy experts. The auditors make recommendations to the owner or renter on how to reduce electricity bills. More efficient appliances can be one of the recommendations. In some cases, the utility will provide feedback to the consumers on the decrease in energy use effected by the changes made by the members of the household. For this type of information program (with feedback), the potential energy savings are typically greater.

Table 10 Average Energy Savings From Information

Type of Information	Average Savings	Range
Energy savings goals	1%	0-1%
Factual or other	4%	0-9%
Feedback on consumption	11%	3-21%

Source: Nancy Collins, ''Past Efforts and Future Directions for the Evaluation of State Energy Programs", Oakridge National Laboratory, April, 1985.

Another mechanism for promoting more efficient appliances is for the utility (or government) to offer cash rebates to consumers who purchase appliances with an efficiency above a prescribed value. Rebates are presently offered by many U.S. utilities in order to reduce electrical demand. A survey of 132 U.S. utilities showed that 60% offered rebates for heat pumps, 40% for central air conditioners and water heaters, and 27% for refrigerators [7]. The median rebate amounts varied from $25-$50 for room air conditioners and from $30-$50 for refrigerators. Offering rebates to consumers can motivate manufacturers to produce more efficient appliances. An example of such a program is the Blue Clue Program sponsored by Bonneville Power Administration (BPA)[8]. BPA distributes electricity to several states in the Northwestern U.S. They utilize blue ribbon labels to inform consumers which refrigerators and freezers are in the top 15% of all similar models in energy efficiency. Several other utilities have now adapted the Blue Clue Program to their own service territories. Information programs of various kinds can be effective in increasing consumer awareness of the energy and environmental impact of their appliance purchase decisions.

Higher electricity prices will reduce demand. Estimates of the elasticity of electricity demand range from 0.1 to 0.3% for each 1% increase in price[9]. Of course, there are many issues that would be impacted by a decision to raise electricity prices. One of these is the detrimental impact on the poor of higher utility bills. A way of avoiding this adverse impact is to maintain very low rates for the first 80-100 kWh per month of electricity use.

Fuel switching from electricity to gas is possible for some appliances. Cooking and water heating are two end uses that are amenable to such policies. Presently, gas water heating is by instantaneous heaters and electric water heating is by storage type water heaters. Switching from electric storage to gas instantaneous water heaters would reduce electricity demand and raise gas demand. Expansion of the natural gas supply system would probably be required to effect this switch.

The last option to be discussed is the imposition of energy efficiency standards. This is the one method which allows a definite energy savings to be achieved, depending on the strictness of the standards. Several nations have appliance labeling programs in effect; for example, Brazil, Canada, France, and the U.S. The U.S. is the only nation to presently have comprehensive appliance efficiency standards in place. The first U.S. standards of any consequence took effect on January 1, 1990. They apply to refrigerators, freezers, room air conditioners and water heaters. The legislation also mandates periodic updates of these initial standards. Because of national concern about global warming, these updates have been the focus of much attention. The present standards eliminate the most inefficient products. Tables 11 through 13 contain the energy efficiency standards for the products mentioned above. They are in the form of maximum allowable energy use or minimum efficiency. An example below, shows how the standards work for refrigerator-freezers.

Table 11 lists the 1990 standards of allowable energy use for ten classes of refrigerators and freezers. Also shown are the 1993 efficiency standards for this product. Since energy use is a function of volume, the standards are in the form of equations which have volume as an independent variable. The equation below shows the energy standard for one product class, top-mount auto-defrost refrigerator-freezers. For this product class (accounting for almost 70% of annual refrigerator sales in the U.S.) the current maximum allowable energy use in kWh/yr is given by:

$$E = 23.5\ AV + 471$$

where AV, adjusted volume, equals refrigerator volume plus 1.63 times the freezer volume. For a typical 18 ft^3 U.S. model, the adjusted volume equals about 21 ft^3 (fresh food and freezer volumes of 13.55 and 4.45 ft^3, respectively), and the allowable energy consumption is 965 kWh/yr.

The room air conditioner standards, in Table 12, are in the form of minimum allowable efficiency. The efficiency is expressed as an energy efficiency ratio (EER). It is equal to the cooling capacity (in Btu/hr) divided by the power input (W). The standards range from 8.0 to 9.0 for different capacity ranges. The storage type water heater standards, in Table 13, are in equation form. A minimum energy factor is given as a function of tank volume for gas-fired, oil fired, and electric storage water heaters. The volume is expressed in gallons and the energy factor as a decimal between 0 and 1.0.

Recommendations

Testing Center

Based on our limited data gathering and analysis, we recommend that lighting and refrigeration be addressed first. At the present time, efficiency gains for these two residential end uses would produce the greatest national energy savings. Room air conditioners may become important if their saturation increases substantially. We are estimating a 5% saturation at present. In the near term, it would still be worthwhile to establish test procedures and labeling requirements for room air conditioners, as well as for refrigerators and lighting. It would be cost-effective to construct a test facility for both refrigerators and room air conditioners at the same time, as opposed to delaying the room air conditioner portion to a later time. This facility could be established at the Egyptian Bureau of Standards. A certification program for these two product types would require one full time engineer and two full time technicians. The estimated cost for a turn-key facility to test refrigerators and room air conditioners is about $875,000. This includes all hardware and software and one week of training for two Egyptian engineers and/or technicians in the U.S.

Appliance Manufacturers

Government owned appliance manufacturing facilities should improve their production efficiency, enhance quality control, and improve safety practice. Private sector manufacturing plants should be emulated by the public sector plants (see Appendix C and Appendix F for details). These private sector plants often utilize more advanced technologies obtained under license to manufacturers in the U.S., Europe, and Japan. Examples of improved designs for refrigerators are the use of thicker blown in foam insulation in side walls and doors and more efficient compressors. For room air conditioners, higher efficiency can be obtained through more efficient rotary compressors and more effective heat exchangers (for example, grooved refrigerant tubes and enhanced fins).

Household Survey

We recommend that a larger sample of households representative of all of Egypt be surveyed with a modified version of the OEP appliance ownership and usage questionnaire. Careful survey design should be done at the start of the project in order to ensure that the sample is representative of the Egyptian population. The survey should include a large sample of low energy users (<100 kWh/month), as well as higher energy users. Rural and urban households should be sampled. This would allow for more accurate estimates of potential energy savings for all end uses, and may lead to additional energy-saving programs for other end uses.

Testing and Labeling

For refrigerators, a test procedure such as the ISO should be adopted for Egypt. Once uniform testing by manufacturers is in place, labels could be placed on each refrigerator sold in Egypt. Consumer education on how to use the labeling information is essential. After a few years of experience with testing and labeling, the OEP may decide to consider the establishment of minimum energy efficiency standards for refrigerators. Meanwhile, it is important to ensure that the new compressor facility being built in Egypt produce state-of-the-art compressors for refrigerators. Once manufacturers become aware of plans to establish a labeling program, it is likely that they will begin improving the efficiency of their products, as was the case recently in Brazil. In that country, the response to labeling and other efforts to promote efficiency has been that the average efficiency of new refrigerators has declined approximately 15% over a three year period[10].

Lighting

For lighting, it may be more practical to establish standards for minimum efficacy ; the efficiency could be expressed in lumens of light output per watt of electricity input. A test procedure would have to be established for fluorescent and incandescent lamps before the standard could take effect. It is important to encourage manufacturers to produce ballasts with higher power factors (90%) than found in presently made Egyptian products (0.55). Short of adoption of efficiency requirements, OEP should work with lamp manufacturers to encourage production of improved efficiency lamps, and with relevant government agencies to increase the import duty on inefficient lighting products. The duty on efficient products which are not currently made in Egypt could be lowered to encourage the use of these products.

Table 11 U.S. Standards For Refrigerators, Refrigerator-Freezers and Freezers

Product Class	Maximum Allowable 1990	Energy Use (kWh/yr) 1993
Manual Defrost Refr and Refr-freezer	16.3AV[+] + 316	19.9AV + 98
Partial Auto-Defrost Refr-Freezer	21.8AV + 429	10.4AV + 398
Top-Mount Auto-Defrost Refr-Freezer	23.5AV + 471	16.0AV + 355
Side-Mount Auto-Defrost Refr-Freezer	27.7AV + 488	11.8AV + 501
Bottom-Mount A-D Refr-Freezer	27.7AV + 488	14.2AV + 364
Top-Mount A-D with TTD* Features	26.4AV + 535	17.6AV + 391
Side-Mount A-D with TTD Features	30.9AV + 547	16.3AV + 527
Upright Manual Defrost Freezer	10.9AV + 422	10.3AV + 264
Upright Auto Defrost Freezer	16.0AV + 623	14.9AV + 391
Chest Freezers	14.8AV + 223	12.0AV + 124

+ AV means adjusted volume; for refrigerator-freezers, AV = Refrigerator Volume plus 1.63 times the Freezer Volume. For freezers, AV = 1.73 times Freezer Volume.

* TTD stands for through-the-door features such as ice makers.

Table 12 U.S. Energy Efficiency Standards For Room Air Conditioners

Product Class	EER
Without Reverse Cycle and With Louvered Sides	
Less than 6 kBtu/hr	8.0
6-7.999 kBtu/hr	8.5
8-13.999 kBtu/hr	9.0
14-19.999 kBtu/hr	8.8
20.0 kBtu/hr and more	8.2
Without Reverse Cycle and Without Louvered Sides	
Less than 6 kBtu/hr	8.0
6-7.999 kBtu/hr	8.5
8-13.999 kBtu/hr	8.5
14-19.999 kBtu/hr	8.5
20.0 kBtu/hr and more	8.2

Effective date January 1,1990

Table 13 U.S. Energy Efficiency Standards for Storage-Type Water Heaters

Product Class	Standard
Gas-Fired	0.62 - (0.0019*V)
Oil-Fired	0.59 - (0.0019*V)
Electric	0.95 - (0.00132*V)

V equals tank volume in gallons.

Effective date January 1, 1990

REFERENCES

1. Annual Report of Electric Statistics 1988/1989, Ministry of Electricity and Energy, Egyptian Electricity Authority, Cairo, Egypt.

2. Robert Adler, "A Survey of the Economics of Electrical Energy in Egypt", U.S. AID, Cairo, Egypt, April 22, 1990.

3. Annual Report of Electric Statistics 1988/1989, supra.

4. Paul O'Farrell, "Residential Electricity: Consumption, Rate Structure and Subsidy", U.S. AID, Cairo, Egypt, August, 1988.

5. I. Turiel, et al., "U.S. Residential Appliance Energy Efficiency: Present Status and Future Policy Directions", Proceedings of ACEEE 1990 Summer Study on Energy Efficiency in Buildings, 1990.

6. Nancy Collins, "Past Efforts and Future Directions for the Evaluation of State Energy Programs", Oakridge National Laboratory, April 1985.

7. "A Compendium of Utility Sponsored Energy Efficiency Rebate Programs", Electric Power Research Institute, EPRI EM-5579, December, 1987.

8. Karen Anderson, "Appliance Efficiency Programs: Beyond Rebates, Home Energy, March 1990.

9. Robert Adler, Ibid, p 3.

10. Howard Geller, "Electricity Conservation in Brazil: Status Report and Analysis (review draft)", Electrobras, University of Sao Paulo, and American Council for an Energy Efficient Economy, March, 1990.

APPENDICES

A. Efficiency and Price Data for Refrigerators and Air Conditioners

B. Appliance Ownership and Usage Survey

C. Residential Appliance Manufacturing Industry Evaluation

D. ETL Testing Laboratories Inc. Report

E. Lighting Energy Use and Conservation Opportunities in Egypt

APPENDIX A
REFRIGERATORS SOLD IN EGYPT

BRAND NAME	ID Number	Retail Price in L.E.	Manuf. Pub/ Priv	License	Type	Defrost	Total Volume liters	Fr-Food Volume liters	Freezer Volume liters	Power Demand W	Amps	Energy Use kWh/day	Fresh-Food Insulation		Freezer Insulation	
													Type	mm	Type	mm
IDEAL	RC225LF	425	Pub	Bosch (FRG)	Top Mount	Man	225			120	0.84	1.7	Foam	25	Foam	50
IDEAL		530	Pub	?	Top Mount	Man	280					2	Foam	25	Foam	50
IDEAL			Pub	?	Top Mount	Auto (FF)										
ELECTROSTAR	R320/2T	960	Priv	Zanussi (I)	Top Mount	Auto (FF)	320	255	65	150						
ELECTROSTAR	Z7270VF	1150	Priv	Zanussi (I)	Upright Freez	Man	260			170						
ELECTROSTAR		700	Priv	Electrolux (SW)	Man/Absorb.	Man	50	50	0	85		1.4	Foam	25		
IBERNA	F 08	620	Priv	Iberna (I)	Top Mount	Man	89			80						
IBERNA	F 2 P 27	865	Priv	Iberna (I)	Top Mount	Auto (FF)	255	195	60	165						
IBERNA	FC. 37	1730	Priv	Iberna (I)	Bottom Mount	Auto (FF)	366	250	116	245						
IBERNA		3950	Priv	Iberna (I)	Side X Side	Fully Auto	611	374	239	250						
IBERNA	EL. 0		Priv	Iberna (I)	Chest Freezer	Man	130	0	130	110						
IBERNA	EL.22		Priv	Iberna (I)	Chest Freezer	Man	200	0	200	165						
IBERNA	V.22	1095	Priv	Iberna (I)	Upright Freez	Man	220	0	220	165						
W.ALSAKA	KS 25	524	Priv	Liebherr (FRG)	Top Mount	Man	232									
W.ALSAKA	KSD 35	760	Priv	Liebherr (FRG)	Top Mount	Man	325									
W.ALSAKA	KGS 4090	1135	Priv	?	Bottom Mount		307	252	87				Foam	25	Foam	50
W.ALSAKA	CH 140	510	Priv	Ariston (I)	Chest Freezer	Man	140	0	140							
W.ALSAKA	CH 20	620	Priv	Ariston (I)	Chest Freezer	Man	200	0	200							
W.ALSAKA	CH 27	725	Priv	Ariston (I)	Chest Freezer	Man	270	0	270							
W.ALSAKA	DF650	1550	Priv	Ariston (I)	Chest Freezer	Man	640	0	640							
SILTAL	FB 15	580			Top Mount	Man	130	121	9			0.9				
SILTAL	FB 19	Discont.			Top Mount	Man	180	169	11			0.9				
SILTAL	FB 23	Discont.			Top Mount	Man	220	209	11			1				
SILTAL	FB 30	895			Top Mount		290	230	60			2.4				
SILTAL	FB 37	1320			Top Mount		360	260	100			2.6				
SILTAL	FB 44	1470			Top Mount		430	330	100			3				
SUPER POSH		655			Upright Freez		168	0	168							
SUPER POSH		935			Top Mount		252									
SUPER POSH		1050			Top Mount		308									
KOLDAIR					Upright Freez		260	0	260							

APPENDIX A
ROOM AIR CONDITIONERS SOLD IN EGYPT

BRAND NAME	ID Number	Retail Price in L.E.	Manuf. Pub/ Priv	License	Type	Cooling Capacity kBtu/hr	Cooling kW	Heating kW	Amps	EER	Weight Kg
MIRACO	YMR 17	1980	Priv	York (USA)	Room	17	2.375	3	12.5	7.16	75
MIRACO	YM-2000/13	2465	Priv	York (USA)	Spilt	13	1.79	2.4	8.8	7.26	91
MIRACO	YM-2000/18	2865	Priv	York (USA)	Spilt	18	2.095	3.6	11	8.59	96
MIRACO	YM-2000/24		Priv	York (USA)	Spilt	24	3.045	3.6	14.9	7.88	110
POWER	PWH 18		Priv	York (USA)	Room	18	2.25	4.1		8.00	59
POWER	PWH 24		Priv	York (USA)	Room	24	2.79	4.72		8.60	71
POWER	PFF 18/CBU18	4550	Priv	Daikin (Japan)	Spilt (Floor)	18	1.89	2.7		9.52	76
POWER	PFW 18/CBU18		Priv	Daikin (Japan)	Spilt	18	1.94	2.7		9.28	74
POWER	PFC 18/CBU18	5100	Priv	Daikin (Japan)	Spilt (Wall)	18	1.88	2.7		9.57	64
POWER	PFF 24/CBU24	5900	Priv	Daikin (Japan)	Spilt (Floor)	24	2.54	2.8		9.45	92
POWER	PFC 24/CBU24		Priv	Daikin (Japan)	Spilt	24	2.55	2.8		9.41	90
POWER	PFW 24/CBU24	6300	Priv	Daikin (Japan)	Spilt (Wall)	23	2.51	2.8		9.16	78
PHILCO	IPC 26 EF	3600	Priv	Philco (USA)	Spilt (Floor)	26.2	2.9	3.5		9.03	
PHILCO	IPC 20 EF	3150	Priv	Philco (USA)	Spilt (Floor)	20	2.9	3.5		6.90	
PHILCO	IPC 26 EC	3700	Priv	Philco (USA)	Spilt (Ceiling)	26.2		3.5			
PHILCO	IPC 20 EC	3250	Priv	Philco (USA)	Spilt (Ceiling)	20		3.5			
PHILCO	PAEI 8P8	2100	Priv	Philco (USA)	Room	8	0.77	3		10.39	
CARRIER	Out38VA 015		Priv	Carrier (USA)		14.4	1.815	2.5	8.9	7.93	
CARRIER	Out38VA 018		Priv	Carrier (USA)	Spilt	17.9	2.02	2.5	9.6	8.86	
CARRIER	Out38VA 024		Priv	Carrier (USA)	Spilt	24.37	2.79	3.5	13.4	8.73	
CARRIER	Out38VA 028		Priv	Carrier (USA)	Spilt	27.38	3.32	3.5	16	8.25	
KOLDAIR	WU1200		Priv	?	Room (HP)	12	1.5	1.8		8.00	88
KOLDAIR	WU1600		Pub	?	Room (HP)	16	2.4	2.6		6.67	99
KOLDAIR	15000		Pub	?	Spilt	15	2.2	1.7		6.82	
KOLDAIR	17000		Pub	?	Spilt	17	2.4	2.6		7.08	
KOLDAIR	20000		Pub	?	Spilt	20	2.6	2.6		7.69	
KOLDAIR	24000		Pub	?	Spilt	24	2.8			8.57	

APPENDIX B
APPLIANCE OWNERSHIP AND USAGE SURVEY

General Remarks

A questionnaire (see Attachment) concerning household appliances ownership and usage was prepared by the Lawrence Berkeley Laboratory (LBL) team while in Cairo. The purpose of the questionnaire was to obtain some limited data on appliances and to test the survey instrument itself. Since it was not known if any appliance ownership or usage data would be available through CAPMAS (an Egyptian government agency), it was important to develop a questionnaire that could be tested on a small group of participants and be improved for potential use on a larger sample of the population.

Thirty questionnaires were filled out, but one person answered it twice. Statistics have been computed based on the 29 valid cases. Only one question did not seem to have been correctly understood: question (22) *Estimate washer load per week.* Answers range from 2 kWh to 5 hours. We expected a number like 2,3,4 loads/week.

We are aware of the limits and the weaknesses of our survey. The sample size is very small and OEP personnel are not a representative sample of the Egyptian population. We can probably consider them as part of the upper economic class. About 80 persons work at OEP, but only English speaking personnel were able to answer our questions. This makes the surveyed group even less representative. The same questionnaire translated into Arabic would have allowed us to reach a wider group, eventually all OEP employes.

Table 1 in the following pages contains all the collected information. One can refer to it to confirm or find new statistics.

• <u>Question 1:</u> Number of persons living in the house

Figure 1 summarizes the responses. For OEP employees, the average number of people living in a house is 4.1. The national average is 4.9.

• <u>Question 2:</u> Saturation of fuel use.

Figure 2 reports the responses. Electricity is used in 100% of the households. The main use of electricity , as we will see later, is for lighting, refrigeration and television. Bottled gas (in the form of 12.5 Kg of butane) has a high penetration (80%). The main use of butane gas is for cooking. Piped gas reaches 28% of the households. This is a high figure compared to the 5% of Cairo population which has utility gas (OEP data). Kerosene, the only other fuel, is used very little, essentially for cooking.

• <u>Question 3:</u> Energy Consumption

Figures 3 summarizes the data. The two bar charts differ by the range of the consumption bins; 61% (14 of 23 responding) of the surveyed population belongs to the 101-200 kWh bin. We know for the overall population that this bin has only 23% of the total Egyptian population (data from the electric utility annual report).

61% (14/23) of the cases show an increased electrical consumption in summer time. All cases which have a room air conditioner belong to this 61%.

The following table, Table 2, shows the average monthly consumption. An annual consumption was estimated using the weight factors shown for each of the given monthly consumptions.

Table 2: Average Consumptions

Month	Consumption	Factor to compute annual consumption
January 90	221 kWh	x3
February 90	224 kWh	x3
One summer month	247 kWh	x6
Estimated average for the year	235 kWh	=2817kWh

Data for piped gas are very poor. We got four answers, two showing a steady consumption of 15 m^3 (households of 3 & 5 persons), the two others, 60 m^3 (households of 6 & 7 persons).

The 23 people who have bottled gas consume an average of 1 3/4 bottles during a winter month and 1.5 during a summer month.

• <u>Question 4:</u> Lighting & Refrigerators

As shown in Figure 4, 89% of the households use incandescent light bulbs, 63% use fluorescent bulbs and 18.5% use flam bulbs. Figures 5 and 6 show installed wattage and lighting energy consumption as a function of lighting type. The percentages shown in the figure are representative of consumption and installed wattage for an average household in this survey. Figures 7 and 8 also show installed wattage and lighting energy consumption as a function of lighting type, but for houses that have flam lighting. We can see that flam bulbs are not used as often as the incandescent and fluorescent lights but their total installed wattage is always very high.

The questionnaire asks for the type of light used, the installed wattage and the average usage in hours per day for each individual lamp. We are able to estimate an average lighting daily consumption. We found an average 785W installed, and a consumption of 3.262 kWh/day or 1,200 kWh/year. This is 42% of the total electricity consumption (from Table 2). However, for some households, reported lighting energy use is greater than the total electricity use. Thus, reported energy use for lighting may err on the high side. On figure 8, we can see that house using flam bulbs show a higher lighting installed wattage and consumption (4.83 kWh/day or 1760 kWh/year) than the average household.

• Refrigerator/Freezer

Figure 9 shows the type of refrigerator.

-17% of the units are manual defrost;

-61% partial defrost (automatic defrost in refrigerator only);

-20% of the households have a second refrigerator (5 of 25) and;

-16% have a stand-alone freezer (4 of 25).

The average age of the main refrigerator is 5.6 years, the oldest being 10 years old. The average age of the second refrigerator is 18.6 years (ranging from 10 to 30).

-56% of all the refrigerator/freezers are Ideal (13 of 23 that gave the appliance's brand name).

The average size is 10.7 ft^3, ranging from 7.5 to 21 ft^3.

• <u>Question 5:</u> Cooking

Gas cooking, either with piped or bottled gas, for cooktops and oven, has a 100% saturation. Only one household has an electric burner. The average cooking hours per day is 3.2 (ranging from 1 to 5 hrs/day).

• <u>Question 8:</u> Domestic Hot Water

-53% (15 over 28) of the households used an instantaneous gas water heater;

-36% (10 over 28) have an electric storage water heater;

-11% (3 over 28) use the gas cooking stove to heat the water;

-3% (one case) use a kerosene stove.

For those who have an electric storage water heater (10 cases), 9 have a 50 liter capacity tank, one has a 70 liter tank. Seven say that the electric storage water heater has an adjustable thermostat. For those who have an instantaneous water heater, 3 say that they don't have an adjustable thermostat and 6 have a storage tank with a capacity varying from 5 to 75 liters.

• Air Conditioning, Electric Space Heater and Fans

For room air conditioners, the usage varies from 90 to 800 hours/year (average 340 kWh/year). For space heaters, use varies from 60 to 420 hours/year (average 207 kWh/year). For fans, the average usage is 536 hours/year, ranging from 60 to 1020 hours/year. It is hard to explain such a wide range of usage values.

• Questions 12 through 20: Other Appliances

The bar chart in figure 10 summarizes the results of questions 12 through 20. We can see a high saturation for clothes washers (96%) and televisions (100%).

Fifty three percent of the clothes washers are fully automatic. There is an average of 2 washing loads per week.

Eighty three percent (83%) of the TV sets have a color screen; 69% of the households have a stereo and 7% (2 cases) have a dishwasher. The average television viewing time is 4.5 hours per day.

Among the miscellaneous other appliances, vacuum cleaner is the most cited (27% or 8 cases).

End Use Consumption Estimations

Despite the limited amount of data collected and the weaknesses of our survey, we have attempted to estimate, electrical end use breakdown. We consider two categories of households, with air conditioning and without air conditioning.

We compute the lighting consumption based on the wattage and time of use directly given in the questionnaire. For room air conditioners, space heaters and fans, the questionnaire also gives the power demand and the time of use throughout the year. For estimation of television energy consumption, we assume an average electrical power of 100W (based on data for TV sold in the US). For refrigerator and freezers, we used a average 1.95 kWh/day based on measured data for one unit and supported by published test data from Ideal. We have not been able to estimate electric storage water heater consumption. For the total of 29 cases, 6 were missing total consumption data and 3 others presented unreasonable lighting consumption. This left us with 20 cases, 4 having air conditioning, 16 without air conditioning.

The following table, Table 3, presents the results of our estimations for electrical end use.

Table 3: Electrical End-Use

	With Air-Conditioning	Without Air-Conditioning
Number of Cases	4	16
Average Consumption	363 kWh/month	212 kWh/month
Lighting	25.18%	33.05%
A/C	12.94%	0%
Space Heating	6.55%	3.31%
Television	3.35%	5.78%
Fan	0.81%	1.31%
Refrigerator	28.62%	32.23%
Miscellaneous	22.56%	24.32%
Total	100%	100%

Figure 11 is a graphical presentation of the data in Table 3.

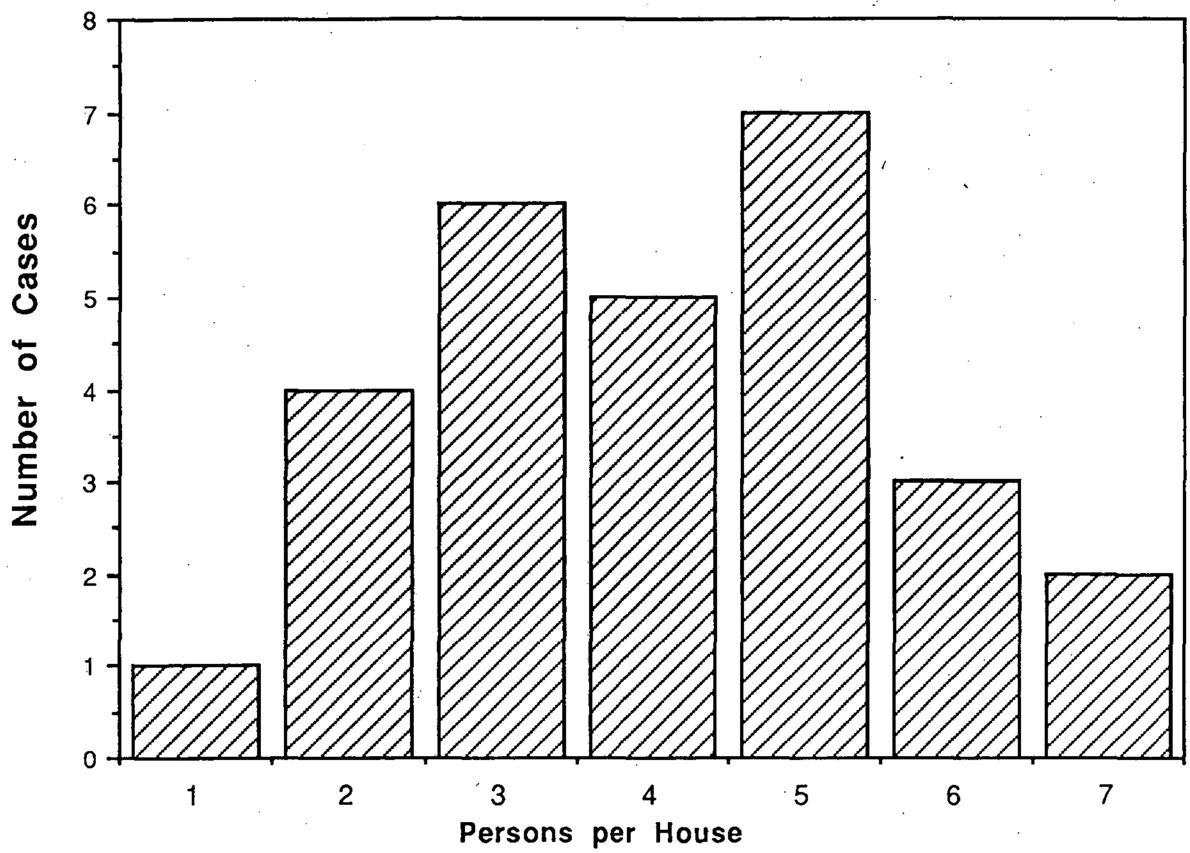


Figure 1: Number of Person in Household (Average of 4.1 Person/House)

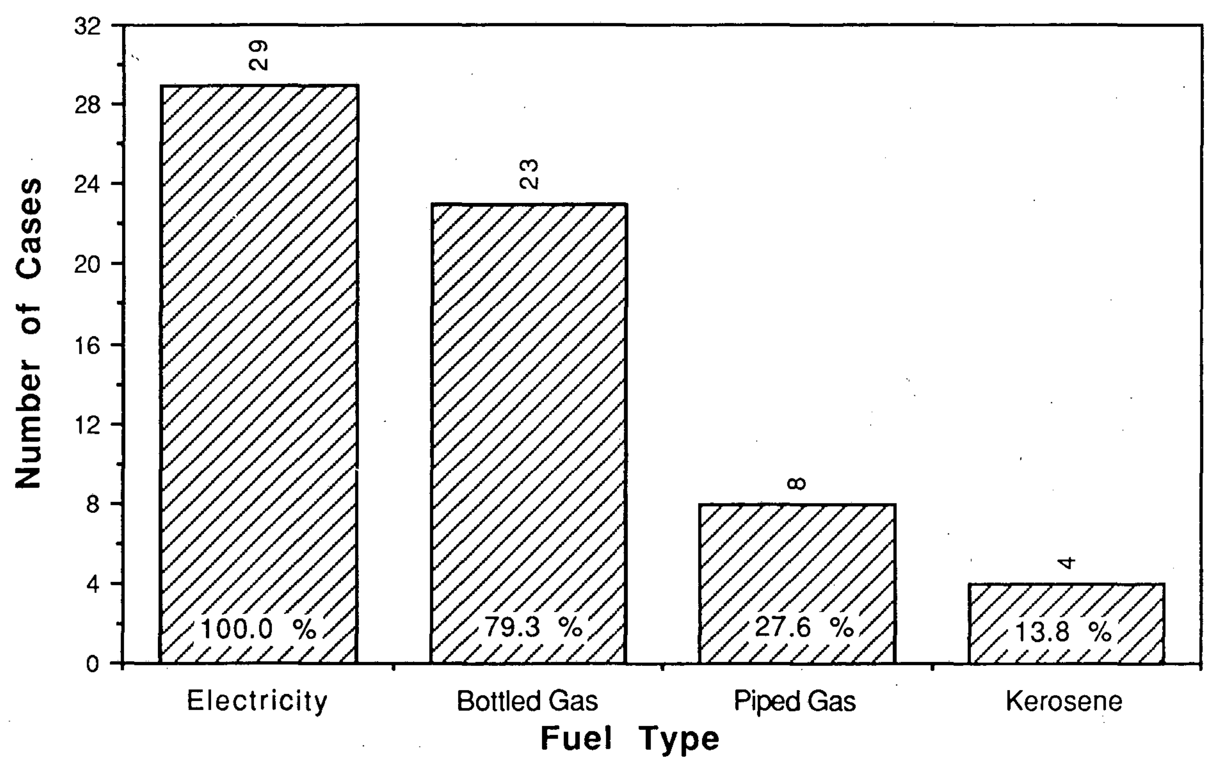


Figure 2: Types of Fuel in Household

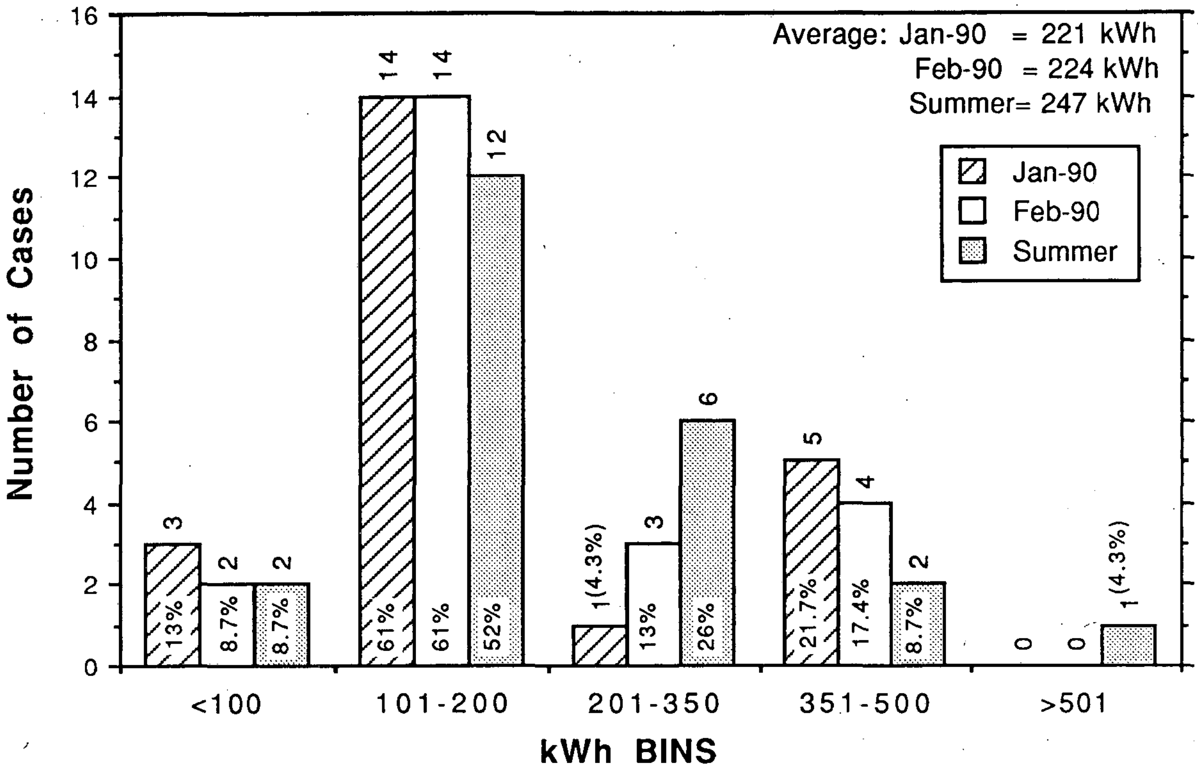


Figure 3: Distribution of Electricity Consumption for the 23 households of which data is available

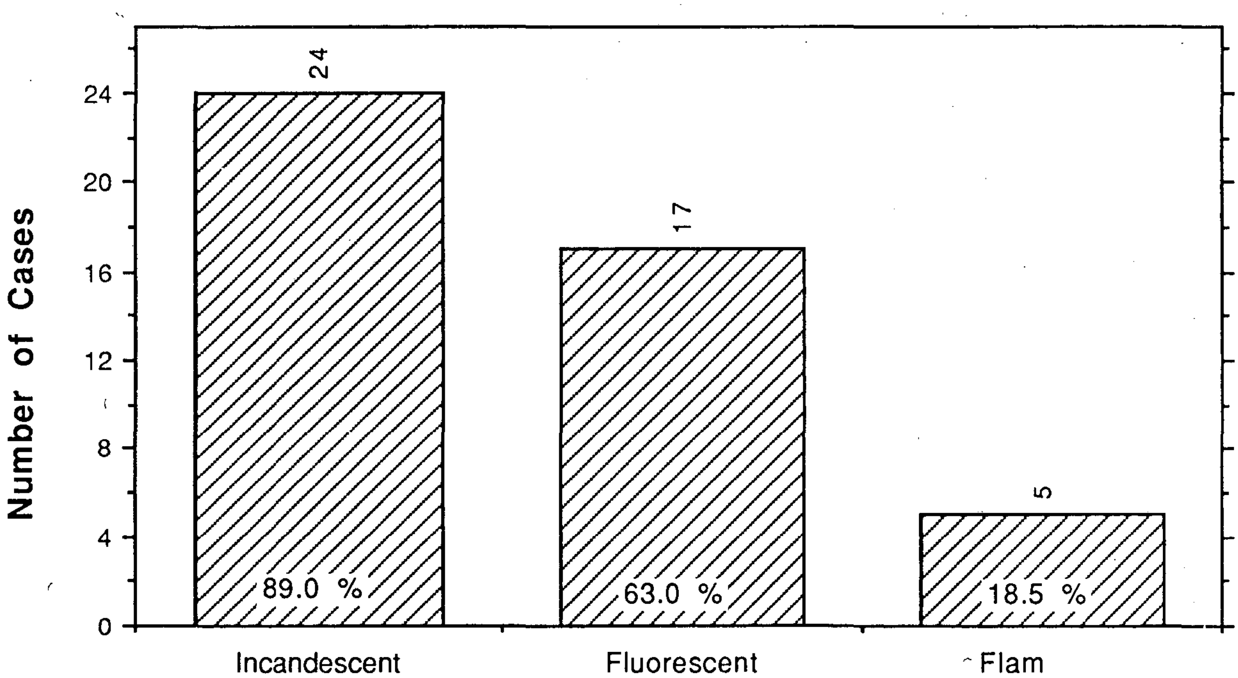
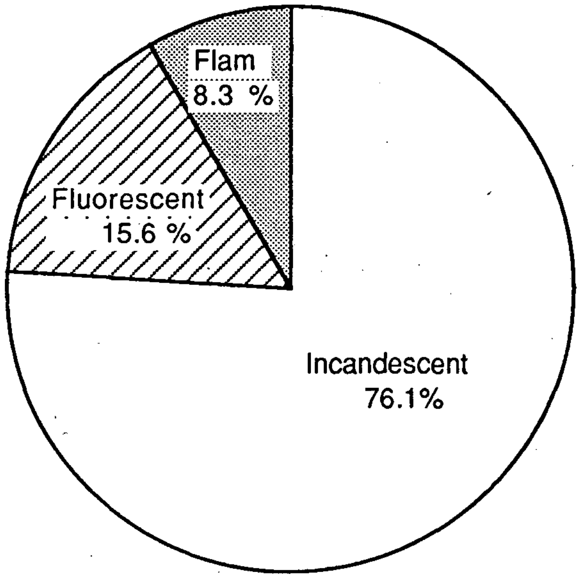


Figure 4: Lighting Type Distribution (Total of 27 Cases)



Average 785 W Installed
& 3.262 kWh/day
(1200 kWh/year)

Figure 5: Lighting Consumption Breakdown For an Average HouseHold in the OEP Survey (Total of 27 Cases)

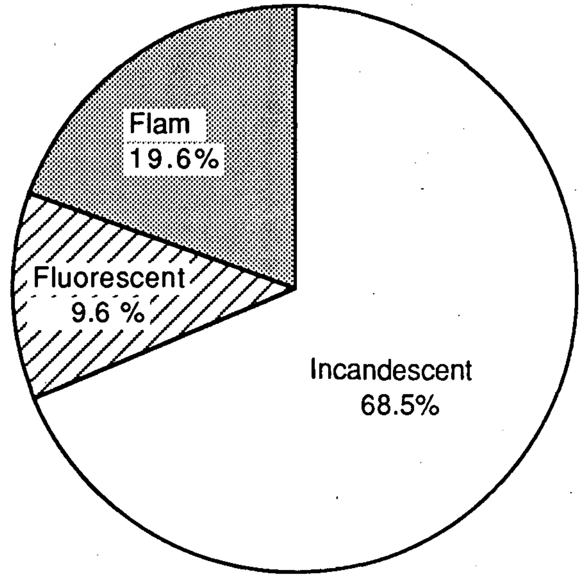
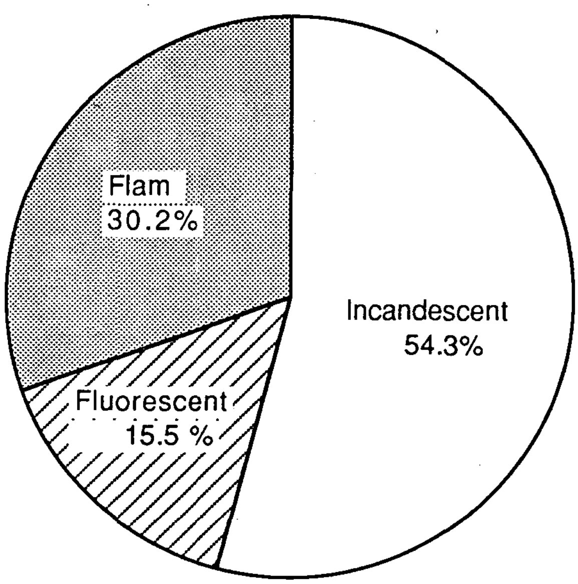


Figure 6: Installed Lighting Wattage For an Average Household in the OEP survey (Total of 27 Cases)



Average 1340 W Installed
& 4.83 kWh/day
(1760 kWh/year)

Figure 7: Lighting Consumption Breakdown for Households in OEP Survey that have Flam Bulbs (5 Cases)

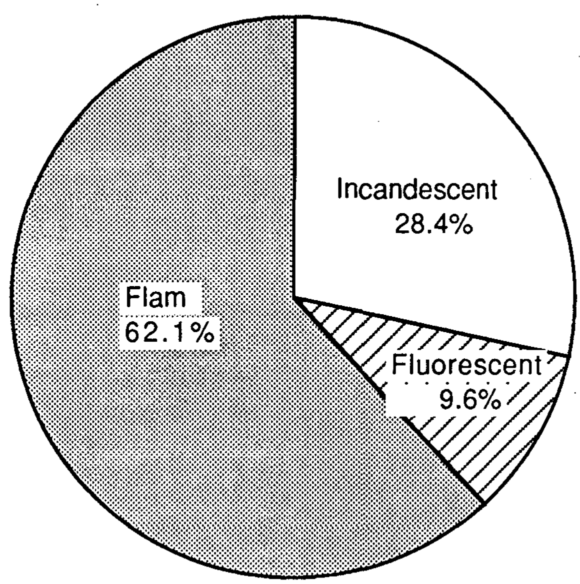
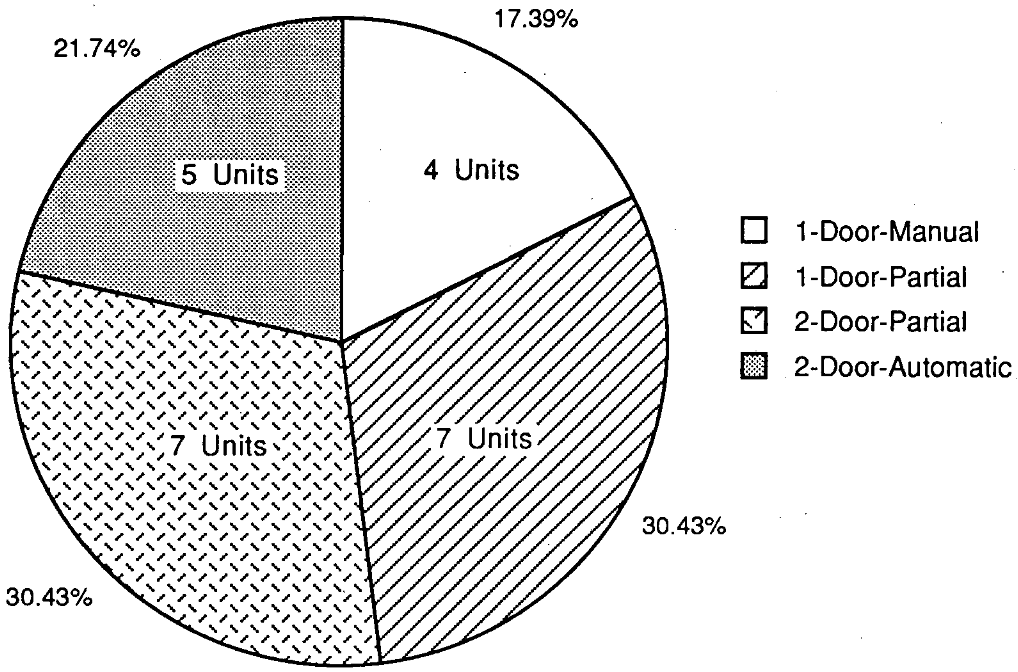


Figure 8: Installed Lighting Wattage for Households in OEP Survey that have Flam Bulbs (5 Cases)



Average Size: 300 liters (10.7 cu.ft.)
Average Age : 5.6 years

Figure 9: Refrigerator Types

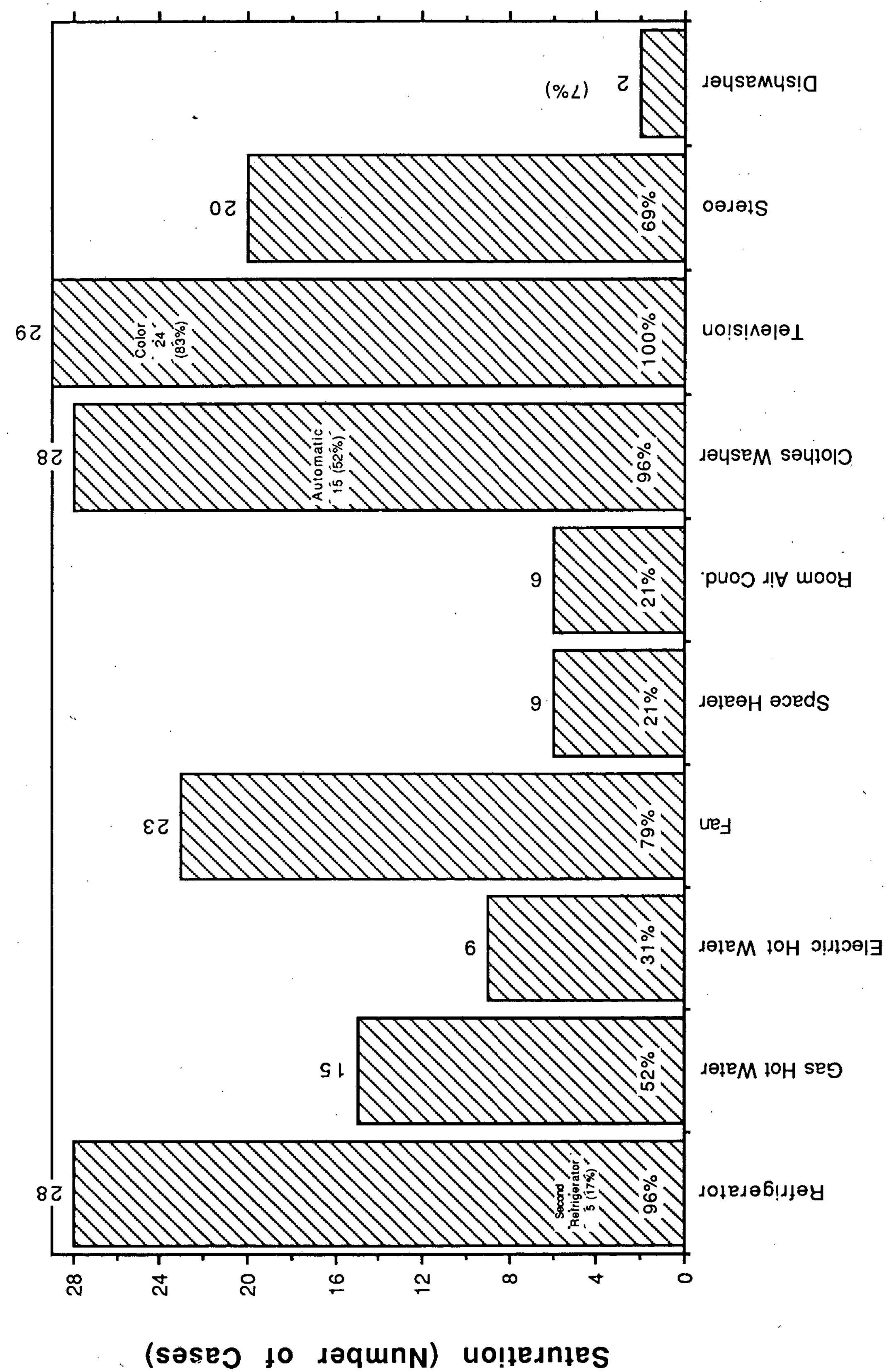
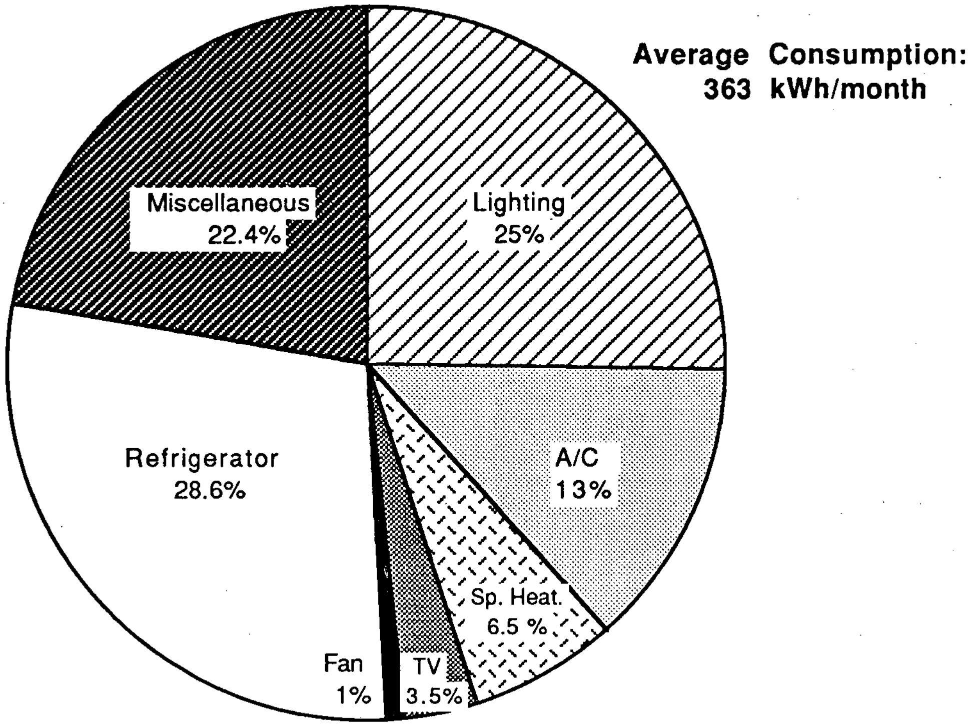


Figure 10: Saturation of Several Appliance Types

4 Cases with Air Conditioning



16 Cases without Air Conditioning

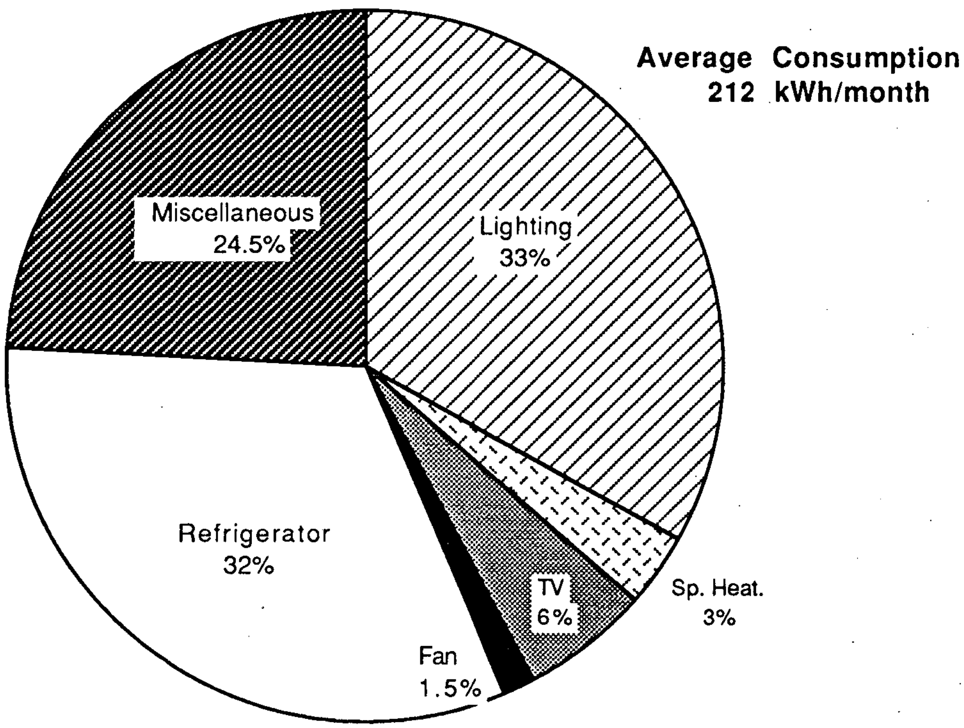


Figure 11: Electricity End Use Breakdown from the LBL-OEP Survey Data

Table 1: OEP Appliance Ownership and Usage Survey

ID #	# of Person in House	Elec-tricity	Piped Gas	Bottled Gas	Kero-sene	Electricity Jan-90 kWh	Electricity Feb-90 kWh	Electricity Summer kWh	Piped Gas Jan-90 m3	Piped Gas Feb-90 m3	Piped Gas Summer m3	Butane Jan-90 # of unit	Butane Feb-90 # of unit	Butane Summer # of unit
1	5	1	0	1	0	500	500	900	0	0	0	5	5	4
2	5	1	0	1	0	360	260	400	0	0	0	2	2	2
3	6	1	0	1	1	145	193	218	0	0	0	1.5	1.5	1
4	4	1	1	0	0									
5	4	1	0	1	0	180	175	130	0	0	0	1.5	1.5	1
6	3	1	1	0	0									
7	5	1	0	1	0	150	130	200	0	0	0	2	2	1
8	2	1	0	1	0	60	60	70	0	0	0	1.5	1.5	1
9	5	1	0	1	0	400	360	325	0	0	0	2.5	2	1.5
10	4	1	1	0	0									
11	5	1	1	0	0	350	350	200	15	15	15			
12	4	1	0	1	0	180	180	200	0	0	0	2	2	1
13	3	1	0	1	0	150	200	200	0	0	0	1	1	1
14	3	1	0	1	1	142	155	120	0	0	0	1	1	1
15	5	1	0	1	0	500	500	450	0	0	0	1	1	1
16	3	1	1	1	0	145	150	180	15	15	15	1	1	1
17	2	1	1	0	0									
18	3	1	0	1	0	191	210	232	0	0	0	4	4	3
19	7	1	1	1	1	150	152	160	60	60	50	1	1	1
20	2	1	0	1	0							1	1	1
21	6	1	0	1	1	174	178	160	0	0	0	2	2	
22	6	1	1	0	0	200	200	300	60	60	60			
23	5	1	0	1	0	100	100	100	0	0	0	1	1	1
24	4	1	0	1	0							0.5	0.5	
25	7	1	0	1	0	500	500	350				3	3	3
26		1	0	1	0	150	150	180				1.5	1.5	1
27	2	1	0	1	0	150	200	290				3	3	3
28	3	1	0	1	0	100	150	200				1	1	1
29	1	1	0	1	0	110	110	120				1	1	1
		29	8	23	4	23	23	23				23	23	21
Average:	4.07				Average:	221	224	247			Average	1.78	1.76	1.50
		100.0%	27.6%	79.3%		79.3%						79.3%	79.3%	72.4%

-54-

Table 1: OEP Appliance Ownership and Usage Survey

ID #	Incan. W	Incan. Conso. Wh/day	Fluor W	Fluor Conso. Wh/day	Flam W	Flam Conso. Wh/day	Lighting Total W	Lighting Wh/day	Refrigerator 1 Brand	Refrigerator 1 Type	Refrigerator 1 Vol Liters	Refrigerator 1 Age Yrs	Refrigerator 2 Brand	Refrigerator 2 Type	Refrigerator 2 Vol Liters	Refrigerator 2 Age Yrs	Freezer Brand	Freezer Type	Freezer Vol Liters	Freezer Age Yrs
1			240	1440	800	1600	1040	3040	5	2	380	9	1	1	250	15	2	1	224	6
2	2015	5130					2015	5130	0	3	588	7								
3	375	7875					375	7875	7	2	230	10								
4									0		1.5*0.6	10								
5			160	2560			160	2560	0	2	1.5*0.8	5	0	2	1.5*0.8	20				
6	950	650	175	595			1125	1245												
7	200	900	40	120			240	1020												
8	400	1390					400	1390	0	2	280	4								
9	685	2440					685	2440	4	2	406	4								
10									0	3	2.5*1.0	5								
11	480	2520					480	2520	1	3	336	2	1	1	280	10				
12	460	2300					460	2300												
13	100	300	280	1360			380	1660	1	2	224	10								
14	60	120	80	500			140	620	0	3	2.0*0.6	3								
15	1155	6475					1155	6475	1		270						3		80*50*50	
16	1000	2203	120	200			1120	2403	2	4	270	6								
17	1060	8550	80	560	1200	1080	2340	10190	4	4	350	9					2	1	250	3
18	480	1280	40	120	800	2640	1320	4040	4	4	330	7	1	1	210	18	4	1	170	10
19	120	280	200	880	1160	1580	1480	2740	1	1	210	5								
30	240	2040	80	720			320	2760	1	2	225									
21	240	3000	80	740	200	400	520	4140	1	1	250	6								
22	850	11900					850	11900	6	3	336	2								
23	380	1420					380	1420	1	3										
24			440	2000			440	2000												
25	660	1590	240	560			900	2150	8	4		4								
26	300	550					300	550	1	4		1								
27	980	920	160	520			1140	1440	6	3		2	9	1		30				
28	125	230	80	640			205	870	1	1	210	10								
29	1200	3000	32	192			1232	3192	1	1	210	2								
	24	24	17	17	5	5	27	27												
Average	14515	67063	2527	13707	4160	7300	21202	88070	Average		300	5.6	10.7		Average	18.6			Average	6.3
	68.5%	76.1%	11.9%	15.6%	19.6%	8.3%					210		7.5							
											588		21							

Refrigerator & Freezer Brands

1: Ideal
2: Iberna
3: Alaska
4: Philips
5: Kelvinator
6: Siltal
7: Minsk 10
8: Bosch
9: Westinghouse

Refrigerator Types	# of Door	Defrost Refrig	Defrost Freezer
1	1	man	man
2	1	auto	man
3	2	auto	man
4	2	auto	auto

Freezer Types

0: Manual Defrost
1: Automatic Defrost

Lawrence Berkeley Laboratory 7/2/90

Table 1: OEP Appliance Ownership and Usage Survey

ID #	Gas # of Burners	Oven 0=No 1=Yes	Cooking Hrs/day	Hot Water Type	liters	Power W	Gas HW Adjust. Therm.	Pilot	1=Bott 2=Pip	A/C Brand	A/C Power HP	A/C Hrs/Year	Heater Brand	Heater Power W	Heater Hrs/Year	Fan Brand	Fan Power W	Fan Hrs/Year
1	6		4	1			1	1	1	1	2.5	800	1	4000	180	1	60	720
2	4	1	3	1	10		1	1	1	0	2.5	300	0	2000	180	2	60	900
3	5	1	1	3									0	0		3	60	60
4	4	1	3	2	50		1											
5	3	1	4	0													60	900
6	4	1	4	1			0	1	2							1		900
7	4	1	4	1				1								1	100	700
8	4	1	2	1	10		1	1	1								60	660
9	4	1	2	1	5		1	1	1					2000	360	2	60	480
10	3		4	2	50		1											
11		1	3.5	2	50	1000	0											
12	2	1	3	1			1	1	2								60	450
13	4	1	4	5	50	1200	1									2	60	480
14			3	2	50	1200	0											
15	5	1	2	2	50		0									4	80	360
16	5	1	3	1			0	0	2	2	1.5	90				5	60	270
17	8	1	4	2	50		1			2	3	420				6	80	495
18	4	1	4	1		72000	1	1	1				1	1500	420	1,6,7,8	340	540
19	3	1	4	1			1	1	1							3	60	150
30	3	1	2	1	10		0	1	1									
21	3	1	3.5	1			1	1	1							1,2		420
22	4	1	5	1	5		1	1	2								100	1020
23	3	1	3	3														
24			5	2	70		1								40			300
25	4	1	3	2	50	1000	1									1		480
26	4	1	1	1	75		1		1								60	225
27	4	1	3	1			1	1	1	2	1.5	90	1	1000	60	3	60	450
28	3	1	3	4												2	60	840
29	4		3	2	50	1200	1											

Average 3.21 Hrs/day

Adjust. Therm.: 0=No 1=Yes; Pilot: 0=No 1=Yes

A/C: Average 340

Heater: Average 206.7

Fan: Average 536.4

Water Heater Types
1 : Gas
2: Electric
3: Using Cooking Stove
4: Using Kerosene
5: 2 + 3

A/C Brands
1: York
2: Koldair

Heater Brands
1: Olympic
2: Dimplex

Fan Brands
1: Toshiba
2: National
3: Sanyo
4: Shirif
5: Olympic
6: Sharp
7: Mistral
8: Calor

APPLIANCE OWNERSHIP AND USAGE SURVEY

To assist the OEP/LBL project for evaluating energy usage in the residential sector, we need your help in determining patterns of appliance usage in Egyptian homes. Your cooperation in providing information on your personal usage is requested. You do not have to sign the questionaire. The information you provide will be treated as confidential.

Please answer the following questions by circling Yes or No.

Introductory Data

1. What is the total number of persons living in the house?...............: __________ (01)

2. Do you use the following utility services or fuels?

-Electricity........................:	YES	NO	(02)
-Piped Gas..........................:	YES	NO	(03)
-Bottled Gas........................:	YES	NO	(04)
-Kerosene...........................:	YES	NO	(05)
-Other (specify)....................:	__________		(06)

3. Please fill up the following table with the consumption of energy for the last few months:

	January 90	February 90	Any Summer Month
Electricity (kWh)			
Piped Gas (m^3)			
Bottled Butane (size + number of units)			

APPLIANCE SPECIFICATIONS

--> LIGHTING

4. Indicate for each bulb in the house, the location, the electric bulb wattage and the average number of hours the bulb is used each day:

Bulbs	Type (incandescent/fluorescent)	Location	Watts (W)	Usage (hour/day)
Example	incandescent	Kitchen	100 W	6 hr/day
#1				
#2				
#3				
#4				
#5				
#6				
#7				
#8				
#				
#				
#				
#				
#				

--> REFRIGERATOR/FREEZER

Brand Name	# of Doors.	Defrost (Manual or Automatic)		.Age.	.Liters (or height and width in cm)
		in Freezer Compartment	in Refrig Compartment		
Example X	2	manual	Automatic	6yr	260 l.

--> COOKING

5. Do you use electricity for cooking?.......: YES NO (07)

If Yes, give total number of surface units.: ________ (08)
Indicate if Oven is electric.......: YES NO (09)

6. Do you use gas for cooking?...............: YES NO (10)

If Yes, give total number of burners.......: ________ (11)
Indicate if Oven is gas...........: YES NO (12)

7. What is the average number of hours you use your cooking appliance (in hours per day): ________ (13)

--> ELECTRIC SPACE HEATER
(which is not part of an air conditioner)

Brand Name	Power (W)	# Days Heating	Hr/day Heating
Example X	1500	35	6 Hours

--> FANS

Brand Name	Power (W)	# Days Used per Year	Average Hours/day when used
Example X	60	75	6 Hours

--> OTHER APPLIANCES

12. Do you have a Clothes Washer?.........: YES NO (18)

If, Yes, is it automatic?.............: YES NO (19)

13. Does the clothes washer heat water?...: YES NO (21)

14. Estimate washer load per week.........: ________ (22)

15. Do you have a Color Television?.......: YES NO (23)

16. Do you have a Black & White Television?: YES NO (24)

17. Average TV viewing hours per day......: ________ (25)

18. Do you have a Stereo?.................: YES NO (26)

19. Do you have an electric iron?.........: YES NO (27)

20. Do you have any other appliances?.....: YES NO (28)
(for example spin dryer, dishwasher...)

If Yes, can you list them?

When completed please return to Engineer **OSAMA NOUR EL DIN** by Tuesday, March 27 th, 1990.

Thank you very much for your cooperation.

--> DOMESTIC HOT WATER

8. Do you have an electric water heater.......: YES NO (14)

If Yes:

Brand Name	Capacity (in liters)	Power (in Watts)	Adjustable Thermostat (Yes or No)
Example X	50	1500 W	No

9. Do you have a gas water heater............: YES NO (15)

If Yes:

Brand Name	Pilot Light (Yes or No)	Input Power (specify units)	Adjustable Thermostat (Yes or No)	Type of Gas
Example X	Yes	6000 Btu/hr	Yes	piped

10. Do you heat water by other means than the two above?...........................: YES NO (16)

11. If Yes, can you specify (for example, solar, use of cooking stove...).: (17)

--> AIR CONDITIONER

Brand Name	Cooling Power (W)	Cool. Capa. (Btu/hr)	# Days used Cool.	Hr/day Cool. when used	Heating Power (W)	# Days used Heat	Hr/day Heat. when used
Example X	2250	20000	45	4 hrs	2500	35	6 hours

Appendix C

RESIDENTIAL APPLIANCE MANUFACTURING INDUSTRY EVALUATION

Section 1

INTRODUCTION

This report summarizes the information gathered on a three-week visit to Egypt from March 10 through March 29, 1990. With the assistance of the Egyptian Organization for Energy Planning, a number of manufacturing operations which produce energy-consuming appliances for the residential sector were visited. This provided insights into the type of products used in Egyptian homes, a feel for the sales volumes and selling prices of the appliances, and the capability of the existing Egyptian manufacturing infrastructure to produce energy-efficient appliances.

Many of the manufacturing operations in Egypt are in the public sector. These government-operated plants produce a wide range of products, ranging from ships to pots and pans. (A publication which describes all the public sector plants in Egypt has been forwarded to LBL.) While the public sector operations have dominated the consumer-product markets in the past, private industry is playing an increasingly significant role. This is providing the Egyptian consumer with a wider array of product choices. The increased competition reinforces the need for uniform test procedures, energy-use labeling, and minimum performance standards, so that consumers can make informed buying decisions. Also these activities can provide some control over the growth of the use of energy in the residential sector which is rapidly expanding in both a population and an economic sense.

In this report, there is a section for each appliance type. This includes:

- Section 2 - Refrigerators
- Section 3 - Air Conditioners
- Section 4 - Space Heaters
- Section 5 - Clothes Washers
- Section 6 - Water Heaters
- Section 7 - Ranges
- Section 8 - Lighting

The report is concluded with an overall summary (Section 9) of the author's observations.

Section 2

REFRIGERATORS

Two manufacturers which produce refrigerators were visited. They were:

• The Delta Industrial Company (IDEAL) (2 plants)	Public Sector
• Electrostar for Refrigeration Company (Zanussi and Elektrosuisse)	Private Sector

Other known manufacturers of refrigerators in Egypt include:

• El Nasr Electrical and Electronic Apparatus Co.	Public Sector*
• Alaska	Private Sector
• Siltal	Private Sector
• Ibernia	Private Sector

(*Phillips has a minority interest.)

<u>The Delta Industrial Company (IDEAL)</u>

IDEAL, a public sector company and the largest manufacturer of refrigerators in Egypt, produces refrigerators in two plants. The Almaza plant produces the "low price" end of the product line. They are "Egyptian" designs which consist of heat-formed plastic inner cabinets and door liners, welded cabinet assemblies, and cut-foam insulation. The refrigerators are devoid of features and constitute the bulk of IDEAL refrigerator sales. The plant has produced as many as 476,000 refrigerators per year (1987-1988 fiscal year), but current production is at about 300,000 per year. The plant is geared for high volume production, but many of the operations remain labor intensive. A new refrigerator design is planned which would include a foam-in-place cabinet with 1 inch of foam in the fresh food area and 2 inches of foam in the freezer area. A pilot production line of this design was set up in the factory.

Each year, the plant shops the world market for the best prices for their annual requirements for each of the major components, such as compressors and controls. As a result, the performance of the refrigerators varies from year-to-year depending on the selected suppliers. The units in production used Danfoss compressors, but in the engineering test lab, compressors from Japan and Yugoslavia were being tested. We saw refrigerator test data that indicated a wide range in kWh/day consumption for the various compressors that were being qualified. These tests were in accordance with Egyptian standards which appeared to parallel ISO standards. Mention was made of testing to "tropical" ambients of 43°C (110°F).

The other IDEAL refrigerator plant in Nasr City is set up to manufacture "upscale" refrigerator models. This plant is a modern hi-bay plant with excellent tools and equipment. The design is derived from "Bosch", a German concern. The cabinet is constructed of foamed-in-place flat panels which are then assembled to form the cabinet. The result is a product that has a somewhat patched up appearance of perceived low quality.

The Nasr City plant has the capacity to build 400,000 refrigerators per year, but production was shut down when we were there. It appeared to have been down for months. There was considerable rearranging and maintenance activity under way and we were told that it would be a month or more before production would be resumed. We learned that this massive plant produced only 50,000 refrigerators last year, about 12% of capacity. The reason expressed was that when consumers are interested in a low cost product they buy the lower-priced refrigerator manufactured in the other IDEAL plant. When consumers are willing to pay a higher price, they opt for the appearance, features (such as automatic defrost), and quality of other brands.

The Nasr City refrigerator plant is therefore somewhat of a white elephant. It is geared to produce a high volume of refrigerators for which there is little consumer demand. The level of rearrangement activity along with the presence in the plant of a large contingent from Bosch suggesting that changes were underway which could convert the plant to production of a more up-to-date design. Much of the equipment in the plant is of a generalized nature that could be used after such a transformation.

Electrostar for Refrigeration Company (Zanussi and Elektrosuisse)

The "Zanussi" refrigerator plant is an modern, well-lit, well-planned, and exceptionally clean facility that turns out about 85 full-size refrigerators per day (17,000 refrigerators per year). The refrigerator design is based of a foam-in-place cabinet with one inch of insulation in the fresh food area and two inches of insulation in the freezer compartment. The cabinets, doors, and heat-formed plastic inner cabinets and door liners are fabricated in the factory. They do not have an extruder, but they purchase sheet plastic from another private sector refrigerator manufacturer who has excess capacity. The limiting stations in the plant are the heat-former for the inner cabinet and inner door and the foaming chest. Doubling up on those stations would permit a doubling the plant output. The plant has about 75 factory employees and it appeared that two professionals (a plant manager and an engineer) were running the facility. This is in sharp contrast to the public sector plants which seemed to have a significantly higher overhead structure. Typical factory wage was stated to be 250 LE per month.

In addition to the electric-motor-driven compressor refrigerators, the plant produces small absorption refrigerators for homes, offices and hotel/motels based on Elektrosuisse designs. These refrigerators can be fired by either kerosene or by an electric heater. They were assembled on a separate line with the complete absorption refrigeration assembly sourced from an Italian supplier.

MISR Compressor Manufacturing Company

Currently all compressors used in refrigerators manfactured in Egypt are imported. A private sector company has been formed which plans to start producing reciprocating compressors for household refrigerators sometime in mid-1991. The compressors will be of Italian design (IRE, an affiliate of Phillips) and will be available in 5 to 6 capacities. An ongoing license agreement will provide for incorporating improvements that the licensor develops. The plan is to initially produce about 1,400,000 compressors per year. That volume is based on the number of compressors that are needed to supply Egypt for new refrigerators, replacements for failed compressors, and a certain quantity for export. Compressor replacements in Egypt run quite high due to motor failures resulting from poor regulation of supply voltages. The compressors produced by this operation can be used as replacements for failed compressors that occur in the existing inventory of refrigerators in consumers' homes regardless of brand. Initial pricing to refrigerator manufacturers will match the import pricing (about 100 LE). It is anticipated that once the factory is up and running that the borders will be closed to imports of refrigerator compressors and then the price to refrigerator manufacturers for the locally made product will be lowered.

Ultimately, it is anticipated that all refrigerators manufactured in Egypt will have to use compressors produced in the local plant. Therefore, the design choices made for this key component will have a significant influence on the energy-consuming charateristics of future refrigerator production for all of Egypt.

The compressors are the same as that now used in the Phillips refrigerators which are manufactured in the public sector plant in which Phillips has a minority interest. Tools for the soon-to-be-produced compressors are being sourced from the US and Europe. Practically all components of the compressor, with the exception of the compressor motor overload and steel for the valves, will be Egyptian-made. That includes the steel for the compressor shell, the castings, the magnet wire, the hermetic motors, etc.

Production of compressors in this new facility is expected to increase to 2,000,000 per year by 1995.

Proposed Test Procedures for Refrigerators

Based on a manufacturer's instruction manual, the Egyptian test standard for refrigerators carries the identification M.S.-320-1972. Existing Egyptian test procedures for refrigerators appear to parallel ISO standards. The areas of difference, if any, were not determined since we were unable to obtain a copy of the Egyptian standard. These procedures produce a kWh/day consumption which can be determined for a number of ambient temperature conditions. It is recommended, that if the Egyptian standard differs from the ISO standard, that consideration be given to adopting the ISO version. This would facilitate the potential for exports to countries which embrace the ISO standard.

Any adopted test procedure should also set minimum standards for fresh food compartment and freezer compartment temperatures. Some manufacturers refer to a star rating for freezer compartments which relates to the achievable freezer temperature and thus the ability to store frozen foods over an extended period of time. This star rating procedure, which is included in the ISO standard, may be part of the Egyptian standard, but this was not confirmed. Test procedures should also include a sweat test to assure adequacy of the cabinet insulation and door seals and the effectiveness of anti-sweat heaters, if used. Also, procedures for determining fresh food and freezer compartment volume would bring uniformity in that area. All of these areas are covered in the ISO standard for refrigerators.

Energy-Use Labeling

An energy-use label would assist consumers in making informed purchasing decisions. A label could include information such as:

Sample Refrigerator Label

Manufacturer	ABC Company
Model Number	XYZ

Fresh Food Volume	230 liter
Frozen Food Volume	70 liter
Total Volume	300 liter

Ambient Temperature	Annual Energy Consumption in kWh/year
Temperate (32°C)	700
Subtropical (38°C)	700
Tropical (43°C)	840

The label would list only those ambient temperatures for which the refrigerator has been qualified for use.

Supplementary Information

Supplementary information that has been forwarded to LBL includes the following:

- ALASKA Sales Brochure with tabulated specs and retail prices
- IBERNIA Sales Brochure with tabulated specs and retail prices
- IDEAL Instruction Manual for "Egyptian design" 280 liter model (in English)
- IDEAL Instruction Manual for "Bosch design" 308 liter model (in English)
- IDEAL Instruction Manual for "Bosch design" 235 liter model (in Arabic)
- IDEAL Compressor Specs for "Bosch design" 308 liter model
- IDEAL Compressor Specs for "Bosch design" 235 liter model
- SILTAL Sales Brochure (in Arabic)
- ZANUSSI Operating Instructions for 260 liter model (in English and Arabic)
- ZANUSSI Operating Instructions for 320 liter model (in English and Arabic)
- ELEKTROSUISSE Operating Instructions (in English and Arabic)
- ZANUSSI and ELEKTROSUISSE Sale Brochure with retail prices
- Photos showing production of ZANUSSI and ELEKTROSUISSE refrigerators

Section 3

AIR CONDITIONERS

Three manufacturers which produce room air conditioners and non-ducted mini-split systems were visited. They included:

• Nasr Engineering and Refrigeration Co. (KOLDAIR)	Public Sector
• Power	Private Sector
• Misr Air Conditioning Mfg. Company (MIRACO)	Private Sector

Nasr Engineering and Refrigeration Co. (KOLDAIR)

KOLDAIR, a public sector company, has produced air-conditioning equipment in Egypt since the 1940s. Products include room air conditioners, non-ducted mini-split systems, chillers, air handlers, evaporative coolers, and milk coolers. They also assemble top-loading, vertical axis clothes washers of Zanussi design. The plant fabricates the sheet metal parts, heat exchangers, fans and blower wheels. Compressors and motors are imported, some from the United States, but also from India. The designs of room air conditioners and ductless split systems are of about 1960 vintage so they are heavier (and thus more costly to produce) than state-of-the-art designs. In spite of this, they sell for lower prices in the market place than units produced by the private sector due to government-subsidized selling prices. While in the plant, all room air conditioner production was exclusively heat pump versions. There was a comment made that the production run of heat pumps was for export, possibly to Greece.

Power

Power is a private sector company which produces room air conditioners and non-ducted split systems under a license from Daikin, a Japanese manufacturer. Mini-splits are the most popular with the majority of sales in the 24,000 to 28,000 Btu/h capacity range. Almost all the parts are imported from Japan or the US, so the manufacturing, other than sheet metal fabrication, is basically an assembly operation. The sheet metal fabrication area included a computer-controller press which contributes to the production of consistent sheet metal parts.

The lack of significant contributed value results in a high product cost which limits their ability to garner a significant share of the market. Last year they produced about 3,500 units (about 18 per day). They are projecting 6,000 units (about 30 per day) for 1990. About 30% of their product is sold to commercial customers and the balance to residential customers. Selling prices are 35 to 50% higher than equivalent capacity equipment manufactured by KOLDAIR.

Copeland and Tecumseh compressors are used. Fan motors are from Emerson and A. O. Smith. Coils from Bohn are used extensively but they are adding US-made (Burr-Oak) coil-making equipment. To achieve lower costs for their mini-split systems they have developed an in-house design of indoor units which appears to be a knock-off of a US-produced Typhoon brand indoor unit. This indoor unit displays a decorative nameplate of "Power-USA" and does not have the highly stylized appearance of the Japanese designs. Heating in all air conditioning products is supplied by resistance heaters and heat pumps are not produced.

The plant also produces chillers, water-cooled packaged air conditioners, and air-cooled packaged air conditioners up to 30 tons on a low volume basis.

They have a somewhat reasonable test facility, but it was not of the calorimeter type. It is used primarily for production quality control since they do very little design work.

The average factory wage was reported to 400 LE per month.

Misr Air Conditioning Manufacturing Company (MIRACO)

MIRACO was established in 1979. In 1983, York International from the US became a partner and contributed significant assistance in the design and manufacturing areas. They have a modern, well laid out plant of approximately 135,000 square feet. A York manufacturing executive managed the plant for a number of years and, although now retired, he returns to Egpyt several times a year on a consulting basis to provide ongoing technical input. He happened to be in the plant during our visit.

MIRACO has a well-instrumented modern engineering laboratory with controlled ambient test rooms (both dry bulb and wet bulb) which, with minor modification, could be converted to a calibrated calorimeter facility. They plan to add improved instrumentation with data logging capability. This lab was by far the best air conditioning test facility that we saw in Egypt. We did have an opportunity to see a copy of the Egyptian room air conditioner standard (MS 585-1969) while in the laboratory. It was in Arabic, but there was an illustration that indicated the tests are based on measurements in a set of calibrated calorimeter rooms. Two alternatives for cooling ratings were provided. The "US-level" of 80/67 (26.7/19.5) indoor, 95/75 (35/24) outdoor and a hot climate rating at 85/74 (29.5/23) indoor, 102/85 (39/29.5) outdoor. Heat pump heating capacity is rated at 70°F indoor and 45°F/43°F outdoor.

MIRACO reported that the Egyptian Organization for Standardization and Quality Control does some checking of air conditioners for compliance to Egyptian standards, but this is mainly in the electrical safety area relating primarily to the electrical insulation integrity of motors. That is an area the standards group is familiar with, but when it comes to performance testing, they have neither the interest, technical know-how, or equipment to perform such investigations.

Products produced in the plant include room air conditioners, mini-split air conditioners, commercial unitary air conditioners up to 20-tons, and fan coil units and air handlers for use with chillers. They market chillers which are imported from York, USA.

MIRACO claims to be the leader in market share in Egypt with 30% share of the window air conditioner market and 70% share of the mini-split market. Their sales manager projected the following estimate of annual sales of window air conditioners and mini-splits by manufacturer:

MIRACO	40,000
KOLDAIR	30,000
Power	6,000
Carrier	4,000
Philco	3,000

This adds to 83,000 units per year, which the sales manager felt could reach as high as 100,000 in 1990.

MIRACO sells one size room air conditioner and three sizes of mini-splits. Retail selling prices which include delivery, installation, and a one year warranty are as follows:

Window air conditioner	17,000 Btu/h	1980 LE
Mini-split	13,000 Btu/h	2465 LE
Mini-split	18,000 Btu/h	2865 LE
Mini-split	24,000 Btu/h	3565 LE

MIRACO also provides product service throughout Egypt with an operation that has 200 employees and 55 trucks.

Average factory wages at MIRACO were reported to be 500 LE per month.

Air Conditioning Summary

The private sector in Egypt is capable of manufacturing state-of-the-art room air conditioner and mini-split air conditioners. This is assured for MIRACO, Carrier, and Philco due to their strong ties to major US manufacturers and Power due to it association with a major Japanese manufacturer. KOLDAIR products would need updating to compete effectively in a free market.

Proposed Test Procedures for Air Conditioners

The Egyptian standard test procedure should be modified to conform with the draft ISO standard for room air conditioners. This draft standard provides for testing at three ambient conditions. Test conditions for Egypt could be at condition "A" which is basically the US conditions of 80/67-95 with 110°F maximum load conditions. This would be suitable for units sold in the Cairo and the Nile Delta region. An additional rating test at ISO conditions "B" (84/67-115 with 125°F maximum load conditions) would provide rating information for the upper Nile and desert regions. Cooling capacity ratings in Btu/h and input ratings in watts would be appropriate since they appear to be widely used in Egypt. Efficiency ratings in terms of BTU/watt-hour (EER) would also be useful.

Energy-Use Labeling

Egyptians typically operate residential cooling products manually. That is they turn them on only during hot spells and then only when the living space is occupied. Therefore, the consumer has direct control on the hours of operation which could vary widely among consumers. Energy-use labeling should recognize this variable. When labeling is considered, the data should be in terms of kWh per year since electric rates vary widely with level of usage. A typical label could be as follows:

Sample Air Conditioner Label

Manufacturer	ABC Company
Model Number	XYZ

	Outdoor Temperature	
	35°C	46°C
Cooling Capacity in Btu/h	18,000	16,000
Input in Watts	2,000	2,200
Efficiency in EER (Btu/W-h)	9.0	7.3

Hours of Operation	Annual Energy Consumption	
per Year	kWh per year	kWh per year
200	400	440
400	800	880
600	1200	1320
800	1600	1760
1000	2000	2200

A comparable label could be used for the cooling performance of heat pumps, but would also have to include information on the heating mode (See Section 4 of this report).

Supplementary Information

Supplementary Information which has been forwarded to LBL includes the following:

- CARRIER writeup listed in US-exhibit pamphlet distributed at the Cairo Trade Fair
- CARRIER Spec Sheet for mini-split air conditioners
- "Introduction to MIRACO", a 2-page summary of the activities of MIRACO
- YORK/MIRACO writeup listed in US-exhibit pamphlet distributed at the Cairo Trade Fair
- MIRACO Spec Sheet for mini-split air conditioners (with retail prices)
- MIRACO Spec Sheet for room air conditioners (with retail prices)
- MIRACO Spec Sheet for commercial air conditioners
- MIRACO Technical Data Catalog for fan coil units
- MIRACO Technical Data Catalog for commercial air-cooled conditioners
- PHILCO writeup listed in US-exhibit pamphlet distributed at the Cairo Trade Fair
- PHILCO Spec Sheet for mini-split and room air conditioners (with retail prices)
- POWER Spec Sheet for mini-split air conditioners
- POWER Spec Sheet for room air conditioners

Section 4

SPACE HEATERS

Space heating requirements are somewhat limited in Egypt. Heating is required only for a fraction of the time, 3 months during the year. Space heating is supplied by small fuel-fired or electric-input heaters, by electric resistance heaters in air conditioners, and in some cases, by reverse-cycle heating from heat pumps. When we toured the KOLDAIR plant, all the room air conditioners on the assembly line were heat pump versions, but it is possible that the production run was for export. No other manufacturer indicated that they produced heat pumps for use in Egypt.

Electric space heaters come in a wide variety of forms. Olympic, a plant which also manufactures electric water heaters, also produces a line of electric space heaters. These include direct radiant, oil-filled radiators, and simulated fireplaces.

Because of the limited heating requirements, Egyptians typically operate these residential heating products manually. That is, they do not operate on thermostats and are typically turned on only during cool spells when the space is occupied. Therefore, the energy consumption is a function of the input and the hours of operation.

Proposed Test Procedures for Space Heating Equipment

The output of electric resistance heaters is readily determinable from the input data. The determination of heat pump heating output would require measurements in a test facility with controlled ambients, such as included in the draft ISO standard for room air conditioners. The output of non-vented gas heaters can also be readily calculated from the input, so testing would not be required. Vented gas heaters would require a measurement of the flue gas losses to determine thermal efficiency.

Energy-Use Labeling

A label for separate electric resistance heating equipment, or electric heaters included in air conditioners could be as follows:

Sample Electric Resistance Heater Label

Manufacturer	ABC Company
Model Number	XYZ

Heating Capacity: 3.6 kW
COP = 1.0

Hours of Operation per Year	Annual Energy Consumption in kWh per year
100	360
200	720
300	1080
400	1440
500	1800

For heat pump heating, a comparable label would be:

Sample Heat Pump Heating Label

Manufacturer	ABC Company
Model Number	XYZ

Heating Capacity: 7.0 kW
COP = 2.5

Hours of Operation per Year	Annual Energy Consumption in kWh per year
100	280
200	560
300	840
400	1120
500	1400

Energy-use labels could also be developed for fuel-fired space heaters with the energy consumption being expressed in terms consistent with the units used for pricing fuels.

Section 5

CLOTHES WASHERS

Two manufacturers which produce automatic clothes washers were visited. They included:

• The Delta Industrial Company (IDEAL)	Public Sector
• Alexandria Metal Products Company (ALEX METAL)	Public Sector

Both factories produced horizontal-axis, front-loading washers based on Zanussi designs. The IDEAL washers carry the IDEAL brand name and the ALEX METAL washers are identified with a ZANUSSI brand.

IDEAL produces clothes washers in the same plant which produces the "Bosch" refrigerator. It is a high-bay factory of fairly recent construction. Sheet-metal fabrication for both the refrigerators and washers is integrated, but separate linear assembly lines of several hundred meters in length are used to assemble the respective products. All sheet metal parts for the clothes washers are fabricated in the plant with the motors and controls being sourced from Zanussi. The outer tub and the rotating drum are stainless steel.

The ALEX METAL operation is basically an assembly operation with sheet metal parts sourced from IDEAL and motors and controls from Zanussi. There is one exception. The outer tube used by ALEX METAL is enameled steel fabricated in their plant instead of stainless steel. They explained that they formerly purchased the stainless steel outer tub from IDEAL, but due to delivery and cost problems, they decided to manufacture an enameled steel version in their factory. This approach was adopted because they already had a conveyorized enameling facility in place for their other products.

The washers, which are designed for a maximum load of 11 pounds of clothing, are connected to a cold water supply only and have a 1950 watt electric heater included which heats the wash water to a selected temperature level. All rinses are with cold water.

IDEAL produces two models of clothes washers, a unit with 14 selections and a premium model with 18 selections. The selections for the premium model are:

Fabric Type	Water Temp	Feature	Clothing Type	Comment	Number of Cold Water Rinses
Cotton/Linen	90°C		Whites - heavy soil	40°C Prewash	5
	60°C	Economy	Whites - heavy soil	40°C Prewash	5
	90°C		Whites - normal soil		5
	60°C	Economy	Whites - normal soil		5
	60°C		Fast colored		5
	40°C	Economy	Fast colored		5
	40°C		Non-fast colored		5
			Rinse only	Also bleaching	5
			Special treatments*		
Synthetics/Wool	60°C		Whites - heavy soil	40°C Prewash	3
	60°C		Whites - normal soil		3
	40°C	Economy	Whites - normal soil		3
	40°C		Delicates		3
	40°C		Woolens		3
			Rinse only	Also bleaching	3
			Special treatments*		
			Spin only	6 minutes	
			Drain		

* Used for adding "scent" to clothing. Was told this selection was rarely used by Egyptians, but is popular in Italy.

The 90°C water temperature setting for white cottons and linens is provided since the custom of the country that is followed in many households is that white clothes must be "boiled" to achieve sanitization. The economy cycles are available for those who will accept a lower wash temperature.

The "14-program" IDEAL washer has the same selections as the "18 selection" IDEAL washer except the four "Economy" lower water temperature selections are eliminated. The "18-selection" model also has half-load options which use less water and thus less energy is required for the cycle.

The "15-program" ZANUSSI washer made by ALEX METAL has the same selections as the IDEAL "14-program" washer plus one economy (60°C) wash cycle for cotton/linen-whites-heavy soil.

There are differences in the controls for the three washers. For example, the water temperature for the wash cycle is controlled as follows:

IDEAL	18-program	One adjustable thermostat
ZANUSSI	15-program	Heater on-time controlled by timer motor
IDEAL	14-program	Multiple thermostats

The technical data for the IDEAL "18-program" washer lists an energy consumption per cycle of 2.7 kWh. While not indicated, this is assumed to be the cotton/linen-whites-heavy soil selection. This energy consumption can be broken down as follows:

Prewash	24 L * 0.2642 G/L * 8.25 #/G * (104-68) =	1883.2 Btu
Wash	24 L * 0.2642 G/L * 8.25 #/G * (194-68) =	6591.3 Btu
		8474.5 Btu

Heat Water	8474.5 Btu/3412	2.49 kWh
Agitate (estimated 30 minutes)	(30/60) * 0.3	0.15 kWh
Spin (6 minutes)	(6/60) * 0.6	0.06 kWh
		2.70 kWh

Note that water heating dominates the energy consumption.

IDEAL indicated that the retail selling price for their automatic washers was about 1250 LE. This is in contrast to the small manually-filled washers which are widely used in Egypt which sell for about 185 LE. IDEAL produced 50,000 automatic washers in 1989 and expect to produce 80,000 washers in 1990. IDEAL also produces about 250,000 of the small manual-fill washers per year. ALEX METAL produced about 25,000 of the 15-selection model automatic washers in 1989. ALEX METAL indicated the following retail prices:

IDEAL 18-selection	1340 LE
ZANUSSI 15-selection	1260 LE
IDEAL 14-selection	1170 LE

Proposed Test Procedures for Automatic Washers

Test procedures for automatic clothes washers could be similar to US DOE procedures. That is to determine by test the kWh/load (including the energy input to the built-in heater) for the significant operating selections. The consumptions for the significant operating cycles could then be averaged in some manner to give a weighted energy consumption per cycle. Discussions with people at the factory indicated that normal usage in Egypt is about one 5 Kg (11 pound) load per person per week.

Energy-Use Labeling

A label for automatic clothes washers could be something along the following lines:

Sample Clothes Washer Label

Manufacturer	ABC Company
Model Number	XYZ
Number of 5 Kg Washer Loads per Week	Annual Energy Consumption in kWh/year
2	730
4	1460
6	2190
8	2920
10	3650

Supplementary Information

Supplementary information which has been forwarded to LBL includes the following:

- IDEAL "14-selection" model (Z935X) User's Manual (in Arabic)
- IDEAL "14-selection" model (Z935X) General Data
- IDEAL "18-selection" model (Z650X) Technical Data
- IDEAL "18-selection" model (Z650X) General Features and Wiring Diagram
- ZANUSSI "15-selection" model (Z734X) User's Manual (in Arabic)
- ZANUSSI "15-selection" model (Z734X) Wiring Diagram
- Control Panel drawing for Z650X and Z734X models

Section 6

WATER HEATERS

Two manufacturers which produce water heaters were visited. They included:

• Olympic	Electric
• Alexandria Metal Products Company (ALEX METAL)	Gas

Olympic

Olympic, a private sector company, produces electric water heaters with storage capacities in the 10 to 120 liter (2.6 to 32 gallon) size range. The product line includes the following:

	Storage Capacity		Heater Size
	Liters	Gallons	in Watts
Stone-lined	10	2.6	2000
	15	4.0	2000
	30	8.0	2000
	50	13.0	1200 or 2000
	80	21.0	1200 or 2000
	120	32.0	1200 or 2000
Stainless steel	40	10.6	1200 or 2000
	60	15.9	1200 or 2000
	100	26.4	1200 or 2000

In Egypt, residential sizes are generally considered to water heaters with a storage capacity of 50 liters or less.

Olympic water heaters are insulated with about 4 cm of urethane foam. They formerly built heaters with just an air gap between the tank and the outer cabinet. Adding foam insulation reduced daily energy consumption by 35 to 45%.

The water heaters are controlled by a non-adjustable thermostat with a fixed factory setting of 70°C (158°F). Based on an annual average of 20°C (68°F) for supply water, the recovery rates for a 1200 watt heater is 21 liters (5.5 gallons) per hour and for a 2000 watt heater is 35 liters (9.2 gallons) per hour. Consideration is being given to providing water heaters which have a user-accessible adjustable thermostat on the face of the unit.

Based on discussions with water heater factory personnel, hot water usage in Egypt was estimated at about 10 liters (2.6 gallons) per person per day. This is in contrast to the estimated US usage of about 15 gallons per person per day. In comparing these usage rates, it should be recognized that hot water temperatures in the US are usually at about the 135°F level. Also, since most clothes washers in Egypt are supplied with cold water and have a built-in heater, laundry requirements are not included in the Egyptian estimate for hot water usage from a water heater.

The dimensions of the 50 liter water heater are approximately 35 cm (13.8 in.) in diameter and 52 cm (20.5 in.) high. This provides a surface area of $3.14*35*52 + 2*3.14*35^2/4 = 7638$ cm^2 (8.2 ft^2). If we assume the 4 cm of foam has an R value of 8 per inch of thickness, the overall R value is 12.6. The hourly standby loss through the insulation is then 8.2*90/12.6=59 Btu. The stored energy is 50*.2642*8.25*90=9808 Btu. The standby loss through the insulation is therefore 59/9808=0.006 per hour. The actual loss would be slightly higher due to conduction losses through the connecting piping. This standby loss rate in the order of 1% per hour is comparable to the better US-type electric storage water heaters.

Olympic produces about 150,000 electric water heaters per year. Olympic also produces thermo-syphon solar water heaters which have sizes which range from a 120 liter (32 gal) tank to dual panel units with a 250 liter (66 gal) tank. The impression is that these are very low sales volume items. Retail prices vary from 1075 to 1600 LE.

Alexandria Metal Products Company (ALEX METAL)

ALEX METAL, a public sector company, produces two models of instantaneous gas water heaters with maximum outputs of 5 and 10 liters per minute. The water heaters consist of a vertical stackup of gas valve, burner, finned copper air-to-water heat exhanger, and a sheet-copper flue gas collector which terminates in a flue collar of about 5 inches in diameter. Preheating of the water is obtained by passing the inlet water through tubing which is bonded to the surfaces of the flue gas collector.

The gas valve/burner assemblies are sourced complete from a Spanish firm, Cointra Godesia. ALEX METAL fabricates the all-copper heat exchanger/flue gas collector which is dipped in molten lead to bond the tubing to the extended heat transfer surfaces. They also fabricate the painted steel casing.

The 10 liter unit is contained in a wall hung cabinet that is 26 inches high by 14 inches wide and 8 inches deep. The 5-liter heater is smaller in all external dimensions. The water heaters have a piezo-electric ignitor and are flow-actuated. The normal operation is to manually turn on the heater and dial in the desired hot water temperature level when hot water delivery is desired. The piezo-electric button is then pushed which ignites a standing pilot. The burner then comes on when water flow as dictated by the operation of the hot water faucet commences. The rate of water flow modulates the height of the gas flame in the burner and maintains some reasonable relationship between the hot water temperature setting and the delivered water temperature. The normal practice is to shut off the water heater (and the standing pilot) when not requiring hot water so, for all practical purposes, there are no standby losses.

The characteristics at maximum flow rates for the two models as given by rating plates are as follows:

Hot Water Output	Nominal Thermal Input	Nominal Rated Output	Implied Thermal Eff.	Implied Temp. Rise
5 liter/min (1.3 gal/min)	150 Kcal/min (600 Btu/min)	125 Kcal/min (500 Btu/min)	83 (83)	26°C (47°F)
10 liter/min (2.6 gal/min)	300 Kcal/min (1200 Btu/min)	250 Kcal/min (1000 Btu/min)	83 (83)	26°C (47°F)

More detailed specifications were obtained for the 10 liter model. The values for water temperature rise are as follows:

	Water Temperature Rise	
Water Flow Rate	Minimum Setting	Maximum Setting
10 liters/minute	10°C (18°F)	35°C (63°F)
7 liters/minute	10°C (18°F)	45°C (81°F)
5 liters/minute	10°C (18°F)	60°C (108°F)

The water heater specifications list the following gas flow rate and water presssure characteristics:

Heating value	Vol/hour	Input/hour	Input/minute
11,350 kCal/m^3	1.74 m^3/hour	19,750 kCal/hour	329 kCal/min
(1275 Btu/ft^3)	(61.44 ft^3/hour)	(78,336 Btu/h)	(1306 Btu/min)

Minimum water pressure for operation:

at 5 liters per minute	0.40 bar	(6 psig)
at 10 liters per minute	0.75 bar	(11 psig)

<u>Maximum water pressure:</u> 10.00 bar (147 psig)

Note these values are not completely consistent with the nominal values listed on the nameplate.

We learned in discussions with various people, that the water pressure in many Egyptian residences, especially in high-rise apartments can be quite low even to the point that an instantaneous, flow-actuated, gas water heater will not operate. Therefore, gas water heaters are viewed by many as a low operating cost, but unreliable form of water heating. Some residences will have both gas and electric water heaters. The gas water heater provides lower cost water heating, and the electric water heater provides a reliable backup.

ALEX METAL produces about 40,000 gas water heaters a year, split 50/50 between the two sizes. The 5-liter per minute model sells for 255 LE and the 10 liter model for 355 LE.

Proposed Test Procedures for Water Heaters

The water heater test for electric water heaters could be a simple standby test which measures the energy lost to the ambient over a 24-hour period. Recovery efficency for electric water heaters can be assumed to be 100%. With these as inputs, the kWh consumption per year could be calculated for a range of daily hot water consumption rates. For instantaneous gas water heaters, annual energy consumption could be calculated based on a thermal efficiency based on a steady-state test which ratios the delivered hot water to the input energy. A more realistic method would be based on a reasonable draw schedule which would include draws at various flow rates. This latter method would account for variations in efficiency during transient conditions and at various burner input levels and for thermal mass considerations.

Energy-Use Labeling

The annual energy consumption data could then be used for labeling which for electric water heaters would take a form such as the following:

Sample Electric Water Heater Label

Manufacturer	ABC Company
Model Number	XYZ

Storage Volume - 50 Liters
Temperature of hot water - 70°C

Liters per Day of Hot Water Usage	Annual Energy Consumption in kWh/year
20	600
40	1020
60	1440
80	1860
100	2280

The label for gas water heater could provide annual energy consumption rates at various daily usage rates in energy terms which are consistent with the way gas energy is billed in Egypt. It is not known if it is on a kWh, Btu, or cubic meters of gas basis. The label could be as shown below:

Sample Gas Water Heater Label

Manufacturer	ABC Company
Model Number	XYZ

Maximum delivery rate - 10 liters per minute
Temperature of hot water - 10°C to 60°C

Liters per Day of Hot Water Usage	Annual Energy Consumption in kWh/year
20	700
40	1400
60	2100
80	2800
100	3500

The annual energy consumption for gas-fired water heaters could alternatively be expressed in Btu per year or in cubic meters of gas per year.

Supplementary Information

Supplementary information that has been forwarded to LBL includes the following:

- User's Manual for 10 liter per minute gas water heater (in English and Arabic)

Section 7

RANGES

One manufacturer that produces gas ranges was visited. It was Alexandria Metal Products Company (ALEX METAL) which also produces gas water heaters, automatic clothes washers, and enameled cookware. The key production facility in the plant is the conveyorized enameling furnace which provides components for these various products.

The gas ranges consist of four surface units and an oven. A manual timer is included on the control panel. The oven includes a viewing window, an interior light, an overhead broil unit, and a rotisserie. There are no pilots and both surface units and oven are lit with matches. The oven does not have a thermostat, so the user must manually adjust the flame to a desired level.

The overall quality of the ranges was detracted by the fit of the oven door and the "feel" of the opening of the oven door. The oven door seal did not appear to be adequate, primarily due to poor dimensional control of the mating parts. The door operation was not smooth and in some cases when attempting to open doors on units on the assembly line, the whole range slid forward. On the other hand, there was intensive testing for potential leaks in the factory-assembled tubing which feeds the various burners in the range.

ALEX METAL produces 50,000 gas ranges per year in three models which have a choice of step-up features. Selling prices range from 315 to 500 LE depending on the feature content.

Proposed Test Procedures for Ranges

If test procedures are instituted, they probably should be limited to oven performance since surface unit performance is dependent on too many uncontrollable variables. This would provide an evaluation of the insulating qualities of the oven casing and the fit and adequacy of the door-to-cabinet seal. Test procedures paralleling US DOE procedures would be appropriate. The output of the test procedure would be the energy required per hour of baking time at a reasonable oven temperature level.

Energy-Use Labeling

An energy-use label for ovens could be as follows:

Sample Oven Label

Manufacturer	ABC Company
Model Number	XYZ
Oven size	50 liters
Hours of Oven Usage per Week	Annual Energy Consumption in kWh per year
5	520
10	1040
15	1560
20	2080
25	2600

The annual energy consumption for gas-fired ovens could alternatively be expressed in Btu per year or in cubic meters of gas per year.

Supplementary Information

Supplementary information which has been forwarded to LBL includes:

- Owner's Manual for an ALEX METAL gas range (in Arabic)

Section 8

LIGHTING

Since it is expected that Steve Nadel will cover the topic of "Lighting" in great detail, the presentation in this report will be quite brief. These are based on visits to two plants, namely:

• Al Sharif	Fluorescent and incandescent lamps
• Mostafa Ali Company	Ballasts and fixtures

Al Sharif is a state-of-the-art lamp manufacturing facility that is highly automated. It has the capability of producing high-efficiency lamps in a variety of forms and configurations. It is exploring the production of electronic ballasts which have low losses and high power factors.

Mostafa Ali produces quality lamp fixtures for both indoor and outdoor installations. It also is a major producer of ballasts. They are also exploring the possibility of producing electronic ballasts. The factory is well equipped with excellent specialized production equipment, but due to the diversity of product, it is not as well automated as the Al Sharif factory.

Both factories are capable of manufacturing lighting products at the leading edge of technology, but their production is driven by consumer demand. Until there is a conservation ethic developed in the lighting area, low first cost will be the strongest consumer motivation. Higher energy prices, consumer education, product labeling, and minimum performance standards are all needed to reduce energy consumption and improve power factors in the lighting sector. The manufacturing capability in Egypt, as demonstrated by these two operations, is well capable of supporting moves in this direction.

Section 9

SUMMARY

Introduction

The Egyptian economy is moving more and more toward privatization of industry. For the most part, the private manufacturing operations have more up-to-date manufacturing facilities which produce higher quality products with fewer workers and a lower overhead structure. In spite of some of their shortcomings, the public sector plants enjoy major shares of the market, primarily due to government price subsidies which make their products more affordable to most consumers.

Production Efficiency

In contrast to the newer private sector plants, the older public sector plants are less efficient from direct labor and material flow considerations, have a much larger overhead structure, pay less attention to quality, and exhibit poorer housekeeping practices. These older plants produce products which are a generation or more behind from both feature and technology standpoints.

In both private and public sector plants, labor costs are relatively insignificant with the product cost being dominated by purchased material costs. Labor rates are somewhat higher in private sector plants, but labor costs per unit are still low compared to direct material costs and therefore a strong incentive to increase worker productivity is currently lacking.

If labor costs escalate, many of the public sector plants will need to improve their productivity if they wish to maintain their current manufacturing cost position relative to the private sector plants. This will include improved plant layouts and mechanization to minimize material handling labor costs, product designs which are more conducive to automation of parts fabrication and assembly operations, and the reduction of burdensome overhead structures. The private sector brings a strong infusion of manufacturing and product technology from the US, Europe, and Japan which embodies many of these needed concepts which should be emulated by the public sector plants.

Quality Control

Quality considerations cover many areas, including product design concepts, testing of engineering prototypes, incoming inspection of purchased materials, control of fabrication processes, assembly-line testing of each product, and the more thorough audit testing of production samples. In general, there was more attention paid to these quality areas in the private sector plants.

Quality concepts must be designed into a product. For example, the specification of corrosion resistant materials for component parts subjected to moisture. Product designs must be subjected to thorough engineering tests prior to production. Most plants had very limited laboratory facilities available for this design testing. For the most part, the private sector plants depend heavily on their foreign affiliates for these functions.

Facilities and equipment for testing and inspection of incoming material were usually not evident. This is especially important for those manufacturing operations which shop the world for the lowest prices for their purchased components and thus undergo frequent changes in suppliers.

Many of the public sector plants exhibited insufficient attention to housekeeping practices. This usually results in decreased quality in the produced product since it is easier to instill in the factory employees a concern for quality in a neat, clean, and orderly facility.

In some plants, products, such as refrigerators with smudges on the inner and outer cabinets, were observed being packaged for shipment. This was also noted on some products displayed in retail stores which, while new, appeared to be used appliances. On the other hand, in some plants, the products were cleaned and wiped down repeatedly prior to packaging to remove all unsightly vestiges of the manufacturing operations.

Plant Safety

Safety practices are quite lax in both private and public sector plants. No evidence of the use such fundamental precautionary measures, such as safety glasses or safety shoes, were apparent. Many welding and brazing operations were observed where the operators did not wear safety goggles. Basic press safety procedures were lacking.

Product Testing and Labeling

At present, energy rates in Egypt are heavily subsidized and are relatively low, especially for consumers which have a low monthly consumption. There is relatively little financial incentive, in the form of payback resulting from lower energy costs, for a consumer to consider energy-efficient appliances. A high-ranking government official stated that Egypt will move to non-subsidized energy pricing within a five year period. While pricing differentiation based on energy usage will continue, the overall level of energy costs will rise significantly.

Because of the wider variety of consumer products that are becoming available and the certainty of higher energy costs for the consumer, the early implementation of a program which includes uniform test procedures for appliances and energy-use labeling has considerable merit. The need for uniform test procedures and energy-use labeling is reinforced by the looming possibility of an Arab-nation common market patterned after the European common market. Free trade among Arab nations would present both challenges and opportunities to Egyptian industry. An orderly appliance rating system could minimize the marketplace confusion that could arise when appliances are exported and imported freely among participating nations.

Energy-use labels should state annual consumption in energy terms, but could also be presented as annual energy cost in Egyptian pounds. The latter approach does present some problems since energy rates vary so widely in Egypt depending on usage levels and it is anticipated that energy costs will rise sharply in the next decade as government subsidies are reduced.

Once such a program is in place for a period of time, minimum performance standards could be implemented which would weed out the lower percentile products. The Egyptian manufacturing infrastructure, with its close ties to US, European, and Japanese technology, is capable of producing energy-conserving, state-of-the-art consumer appliances, but needs the incentive provided by a well-structured energy-use rating and labeling program to gravitate in that direction.

To implement such a program requires that the role of the Egyptian Organization for Standardization and Quality Control be strengthened. Test standards for consumer appliances need to be updated or added. When available, International Standards Organization (ISO) formatted test procedures are recommended. This will provide rating procedures similar to those used by European manufacturers and will enhance the opportunity for export shipments to Europe, the Middle East, and other African nations. Modifications of US Department of Energy test procedures should be considered for products not covered by ISO. To monitor compliance with prescibed procedures will require improved testing facilities especially for products which are influenced by climatic conditions, namely air conditioners, heat pumps, and refrigerators. While manufacturers may opt to install their own test facilities, the Egyptian Organization for Standardization and Quality Control should have adequate facilities at their disposal for compliance testing. Competent technical support in the design, installation, and qualification of improved testing facilities and the training of operating personnel is available from the professional staff at the engineering departments of the University of Cairo.

Conclusion

In this report, a number of opportunities for improving the production efficiency, product quality, and performance of appliances produced for sale in Egypt were identified. In general to improve production efficiency and product quality, the older public sector plants should embrace many of the more up-to-date concepts exhibited the facilities, processes, and products of the newer private sector operations. Uniform testing procedures for rating the performance and energy use of the appliances supported by third-party audit testing for compliance, followed by the implementation of a product labeling program, would provide consumers with reliable information to guide them in their value judgments. Ultimately, minimum efficiency standards could be introduced to remove the less efficient products from the marketplace.

REPORT
ETL TESTING LABORATORIES, INC.

INDUSTRIAL PARK CORTLAND, NEW YORK 13045

Order No.: 54046-H Date: April 25, 1990

REPORT NO. 498790

RENDERED TO

LAWRENCE BERKELEY LABORATORY

EGYPT TRIP REPORT

Appendix D

General

This report contains the observations and recommendations made by Mr. Lawrence R. Wethje, P.E. of ETL Testing Laboratories, Inc., during a two week visit to Egypt. Mr. Wethje was part of a team of United States representatives sent to Egypt to consult with their Organization for Energy Planning (OEP) regarding Egyptian energy policies, specifically with respect to residential appliances.

The U.S. team was assembled and directed by Dr. Isaac Turiel of Lawrence Berkeley Laboratory (LBL). The team consisted of Dr. Turiel, Mr. Benoit Lebot of LBL, Mr. Joseph Pietsch engineering consultant, Mr. Steven Nadel of the American Council for an Energy-Efficient Economy, and Mr. Wethje of ETL.

ETL was subcontracted by LBL to participate on the team. Mr. Wethje's visit to Egypt occurred between March 9, 1990 and March 23, 1990.

ETL's role was to provide consultation and recommendations related to Egyptian test facilities and test procedures. ETL also provided a limited measurement of energy consumption by refrigerators in the field.

SINCE 1896

Observations

Several factories and organizations were visited while in Egypt. A summary of the specific observations made at each visit was provided as a separate document to LBL.

In essence, it was observed that performance testing of appliances within Egypt is given very low priority. In general, the current test facilities are not properly designed or equipped to provide reliable test results. There is very little attention given to the calibration of instruments, and there is no third party verification of the performance of residential appliances.

Recommended Certification Program

Based on the above observations, and those of the other members of the U.S. team, it is recommended a third party certification program be established to verify the performance of residential appliances. Due to the lack of independent laboratories within Egypt, it is suggested that either OEP or the Egyptian Organization for Standardization and Quality Control be expanded to administrate the certification program.

A performance certification program typically allows the manufacturers to determine their own ratings by testing at least two samples per model, using either their own test facilities or others. The administrator of the program then publishes the model listings of all participants in a directory, with their respective ratings, updated twice per year. The models listed in the directory are subject to random follow-up verification tests by the administrator, selected from the manufacturers production stock. Typically one sample of between 1/3 and 1/2 of the models listed in the directory are randomly tested each year.

Based on approximately 40 room air conditioner models and about 50 refrigerator models produced within Egypt, one facility could be designed to test both refrigerators and room air conditioners, which would adequately handle the test load of a certification program. There would still be ample facility time available for research and development testing.

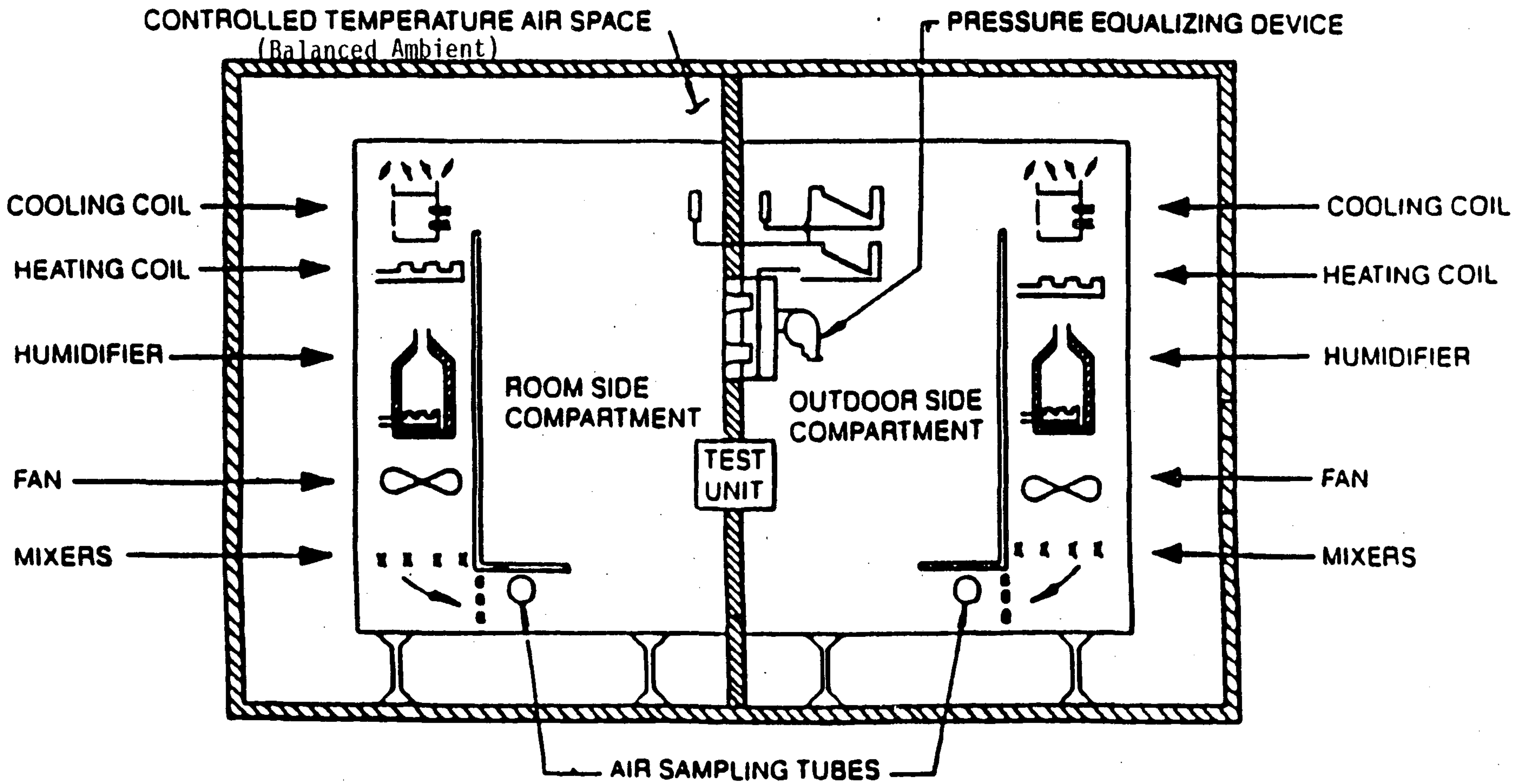
Recommended Test Facility

It is recommended the testing be conducted in a balanced ambient room-type calorimeter. A simplified schematic of a test facility is shown in Figure 1, as taken from the International Organization for Standardization (ISO) 5151 standard entitled "Room Air Conditioners and Heat Pumps - Testing and Rating".

The proper design of a balanced ambient room-type calorimeter requires automatic data acquisition and room temperature control. Sophisticated instrumentation, computer systems, and electronic controls should be incorporated to provide simple operation of the facility, with excellent repeatability and accuracy of test results.

ETL offers three options, as outlined below, for the development of such a test facility:

1. "Turn-Key" facility - This would provide a completely assembled and fully debugged test facility, inclusive of all hardware, software, and travel, necessary to get the facility operational. The facility would be erected and operated in the U.S. first, then shipped and reassembled in Egypt. The budgetary cost for a turn-key balanced ambient room-type calorimeter, designed to test refrigerators as well, is about $875,000 U.S. dollars. This fee also includes expenses for two personnel from Egypt to visit ETL for one week of training.



Typical Balanced Ambient Room-Type Calorimeter

Figure 1

A generic detailed proposal for a turn-key calorimeter facility to test room air conditioners is included with this report as Attachment A. The proposal does not necessarily reflect the exact design needed for Egypt. It is only included to provide a more detailed description of a typical calorimeter test facility, and the requirements necessary, from both the client and ETL, to develop a facility. Several specific design requirements would need to be discussed before a firm proposal and price could be quoted.

2. Facility design, including all electronics and software - This would provide the complete engineering design prints, and mechanical equipment specifications. Also included would be all electronic hardware (computers, transducers, controls, etc.). The data acquisition system would be assembled and debugged in the U.S., then shipped to Egypt. The budgetary cost for this option is about $375,000 U.S. dollars. This figure includes expenses for two personnel from Egypt to visit ETL for one week of training. It also includes the necessary travel by ETL personnel to visit Egypt to get the data acquisition system "on-line".

3. Facility paper design only - This would provide the complete engineering design prints, with all mechanical and electronic equipment specifications. No hardware, software, or electronics would be provided. The budgetary cost for the paper design only is about $95,000. The only travel included in this figure is for ETL personnel to visit the site of the facility location in Egypt at the start of the project.

The budgetary prices included in the above options are estimates only, based on discussions with ETL's Facility Design Division. Several specific design requirements would need to be discussed before a firm proposal and price could be quoted.

Facility Manpower Requirements

To administrate a certification program for refrigerators and room air conditioners in Egypt, one full time engineer and two technicians would be required. It would be recommended that these personnel visit ETL in the U.S. for one week to experience certification program activities first hand. Option numbers one or two under "Recommended Test Facility" include expenses for two personnel from Egypt to visit ETL for one week of training.

Test Procedures

This area is adequately discussed in Mr. Joseph Pietsch's report dated April 13, 1990. ETL agrees with the observations and recommendations outlined in his report.

Field Data

While in Egypt, two household refrigerators were field monitored for electric energy consumption over a 24 hour period, using ETL's portable watt-hour meter (a Scientific Columbus watt hour transducer connected to a mechanical totalizer).

The first refrigerator was at the home of OEP engineer, Mr. Osama Nor-el-din. It was a two door, top freezer, partial automatic defrost (refrigerator only), 270 liter (9.6 cubic feet), made by Iberna. Over a 24 hour period the unit consumed 1,972 watt-hours in an ambient of about 23°C (73°F). The unit was heavily loaded and used normally by Mr. Osama's family during the metered period.

The second refrigerator was at OEP headquarters, seventh floor. It was a single door, 224 liter (8 cubic feet) unit, with an internal freezer compartment of 28 liter (1 cubic foot), made by Ideal. Over a 24 hour period, the unit consumed 820 watt-hours in an ambient around 21°C (70°F). It should be noted that this unit was very lightly loaded, with very few door openings during the metered period.

Report Prepared by:

Lawrence R. Wethje, P.E.
Manager
Heating/Mechanical Division

Report Reviewed by:

James R. Williams
Vice President
Facility Design Division

Copied by: tks
Checked by:

ETL TESTING LABORATORIES, INC.

SINCE 1896

ATTACHMENT A

A GENERIC PROPOSAL FOR A ROOM AIR CONDITIONER CALORIMETER TEST FACILITY

MAY 14, 1990

Prepared By Louis Fiske
Manager, Engineering Services
ETL Testing Laboratories, Inc.

ETL
SINCE 1896

FOREWORD

ETL Testing Laboratories, Inc., established in 1896, has earned a reputation as one of the finest independent testing laboratories in the world. ETL's operations are international in scope and its credentials are accepted world-wide.

ETL's experience has been particularly intense in the environmental testing business, especially in the air conditioning and refrigeration areas, over the past several decades. This experience has developed into a broad depth of expertise which is difficult to be found elsewhere in the environmental testing field.

ETL has performed testing for the Association of Home Appliance Manufacturers (AHAM) for over 20 years. We have designed and built all of our own test facilities, including two room air conditioner calorimetric facilities and a household refrigerator test facility which we have successfully operated for the past 15 years.

ETL completed the design of an entire laboratory complex for a company in Saudi Arabia. The complex consisted of several test facilities including a multi-faceted Acoustical Test Facility, Unitary Air Conditioning Test Facility and two Room Air Conditioner Calorimetric Test Facilities. We have just completed a RAC Calorimeter Facility Design and a Psychometric Test Facility design for two different United States manufacturers. The Psychometric design includes a state-of-the art data acquisition system which is an update of the system we have used in several of our own facilities for the past five years.

During 1988 ETL designed a new RAC Calorimeter, with data acquisition and control, for a Middle Eastern Government Standards Laboratory. Successful installation of this project was completed during November of 1988.

ETL, because of our knowledge and experience gained from involvement with many major U.S. Manufacturers, has evaluated and participated as consultants in a variety of industry design efforts.

SINCE 1896

CONTENTS

Section	Page Numbers
Technical Specifications	1-5
Major Components Supplied by ETL	6-10
Assumptions and Exclusions	11-12
Fee	13
Appendix I - Warranty	14
Appendix II	15-17

SINCE 1896

SECTION 1

TECHNICAL SPECIFICATIONS

ETL offers the following project specifications for a test facility design capable of room air conditioner testing. The specifications consist of two parts. The first is an outline of the proposed design of the test facility. The design will be complete with detailed material listings.

The facility will be a balanced ambient room-type calorimeter which will be able to test various air cooled room air conditioners such as window, console, split systems, or through the wall type units for testing in accordance with the performance requirements of ISO Standard R859-1968, entitled Room Air Conditioners and Heat Pumps - Testing and Rating. The test facility shall be designed for the testing of room air conditioners with air cooled condensers only; therefore any sections of the standard referencing water cooled condensers, steam heating or hot water heating shall not apply.

CAPACITIES AND ACCURACIES

Test Unit Capacities:	Cooling: (to be decided) KCAL/Hr. Heating: (to be decided) KCAL/Hr.
Repeatability:	Test results repeatable within 1.0% based on identical test conditions for rated test unit capacities.
Heat Balance:	Heat balance within 4.0% for rated test unit capacities. when the test rooms are completely stabilized.

I. DESIGN DESCRIPTION

A. Insulated Test Room - An insulated room that is divided by a barrier wall effectively creating two adjacent rooms, one being the room side compartment and the other the outdoor-side compartment. ETL will specify and procure the room. The insulated test room will be assembled at the client's site using modules supplied by ETL.

The test room will be enclosed in a controlled temperature air space to aid in maintaining the test room ambient conditions.

B. Test Room Reconditioning Equipment - Will include an individual design for both the outdoor-side compartment and the room-side compartment. The following is a listing of the systems and their component items.

1.0 Room-side Compartment:

1.1 The Air Reconditioning and Distribution System will consist of the following:

a. blower(s)
b. air mixer
c. steam generators
d. electric heater
e. auxiliary cooling coil
f. all necessary control equipment directly compatible with the ETL Data Acquisition/Control System.

1.2 Steam Generator Water Supply Measuring System:

a. metering tubes with data acquisition
b. valves

1.3 Air Temperature Sampler System:

a. air sampling device
b. psychrometric box
c. wet bulb mercury-in-glass thermometers
d. dry bulb mercury-in-glass thermometers
e. platinum RTD thermometers (to be used with the ETL Data Acquisition/Control System.)
f. blower
g. ducting

1.4 Auxiliary Air Cooled Refrigerant Condensing Unit - to be located near the facility, with necessary accessories to provide auxiliary cooling for:

a. room-side compartment
b. controlled temperature air space cooling system

SINCE 1896

I. DESIGN DESCRIPTION (Cont'd)

2.0 Outdoor-Side Compartment

2.1 Air Reconditioning and Distribution System:

a. blower
b. air mixer
c. cooling and dehumidifying coils
d. auxiliary heaters
e. air flow control devices
f. necessary control equipment directly compatible with the ETL Data Acquisition/Control System.

2.2 Air Temperature Sampler System - as described above for the room-side compartment.

2.3 Seven and one-half HP Chilled Water System - to be located near the test facility:

a. air cooled water chiller
b. evaporator pressure regulator
c. a hot gas bypass/liquid quench system (to insure proper system operation under all load conditions dictated by test facility requirements).
d. mass flow meter for water flow
e. platinum RTD thermometers
f. all necessary control equipment directly compatible with the ETL Data Acquisition/Control System.

C. Test Unit Air Leakage Balancing/Air Flow Measuring Apparatus: (Maximum measurable airflow is 10 CFM):

a. nozzles for the room-side and outdoor-side compartments
b. blowers for the room-side and outdoor-side compartments
c. manometers, etc.

2.4 Airflow measuring apparatus to be installed permanently in the outdoor side compartment:

a. auxiliary blower
b. airflow measuring nozzles
c. air temperature sampling system
d. platinum resistance thermometers
e. electronic blower speed controller (to be installed outside the calorimeter)

ETL
SINCE 1896

II. DATA ACQUISITION AND CONTROL SYSTEM - (See Note (1) below)

ETL will supply, fabricate and test a Data Acquisition/Control System designed specifically for use with the client's test facility. The system will include a computer with all necessary I/O hardware, printer, software, analog data sub-system and transducer packages (e.g., power consumption, signal conditioners/sensors, such as platinum RTD thermometers), control system electronics, automated test unit power system, and the required documentation, schematics, etc.

A. Computer System

The computer will be an IBM AT compatible computer. Commercially available electronics items will be added to this computer to help accomplish data acquisition and control functions. Also included in the system is a high speed numeric co-processor, an industry standard floppy disk drive, and a 40 MB hard disk drive to provide data and program storage. An additional 40 MB hard disk drive will be supplied for system back up and program storage. A dot matrix printer will also be supplied.

B. System Software

The operating system will be DOS. Applications software for data acquisition, facility control, and report generation will be supplied with the system by ETL. This software is proprietary to ETL and cannot be sold or reused by the client or anyone else unless a contractual arrangement is negotiated with ETL to do so. Software will be installed on the system hard disk by ETL at the time of facility installation.

C. Analog Data, Sub-System

This system which is used as a "data logger" contains a highly efficient and accurate 60 channel analog intelligent front end which communicates with, and is remotely programmed through the computer system. The "data logger" is expandable to 100 channels, without requiring an extender chassis.

D. Transducer Packages

There will be included both for the room-side compartment and the outdoor-side compartment, precision watt/watt hour transducers for measuring power consumption in the two compartments.

NOTE (1): The exact computer configuration will be selected at the time of the contract signing; and is subject to U.S. Export restrictions.

SINCE 1896

II. DATA ACQUISITION AND CONTROL SYSTEM - (Cont'd)

The test unit power system also contains a package consisting of precision transducers for conversion of voltage, current and watt/watt hour information.

E. Control System Electronics

All of the necessary control electronics (e.g., regulators, phase controllers, etc.) and their sensors will be provided for use in the control loops.

F. Automated Test Unit Power System

This will include a variable single phase voltage source, operating under computer control, capable of delivering the required test unit power per the client's specifications. This system automatically regulates and maintains test unit power during the course of the test.

NOTE (1): This test unit power system will also control and regulate 60 Hz power supplied by the client from a separate source.

NOTE (2): Test units requiring three phase power cannot utilize this automated system. In order to test a three phase unit, the client could bypass the automated system and supply power directly to the air conditioner being tested.

SINCE 1896

MAJOR COMPONENTS

SUPPLIED BY ETL TESTING LABORATORIES, INC.

FOR A

ROOM AIR CONDITIONER TEST FACILITY

(Partial Listing)

A. TEST UNIT POWER SOURCE

B. ROOM POWER TRANSDUCERS

C. TEMPERATURE / HUMIDITY CONTROLLERS

D. COMPUTERIZED DATA ACQUISITION SYSTEM

E. AIR FLOW MEASURING APPARATUS

F. CHILLED WATER FLOW METER

G. TEST CONSOLE

SINCE 1896

A. TEST UNIT POWER SOURCE:

Input Power: 230 VAC 50/60 Hz +5% -10% 40 A service
Output, High Range: any voltage from (208V -10%) to (240V +10%), 30 A max
Output, Low Range: any voltage from (110V -10%) to (120V +10%), 30 A max

Major System Components:

- Dual variable transformer, motorized
- 2 kVA Buck-Boost Transformer
- 5 kVA Auto Transformer

- 25 A / 240 V Watt-Watthour transducer with remote voltage sensing. Accuracy 0.1% of reading from 10% to 150% of FS

- 150 V true RMS Voltage transducer. Accuracy 0.25% of FS
- 300 V true RMS Voltage transducer. Accuracy 0.25% of FS

- 25 A true RMS Current transducer. Accuracy 0.25% of FS (30 A max.)
- 15 A true RMS Current transducer. Accuracy 0.25% of FS
- 7.5 A true RMS Current transducer. Accuracy 0.25% of FS

- High/Low Voltage Range Switch
- Current Range Switch

- Computer and Analog data acquisition sub-system interface

B. ROOM POWER TRANSDUCERS:

- Indoor Room: 3 Phase 4 Wire 15 A / 240 V Watt-Watthour transducer
  Remote voltage sensing
  Accuracy 0.1% of reading from 10% to 150% of FS

- Outdoor Room: 3 Phase 4 Wire 15 A / 240 V Watt-Watthour transducer
  Remote voltage sensing
  Accuracy 0.1% of reading from 10% to 150% of FS

- Computer and Analog data acquisition sub-system interface

C. TEMPERATURE / HUMIDITY CONTROLLERS:

- Indoor Room: Dry bulb temperature controller with
  - Temperature Sensor
  - SCR heater power controller
  - Computer interface

  Wet bulb temperature controller with
  - Relative Humidity Sensor
  - SCR heater power controller
  - Computer interface

SINCE 1896

Balanced ambient temperature controller with
- Temperature Sensor
- Heat and Cool analog output
- Heat and Cool solid state relay output
- Computer interface

- Outdoor Room: Dry bulb temperature controller with
  - Temperature Sensor
  - Current / pressure transducer
  - Computer interface

  Wet bulb temperature controller with
  - Relative humidity sensor
  - Current / pressure transducer
  - Computer interface

  Balanced ambient temperature controller with
  - Temperature Sensor
  - Heat and Cool analog output
  - Heat and Cool solid state relay output

- Water Chiller: Water temperature controller with
  - Temperature Sensor
  - Current / pressure transducer
  - Computer interface

Note: The above controllers will be supplied with full auto / manual control capability.

D. COMPUTERIZED DATA ACQUISITION SYSTEM:

- Computer: Configured for data acquisition and test facility control

  - IBM AT compatible desk top computer with:

    - Co-processor
    - 2 MB RAM
    - Floppy disk drive
    - 2 Hard disk drives

  - Serial/parallel ports

    - Color graphics interface
    - Color CRT monitor
    - Printer, dot matrix, 24 pin printhead

SINCE 1896

- Software, installed on each drive
  - DOS Operating System
  - Room air conditioner test software by ETL

• Analog data acquisition sub-system:

  Fluke HELIOS I Computer Front End Mainframe with
  - High performance A/D converter
  - 20 channel RTD scanner
  - 20 channel RTD connector
  - 40 channel direct volt / thermocouple scanner
  - 40 channel direct volt / thermocouple connector

  8 individually calibrated platinum RTD's to measure
  - Indoor room dry bulb temperature
  - Indoor room wet bulb temperature
  - Outdoor room dry bulb temperature
  - Air flow measuring apparatus dry bulb temperature
  - Air flow measuring apparatus wet bulb temperature
  - Chilled water inlet temperature
  - Chilled water discharge temperature

E. AIR FLOW MEASURING APPARATUS:

Measurement range: 150 to 800 CFM
Air Flow Control: variable speed exhaust blower

Major system components:

• Receiving chamber with:
  - Mixer
  - Air temperature sampling system
  - Access door
  - Diffusion baffle
  - Pressure taps
• Nozzle assembly with:
  - 3 air flow measuring nozzles
  - 1 air leakage measuring nozzle
• Discharge chamber with:
  - Pressure taps
  - Access door
  - Auxiliary damper
• Exhaust blower with:
  - Motor
  - Variable frequency motor-speed controller

F. CHILLED WATER FLOW METER:

- Turbine-type water flowmeter with:
  - Preamplifier
  - Computer interface
  - Accuracy: 0.25 % FS

G. TEST CONSOLE:

- Work-station for the
  - Computer
  - HELIOS I
  - Printer

- Electronic equipment cabinet for the
  - Test unit power source
  - Room power transducers
  - Temperature / humidity controllers

H. ROOM SIDE RECONDITIONING EQUIPMENT:

- See Page 2 - 4 of this proposal.

I. OUTDOOR SIDE RECONDITIONING EQUIPMENT

- See Page 2 - 4 of this proposal.

J. MOTOR WINDING RESISTANCE TESTING EQUIPMENT

- Test Equipment will be provided to analyze the resistance characteristics of motor windings.

SINCE 1896

ASSUMPTIONS AND PROVISIONS

This proposal is based on certain assumptions, such as the laboratory building already being in place. Also that all preliminary site preparation will be done by the client. Finally, it is assumed that the client will provide at the site such items as a fork truck, ladders, etc., and other general purpose tools. Additionally, the client shall provide sufficiently skilled laborers with basic skills and tools to assist in installing the facility/equipment utilizing design drawings supplied by ETL Testing Laboratories, Inc. This may include plumbing, welding, electrical wiring, mechanical installation, etc.

In the preparation of this proposal, ETL Testing Laboratories, Inc., has assumed that the client will assure that the following site conditions will be satisfied without effort or expense to ETL:

(1) An appropriate building structure will be provided to accommodate the room air conditioning test facility being proposed.

Building Requirement

Ambient Temperature:	25 +5, -10°C
Clear Ceiling Weight:	4.5 meters minimum
Floor Space:	Per attached floor plan.
Floor:	Weight bearing capacity of 2,000 Kg/m^2 minimum.
Utilities:	Power, cooling water, distilled or demineralized water, compressed air, drain, and lighting must all be available for connection to the test facility.

(2) The Room Air Conditioning Test Facility will require certain utility support which must be provided by the client and must be in place and ready at the time of facility installation:

Electrical Power:	220/380 VAC ± 10%, 3Φ, 50 Hz. 125A maximum. Drift of less than 1 volt per minute.
Cooling Water:	30°C maximum @ 3.0 liter per second @ a pressure of 2 Kg/cm.
Demineralized Water:	6 liters per hour with 10 liter storage capacity.
Compressor Air:	Dry, 3 liters per second. Pressures @ 3 Kg/cm^2 minimum.

ASSUMPTIONS AND PROVISIONS, (Cont'd)

(3) ETL's mechanical design will be modular in order to allow for construction and testing of major reconditioning assemblies at ETL prior to shipment.

(4) All major system components will be sourced in the United States.

(5) Appropriate ETL personnel will visit the site as necessary to assure the proper construction and calibration of the test facility.

(6) System documentation, manuals, software listings, will be suitable for use by trained engineers to operate and maintain the system. All documentation will be in the English language.

(7) The computer system used in the data acquisition and control system is microprocessor based. The computer is sourced in the U.S. Applicable U.S. Technology Export Regulations will apply.

FEE

ETL Testing Laboratories, Incorporated, agrees to do the work and provide the equipment as described in this proposal, for a fee of (to be determined).

Also included are the following:

(1) ETL will host, at ETL's expense, two of the client's personnel at ETL's Cortland, New York, headquarters for a period of one week to witness the testing of the major mechanical assemblies prior to shipment. This visit will be scheduled by ETL. One of the visitors should be skilled in speaking English in order to act as interpreter.

(2) Shipping costs for all ETL supplied items will be paid by ETL from ETL's headquarters to the client's Port of Entry. The client will be responsible for movement of all items from the Port of Entry to the site.

(3) ETL will provide three air conditioners, tested in ETL's test facilities, to be used as test standards by the client.

One Unit - 1000 - 2000 Kcal/hr.
One Unit - approximately 3000 Kcal/hr.
One Unit - 5500 - 6500 Kcal/hr.

All of the above units will be 220 AC / 50 Hz.

(4) ETL will provide a set of manuals, in English, which describe the operation of the test facility, periodic preventive maintenance procedures, and calibration requirements. ETL will also provide a complete set of engineering drawings and schematics for the test facility. Wherever available, ETL will provide manufacturer's documents and manuals for the commercial equipment used.

(5) Using the three air conditioners described in (3) above, an ETL engineer will test the calorimeter facility as constructed and assembled to assure proper operation. As a part of this procedure, the client's technicians and engineers will be trained to operate the facility. At the completion of this activity, which is planned to be three weeks in length, ETL will issue documents which certify the operation of the test facility and the training of the client's personnel.

(6) ETL will furnish calibration records for all instrumentation requiring calibration. Calibration markings will be affixed to calibrated instruments wherein practical.

ETL SINCE 1896

APPENDIX I

LIMITED WARRANTY

ON TEST FACILITY DESIGN AND INSTRUMENTATION

ETL TESTING LABORATORIES, INC.

In lieu of all other warranties of whatever kind or nature, be they specific, general or for merchantability, ETL issues the following warranty for its design and instrumentation of a test facility to be constructed pursuant to its design documentation and contract.

1. ETL warrants that the facility built pursuant to its design documents will function and accurately operate as a test facility which warranty is limited by the following criteria:

   a. All materials, construction, techniques and installation are to be completed pursuant to ETL's specifications. Any substitutions for any of the specified procedures, materials or techniques will act as cancellation of this warranty unless approved by ETL in advance in writing.

   b. The construction techniques and workmanship in the erection of the facility is of a quality to assure that the facility meets the design criteria.

   c. All utilities and ambient conditions, i.e., electrical power, water, air temperature, et al, utilized in the facility once it is operational are within the perimeters specified in ETL's design criteria.

2. This warranty is limited to the function and accuracy of the test facility at the completion of construction. ETL shall not be responsible for maintenance and repair of the facility or failure of the facility due to misuse of the facility or failure to maintain or repair the facility.

3. Any hard goods, materials, supplies, equipment and software supplied by ETL pursuant to the contract shall be governed by the warranty of the manufacturer of such hard goods. ETL makes no further warranty as to these items. In the circumstance where ETL has altered the supplied materials in any way, the manufacturer's warranty shall apply except as to the modification made by ETL and as to that modification ETL warrants its merchantability for the purpose intended for a period of not more than one year after the facility has become operational. ETL's sole liability for such failure during the one year period shall be for replacement or repair of the item at ETL's option. ETL shall not be liable for any consequential or special damages beyond the repair or replacement, as the case may be.

4. Any costs to ETL, based on Item 1., 2., and 3. above must be authorized, in writing, in advance of any expenditures.

SINCE 1896

APPENDIX II

COMMENTS ON HEAT PUMP TESTING

IN COMPLIANCE WITH THE

FOURTH DRAFT PROPOSAL (DP 5151) OF ISO/TC 86/SC 8

REVISION OF ISO R 859

TESTING AND RATING ROOM AIR CONDITIONERS

AND HEAT PUMPS

May 14, 1990

SINCE 1896

General Comments

In addition to the test procedures described in ISO RECOMMENDATION R 859, TESTING AND RATING ROOM AIR CONDITIONERS, the fourth draft proposal (DP 5151) recommends procedures for testing Room Heat Pumps. Also, the document states:

"1.2.1 - Room Air Conditioner: An encased assembly or assemblies designed as a unit.... Where such equipment is provided in more then one assembly, the separated assemblies are to be designed to be used together, ..."

The inclusion of split room air conditioners requires humidifiers in both rooms of the calorimeter. This requirement presents no technical difficulties. The testing of small heating capacity room heat pumps, however is not without problems, as discussed in the following:

A Room Heat Pump is a room air conditioner in which refrigeration equipment takes heat from a heat source and delivers it to the conditioned space when heating is desired. During testing, the heat is delivered to the room side compartment of the calorimeter. In addition, the electrical energy consumed by the heat pump is converted to heat and is delivered to the room-side compartment.

The heat removed from the heat source (the outdoor side compartment):

HEAT REMOVED (W) = HEATING CAPACITY (W) - TEST UNIT POWER (W)

Once the desired test conditions are established in the calorimeter, the outdoor side compartment's heat balance can be expressed as follows:

RECONDITIONING EQUIPMENT POWER (W) + AUXILIARY EQUIPMENT POWER (W) +

HEAT GAIN THROUGH WALLS (W) - HEAT REMOVED BY THE HEAT PUMP (W) = O

The outdoor side reconditioning equipment consumes electric power for the following:

a. Main reconditioner blower
b. Dry bulb temperature controller
c. Wet bulb temperature controller

Both temperature controllers must consume some amount of power to maintain test conditions. Therefore, there is a minimum power consumption in the outdoor side compartment below which proper temperature control is not possible:

OUTDOOR SIDE POWER min (W) = RECONDITIONING EQUIPMENT POWER min (W)+

AUXILIARY EQUIPMENT POWER (W) + HEAT GAIN THROUGH WALLS (W)

Testing Small Heat Pumps

If the heat pump under test is unable to remove the heat generated in the outdoor side compartment, an auxiliary cooling equipment is required to maintain test conditions. The common practice in the air conditioning industry is to install a small, direct expansion type cooling coil for auxiliary cooling. The required coil temperatures are too low for water cooled equipment to operate with any safety margin. Also, water cooled equipment is very expensive compared to direct expansion type equipment.

The problem one has to face with direct expansion type cooling coils is that their cooling capacity cannot be measured with sufficient precision in the calorimeter, therefore no heat balance calculation is possible. One has to rely on the accuracy of the primary, room-side measurements.

In the various room air conditioner test standards only the room side capacity measurements are used for rating purposes. The proposed REVISION of ISO R859 permits testing without outdoor side compartment capacity measurements when such measurements are impractical (4.6.1.3 AIR-ENTHALPY TEST METHOD (HEATING)), or as the alternative test method (6.1.2 REQUIREMENTS FOR THE COOLING CAPACITY TESTS), if the room side measurements can be verified periodically by other means.

The primary measurement's accuracy can be verified rather easily for heating, by adding a measured amount of electric heat to the room side and measuring the heaters capacity by the calorimeter. Even though the draft does not specifically mention this particular problem, the procedure would not violate the spirit of the (proposed) standard. Also, one could measure the heating capacity of the test unit by air-enthalpy test method, as required by the Association of Home Appliance Manufacturers (AHAM).

LRW/tks

Appendix E. Lighting Energy Use and Conservation Opportunities in Egypt

This memo is an initial exploration of lighting energy issues as they pertain to the Arab Republic of Egypt. This memo summarizes the results of fieldwork conducted in Egypt during March, 1990. Information reported is primarily subjective in nature and is based on a series of discussions with lighting equipment manufacturers and distributors, and on my own observations. The conclusions stated here should be viewed as tentative -- additional discussions and field observations will likely lead to some changes.

This memo first briefly reviews lighting energy use by sector (residential, commercial and industrial). Next, lighting equipment which is available in Egypt is discussed including incandescent, fluorescent and high intensity discharge (HID) lamps, ballasts, and fixtures. A brief section then discusses lighting design and lamp testing practices in Egypt. Finally, conservation measures and program/policy options are presented.

A. LIGHTING ENERGY USE BY SECTOR

Residential

Approximately 35% of residential electricity use in Egypt is for lighting. This is a rough estimate based on very limited data on appliance saturations and use, and on more detailed data on the number of households in different kWh per month classes. In Egypt the majority of households (67% in 1988) use less than 100 kWh/month (Electricity Distribution Authority, 1989). Among these households, lighting probably accounts for the majority of electricity use. At the other extreme, approximately 10% of households account for approximately 40% of residential electricity use. Among these households, lighting probably accounts for less than 20% of electricity use.

Residential households use a mixture of incandescent and fluorescent lamps. A single bare incandescent bulb hung in the middle of a room is a particularly common arrangement. A rough count in approximately 20 homes in one village (located 40 km from Cairo) indicated that incandescent lamps outnumber fluorescent lamps approximately two to one. The majority of fluorescent lamps were 120 cm (4 feet). Philips, Egypt's largest lamp manufacturer, estimates that 120 cm lamps outnumber 60 cm lamps approximately seven to two. Circular and 30 cm straight fluorescent lamps are also occasionally used in the residential sector.

Commercial

No estimates of lighting energy use are available for the Egyptian commercial sector. A very rough indication of lighting energy use may be provided by other countries. For example, Marques (1989) estimates that 44% of commercial sector electricity use in Brazil is for lighting. In the United States, approximately 37% of commercial electricity use is for lighting (Brookhaven National Laboratory 1987).

Egyptian commercial buildings primarily use fluorescent lamps, particularly 120 cm straight tubes. Most fluorescent fixtures are either "strip" fixtures with no enclosure, or simple boxes with a wrap-around plastic lens. In these fixtures, no special design features, such as angled sides, are incorporated to direct light down to the work surface. European-style louvered fixtures with angled aluminum sides are sometimes used.

In the course of my fieldwork, I made random measurements of ambient light levels in the offices that I visited. Ambient light levels (i.e. without task lights) ranged from approximately 15-75 footcandles (150-800 lux), with levels of 20-40 footcandles (200-400 lux) most common (measurements were made in the middle of each room at desk level). In addition, task lights are sometimes used. These light levels are less than typical levels in the U.S., although light levels in Egypt are in line with illuminance recommendations in the U.S. for reading magazines, first and second generation photocopies, and handwriting done with a ballpoint pen (Illuminating Engineering Society 1985). For reading smaller and lighter printing, higher light levels are recommended. Task lights are an excellent way to supply additional light in these situations.

Industrial

No data on industrial lighting use in Egypt is available. In the U.S. an estimated 7% of electricity use is for lighting (Miller et al. 1989). In Brazil one study estimated that only 2% of electricity use is for lighting (Moraes et al., 1985). The Brazilian estimate seems low to me.

Industrial lighting is primarily provided by 120 cm fluorescent lamps. These are generally used in simple strip-fixtures or simple open industrial-type fixtures. In addition, HID lamps are used in some facilities. Until recently mercury vapor lamps accounted for nearly all HID installations. In the past few years, high pressure sodium lamps have been used in some new facilities. When HID lamps are used, sometimes bare bulbs are suspended from a wire and sometimes simple aluminum open fixtures are used.

C. EQUIPMENT

Incandescent Lamps

Incandescent lamps are made in Egypt by several manufacturers. The two largest are Philips (half owned by the Egyptian government and half by the Dutch lighting manufacturer by the same name) and Alsharif (a private Egyptian company which works closely with Tungstrom, the large Hungarian lamp company). Incandescent lamps manufactured in Egypt are all clear (unfrosted) and come in 25, 40, 60, 100, 150 and 200 Watt sizes.

Based on test data compiled by Philips and Alsharif, lamps appear to be similar in lumen output to typical European lamps (based on published values in Philips' European catalog). Lamp life in Egypt is reported to be "at least 1000" hours, including high wattage lamps. Compared to American lamps, the Egyptian lamps appear to have longer lives (e.g. the standard U.S. lamp is rated at 750-1000 hours) but lower lumen output. For example, a Philips 60 W European lamp is rated at 740 lumens (at 120 volts), while Philips standard 60 W American lamp is rated at 890 lumens (Philips 1988a and 1988b. Thus, the Egyptian/European lamps provide about 15% less lumens per Watt (LPW) than American lamps, but last somewhat longer (the tradeoff between life and lumen output is a common one in the lamp industry).

In Egypt, as in Europe, no reduced wattage incandescent lamps are available. By way of comparison, in the U.S. and Brazil, lamps with 5-13% lower energy use (and perhaps 2-8% lower light output) are produced (e.g a 55 W lamp designed to replace a 60 W lamp) (Nadel et al. 1989; Geller 1990). The general manager of Philips plant in Egypt said it would be easy to adopt their present equipment to produce reduced wattage incandescent lamps in Egypt.

On the other hand, it appears that light levels in Egyptian homes are generally fairly low by American and European standards, so any technology which saves energy at the expense of light levels may not be desirable. Thus, if reduced wattage incandescent lamps were to be introduced in Egypt, the energy savings should probably come at the expense of reduced lamp life and not at the expense of reduced light output.

Typical incandescent lamp costs and approximate market shares are listed in Table 1.

Table 1: Incandescent Lamp Costs and Approximate Market Shares in Egypt.

Lamp Wattage	Price per Lamp (Egyptian Pounds) Wholesale-Delivered	Consumer	Approximate Market Share
40	.55	.60	5-10%
60	.60	.65	40-45%
75	.64	.70	15-20%
100	.68	.75	25-30%
Others			5-10%

Source: Alsharif price schedule, estimates by Alsharif.

Reflector incandescent lamps are only occasionally used in Egypt. These lamps are not produced in Egypt and must be imported. In the U.S., reflector lamps are commonly used for recessed ceiling fixtures, outdoor lighting near buildings, and retail display. In Egypt, general service incandescent lamps are generally used in recessed ceiling fixtures, fluorescent tubes are commonly used for outdoor lighting near buildings, and a mixture of fluorescent tubes, general service incandescent, and reflector incandescent lamps are used for display lighting.

Reflector lamps (R type) cost approximately 2.5-3.5 Egyptian pounds (based on retail prices in one electric store in Cairo). This is approximately four-five times more than a general service incandescent lamp (approximately the same relative price difference as in the U.S. -- Nadel et al. 1989). Reflector lamps at the lower end of this price range did not appear to be of very high quality.

Circular fluorescents and compact fluorescents are an alternative to incandescent lamps in many applications. Compared to a general service incandescent lamp, compact fluorescents reduce energy use approximately 75% (while maintaining light output). Circular fluorescents can reduce energy use by approximately 55-65% (General Electric 1988b). Both products have a rated life of approximately 9000 hours -- about nine times longer than a general service incandescent lamp.

Both circular and compact fluorescent lamps can be purchased in Egypt. Circular fluorescent lamps are available in many electric equipment stores, compact fluorescent lamps are available from only a very limited number of distributors (for example, Mostafa Ali Co. said they stock compact fluorescent lamps). Both circular and compact fluorescent lamps are imported -- at present their is no domestic manufacturing capability. Philips told me that new equipment would be required to manufacture either of these products in Egypt. This would take time and money.

I saw circular fluorescent lamps for sale for 7.5-13 Egyptian pounds (for 32 Watt and 40 Watt Japanese-made products). Thus, a circular fluorescent costs about 10-20 times more than a conventional incandescent. In addition to the lamp, with circular fluorescent lamps, a fixture, ballast and starter is also required. Compact fluorescent lamps are considerably more expensive. Mostafa Ali (an importer of Sylvania products) said they could sell thin-tube compact fluorescents for approximately 20 Egyptian Pounds without the ballast and starter. Egyptian produced ballasts can run the lamps. Thus far, compact fluorescent use in Egypt is limited to a few isolated projects, e.g. at the American University in Cairo (applications unknown), at Beneton Shops (display lighting) and at the Nile Hilton (in some recessed ceiling lights). Given the low (i.e. subsidized) electricity rates in Egypt, and the high initial cost of compact fluorescents, even commercial customers have shown only limited interest in compact fluorescents.

Fluorescent Lamps

Fluorescent lamps are made in Egypt by three manufacturers (Philips, Alsharif and Canal Electric). Philips makes both 60 and 120 cm lamps, Alsharif and Canal Electric only make 120 cm lamps. Philips makes approximately 8 million fluorescent lamps a year, Alsharif approximately 3.5 million, and Canal Electric makes only a small quantity of fluorescent lamps (based on discussions with Philips and Alsharif). In addition to domestic manufacture, many lamps are imported, including low-cost 60 cm and 120 cm lamps from Eastern Europe, West Germany and Japan, 30 cm and circular fluorescents from Japan and other countries, and premium cost lamps (e.g. compact fluorescent lamps), primarily from Europe.

Over 90% of fluorescent lamp sales are for 60 cm and 120 cm lamps. As previously noted, 120 cm lamps outnumber 60 cm lamps approximately seven to two. Prior to 1989, all fluorescent lamps manufactured in Egypt were 38 mm (1.5 inches) in diameter. In 1989, several Egyptian manufacturers began producing 26 mm (1 inch) diameter lamps. The thinner lamps reduce energy use while maintaining light output. For example, a 26 mm diameter, 120 cm long lamp has a rated wattage of 36, 4 watts less than a comparable 38 mm lamp. Thus, the thinner tubes reduce energy use approximately 10%. Rated light output for both lamps is 2500 lumens in the commonly used "cool daylight" color (Philips 1988a). Test data I saw at Philips' Alexandria plant supported their claims for equivalent light output.

The thin-tube lamps described above are similar to the 32 Watt 1 inch diameter lamps ("T8" lamps) sold in the U.S. The U.S. lamps require a special ballast; conventional 120 volt U.S. ballasts will not start a 1 inch diameter lamp. However, a 220 volt preheat ballast will start a 1 inch lamp, although when used on ballasts designed for 1.5 inch lamps, power requirements increase to 36 Watts, 4 Watts more than is required with ballasts optimized for the thinner diameter lamps.

Approximately half of Philips' annual fluorescent lamp production is of the thin-tube lamps. Philips reports that they will switch entirely to the thin-tubes at the end of this year. Alsharif makes only thin-tube lamps. Thus, in 1991, nearly all fluorescent lamps made in Egypt will be thin-tube lamps. The only thick-tube lamps will be the limited number made by Canal Electric, plus imports.

Thin-tube lamps are currently about 15% more expensive than the thicker lamps. Fluorescent lamp prices for the two major manufacturers are summarized in Table 2.

Table 2: Fluorescent Lamp Prices in Egypt

Lamp Wattage	Length (cm)	Diameter (mm)	Price per Lamp (Egyptian Pounds) Wholesale(deliv'd)	Consumer
Philips:				
18	60	26	2.60	2.90
20	60	38	2.00	2.20
36	120	26		3.35
40	120	38	2.70	2.85
Alsharif:				
36	120	26	2.70	3.20

Source: Alsharif price schedule, estimates by Philips and Alsharif.

According to Philips, the thinner lamp is more expensive because the equipment to produce the lamps is still being depreciated. Ignoring depreciation costs, the thin lamps are actually less expensive to produce.

Despite the strong interest by manufacturers to promote the thin lamps, consumers have been resistant thus far. They are reluctant to switch to products they are unfamiliar with, particularly a product which is smaller and hence is perceived to produce less light. Also, both manufacturers report starting difficulties with the thin lamps when inexpensive, low-quality starters (primarily of Taiwanese and Korean manufacture) are used. Alsharif claims to have surmounted this problem.

Until 1989, Philips had over 80% of the Egyptian fluorescent lamp market. During this period, Philips assembly line was partly manual and partly automated. For the past five years of so, Philips has been planning to upgrade their fluorescent production facilities, but had difficultly getting capital due to the government's limited resources (Philips, Egypt is half owned by the government) and due to decisions by Philips management to allocate resources to more profitable products. In 1989 Philips finally added a new production line that is largely automated, but considerable manual steps are still involved. Lamps are produced single file. Alsharif on the other hand has a highly automated production facility in which lamps are produced approximately ten abreast. This facility can produce 3.5 million lamps/year on only one shift. Alsharif hopes to increase to two shifts later this year. Joe Pietsch observed that the Alsharif facility is comparable to General Electric facilities in the U.S.

Despite the sophistication of Alsharif's facility, Philips alleges that Alsharif cuts corners. In particular, Philips claims that Alsharif skimps on phosphors (which reduces the lumen output of lamps) and that Alsharif may skimp on fill gas (which makes starting easier but shortens lamp life). Philips claims that Alsharif lamps average only 2300 lumens while Philips lamps average 2550 lumens. Some very limited test data I saw at Alsharif indicates an average of approximately 2470 lumens.

In addition to concerns about competition from Alsharif, Philips is also concerned about competition from imports. Philips notes that due to government involvement it has a bloated bureaucracy and hence high overhead costs. Inexpensive imports can underprice Philips, despite an import duty on fluorescent lamps of approximately 25%. To deal with this problem, Philips advocates import restrictions for products that are similar to domestically produced products. On the other hand, Philips Egypt is now trying to get permission from Philips Holland to export lamps to other countries in the Middle East.

HID Lamps

All HID lamps used in Egypt are imported. Philips used to manufacture mercury vapor and high pressure sodium lamps in Egypt but production was ended approximately seven years ago due to low sales. By far the most common HID lamp in Egypt is an unballasted mercury vapor lamp. For example, Philips (Europe) makes these lamps in 100, 160, 250, and 500 Watt sizes. Prices in one store were 9.90 EL (Egyptian Pounds) for the 160 Watt lamp and 13.50 EL for the 250 Watt lamp. Efficacy of these lamps ranges from 11 lumens per Watt (LPW) for the smallest lamp to 26 LPW for the largest (Philips 1988a).

A number of energy-saving alternatives to these lamps are available including ballasted mercury lamps (typical efficacy 28-40 LPW), high pressure sodium lamps designed to operate on a mercury ballast (typical efficacy of 60-75 LPW), and high pressure sodium lamps designed to operate on a high pressure sodium ballast (typical efficacy 55-100 LPW) (General Electric 1988a and 1988b). My understanding is that all of these products are generally available to a sophisticated commercial or industrial customer. Availability in small electrical supply shops is limited. I was not able to get detailed price data on these products. Metal halide lamps, which produce better color than high pressure lamps, but at a small efficiency penalty, appear to be rarely used in

Egypt. According to Mostafa Ali (a major fixture and ballast manufacturer and lighting product importer), in recent years, high pressure sodium lamps are being used extensively in new, large projects, including about 90% of streetlighting projects.

Ballasts

Egyptian ballasts are essentially all preheat ballasts (i.e. they require a separate starter). All the ballasts I saw were single-lamp ballasts (each ballast controls only one lamp). According to Mostafa Ali, there are approximately seven major ballast manufacturers in Egypt. In their estimation, about half of the manufacturers make quality products (usually under license to European companies) and half make less expensive, lower quality products. Mostafa Ali estimates that a typical quality ballast costs 6.50 EL. The cheaper ballasts cost about 6.00 EL.

According to data from Philips (1988) and Mostafa Ali, a quality ballast combined with a 40 Watt lamp uses about 48 Watts. The Egyptian Office of Energy Planning (OEP) tested one lower quality Egyptian made ballast and measured the power used by the lamp and ballast at 56 Watts. Based on data from other tests conducted at the same time, the OEP numbers look a little high to me, but they may indicate that the lower quality ballasts use significantly more power than the higher quality ballasts.

Most ballasts manufactured and used in Egypt are low power factor ballasts. For example, the rated power factor of Mostafa Ali ballasts ranges from .37-.57. Mostafa Ali will install a capacitor in the ballast to improve the power factor to .90+. This raises the ballast cost by 3.00 EL -- approximately 50% higher than for a low power factor ballast. Mostafa Ali estimates that less than 10% of their sales are high power factor ballasts. Capacitors can also be purchased separately and installed by an electrician, although people I talked to felt that this practice was uncommon. Low consumer interest in power factor is to be expected because only large customers (billing demand greater than 500 kW) are subject to penalty charges on their electric rates for low power factor. Penalties, I was told, amount to 0.5% of the electric bill for each percentage point the power factor is below 90%, and 1.0% of the electric bill for each percentage point the power factor is below 80%.

In the U.S., energy-saving magnetic ballasts are widely used. These ballasts incorporate improved quantity and quality of materials in order to reduce energy losses. Such ballasts are also produced in Europe. In Egypt these ballasts appear to be unavailable. According to Mostafa Ali, these ballasts would not be difficult to manufacture, but due to the increased amount of materials involved (much of which would be imported), energy-saving magnetic ballasts would cost twice as much as standard ballasts, and would be unlikely to sell.

The power use of different lamp/ballast combinations is summarized in Table 3.

Table 3: Power Consumption (Watts) of European Lamp/Ballast Combinations (220 V, Preheat)

Lamp Type			Std. Efficiency, High Quality, Magnetic Ballast	Improved Efficiency High Quality, Magnetic Ballast
Watts	Length	Diameter		
18	60	26	27	24
20	60	38	29	26
36	120	26	43-44	41
40	120	38	47-48	45

Source: Phillips 1988

In recent years, there has been a lot of interest in the U.S. and Europe in electronic ballasts. These ballasts increase the lamp/ballast efficiency significantly (for example, Philips (1988) reports that their electronic ballast uses only 37 Watts when used with a 36 Watt lamp).

Several Egyptian companies are also interested in electronic ballasts. Alsharif has built a prototype electronic ballast which they showed us. They claim the ballast has a power factor of close to unity. Their ballast uses off-the-shelf electronic parts. They claim that in large quantities, they could manufacture and sell these ballasts for 5 EL wholesale and 7 EL retail (these prices sound low to me). They note that the ballast components cost less than 1 EL when purchased in large quantities. When I asked them about harmonic and radio frequency interference, they said that they include harmonic and radio frequency interference filters in their design. Alsharif said they could produce the ballast in large quantity next year <u>if</u> the government mandated its use.

Mostafa Ali also told us that they have built a prototype electronic ballast. Their model is a two-lamp ballast which they hope to produce by the end of the year. The ballast is partly copied from European and Asian designs and partly their own design. Estimated retail price is approximately 26 EL -- twice as much as two one-lamp conventional ballasts. Mostafa Ali plans to test the ballast for energy use and harmonics at Cairo University.

Philips mentioned that a company named Telemas recently approached them about a joint venture to produce electronically ballasted compact fluorescent lamps (Telemas would produce the ballasts, Philips the lamps). Discussions are still at a preliminary stage.

Fixtures

Most fluorescent fixtures used in Egypt are simple strip or plastic wrap-around fixtures. These fixtures use a minimum of materials and usually contain no special design features (e.g. angled sides) to direct light out of the fixture and on to the work surface. These fixtures are made by many manufacturers -- all one needs is some basic metal bending equipment. Data on the efficiency of these fixtures (i.e. amount of light leaving the fixture as a percentage of the light provided by the lamps) is not presently available, but is likely to be low (even the strip fixtures are constructed in a way that the fixture blocks a considerable amount of light -- see drawing in the Appendix). Mostafa Ali is having its low-cost fixtures tested in Europe and will publish light distribution curves in its next catalog. From this data it should be possible to estimate fixture efficiency.

Several manufacturers are making higher quality fixtures in Egypt. Generally these fixtures are made under license to European companies. For example, Mostafa Ali has an arrangement with Siemens, and Arab Contracting has an arrangement with Asea Brown Boveri. These higher quality fixtures usually include angled sides (typically dull aluminum) to reflect light out of the fixture, and sometimes include aluminum louvers. Arab Contracting, in its catalog, reports an efficiency for its 2-lamp and 4-lamp units of 50-65%. They do not state where their data came from. These efficiency levels are lower than typical U.S. fixture efficiencies (which range from approximately 50-90% with an average of about 68% -- Lovins et al. 1988). Mostafa Ali says about 30% of their fixture sales are from their Siemens-designed line, and 70% are lower cost fixtures of Egyptian design. I was not able to get good data on the relative cost of the high quality versus the commodity-grade fixture lines. Mostafa Ali has recently begun to export its high-quality fixture line to other countries in the Middle East.

Fixtures for circular fluorescent lamps are also made in Egypt. For example, Mostafa Ali makes several different decorative fixtures for residential use (see illustrations in the Appendix). These are designed for the middle-and upper-class market.

Most incandescent lamps appear to be used as a bare bulb without a fixture. Even recessed incandescent fixtures (a fairly common arrangement in commercial buildings) are usually a bare general service lamp suspended from a metal bar. Most of the light given off by the lamp illuminates the space <u>above</u> the ceiling. Furthermore, the diameter of most recessed incandescent fixtures is scarcely bigger than the bulb, which further restricts the amount of light which escapes the fixture. I did see a few small aluminum reflectors for recessed fixtures, but these were generally so small that there was little room between the reflector and the bulb. When I talked to Mostafa Ali about this, they said that due to first cost considerations, an enclosed, reflective, recessed incandescent fixture would not sell. While I agree that fancy fixtures of the type used in Europe and the U.S. would be too expensive, I think there is room to develop a wider diameter, recessed incandescent fixture with a simple aluminum reflector.

HID lamps are also often suspended from a bare wire. However, simple industrial fixtures (basic aluminum reflectors) are made in Egypt. For example, Arab Contracting makes a line for which they claim an efficiency of 65-80%. Both Arab Contracting and Mostafa Ali manufacture street lights in Egypt using European designs, Arab Contracting claims efficiencies of 60-80% for their units.

C. MISCELLANEOUS ISSUES

Lighting Design

I had a talk with Nader Mostafa Ali (Mostafa Ali Co.) about current lighting design practices in Egypt. In his experience, few people in the country actually know how to do lighting design calculations. Instead, an architect, engineer, or electrician will estimate the number of fixtures that are needed based on past experience and other considerations. Mr. Nader estimates that lux calculations are only done for about 10-15% of commercial projects. In a few cases, bids will be requested to provide specified light levels. Mostafa Ali uses European lighting design software to do these calculations, but they say they are one of the few companies in Egypt that have this capability. According to Mr. Nader, little training in lighting design is presently available in Egypt. Current efforts are limited to an electrical design course in engineering curriculums. He thinks short courses for practicing engineers and architects, as well as full courses in engineering and architecture schools would be very useful.

Testing

The two largest lamp manufacturers (Philips and Alsharif) both test lamps on a daily basis for power consumption and lumen output. I saw both of their laboratories and both seemed fairly sophisticated. Copies of the standard data sheets for these two companies are in the Appendix. The two major lamp manufacturers, as well as the Egyptian Organization for Standardization and Quality Control (a government agency) test lamps for mean lifetime. Philips sends samples of its lamps to the Netherlands each month for testing. I am not sure whether these results are used to calibrate the Egyptian measurements. Mostafa Ali is probably the largest ballast and fixture manufacturer in Egypt but has only basic testing equipment (e.g. hand-held light meters). Fixtures are sent to Europe for testing. They plan to test ballasts at the University of Cairo.

D. CONSERVATION OPPORTUNITIES AND PROGRAM/POLICY OPTIONS

Based on the preceding discussion, there are many opportunities for increasing lighting energy efficiency in Egypt. Some of the available options are summarized in Table 4. This table only includes options which might be practical in Egypt in the near-term. Other options, such as use of specular reflectors and advanced lighting controls are probably not practical today due to low electricity prices in the Egypt, the high relative cost of these advanced energy-saving measures, and other constraints (e.g. dusty environments which would quickly lower the efficiency of specular reflectors).

Table 4: Approximate Cost and Savings for Improved-Efficiency Lighting Equipment in Egypt

Measure	Savings	Extra Cost (EL)	Life (years)	EL/kWh
26 mm fluor. lamp	10%	.45	3	.015
Effic. magnetic ballast	6%	6.50	15	.095
Electronic ballast	10-16%	6.50	15?	.057
Reduced wattage, shorter life incandescent lamp	15%	.30	.25	.047
Improved fluorescent fixture	0-40%	NA	20	
Improved recessed incandescent fixture	45%	NA	20	
Reflector incandescent lamp	20%	1.60	.67	.057
High pressure sodium lamps	40-75%	105	8	.042
Circular fluorescent	45-65%	6.00	3	.015
Compact fluorescent	75%	25.00	3	.074

Notes:
NA = not available.
All figures are rough estimates based on data reported in this memo and on European/U.S. data.
Life based on 3000 operating hours/year. Where lamps have different rated lives, replacement of the shorter lived product is assumed in the cost figures. Also, ballast costs are prorated based on the rated life of the lamp and ballast.
EL/kWh is a levelized cost assuming a 10% real discount rate. Additional details can be found in the Appendix.

In order to determine which efficiency improvements are cost-effective in the Egyptian context, the levelized cost of efficiency improvements need to be compared to the marginal cost of a kWh of electricity production. O'Farrell (1988) recently estimated the long-run marginal cost of electricity for the Egyptian residential sector at .132 EL/kWh. Based on this estimate, all of the measures listed in Table 4 appear to be cost-effective.

However, some measures have lower levelized costs than other measures, which allows us to prioritize measures. In the first tier are 26 mm and circular fluorescent lamps, whose levelized cost (.015 EL/kWh) is less than the average residential electric rate (.026 EL/kWh according to O'Farrell). In the second tier are high pressure sodium lamp and ballast retrofits (assuming replacement of unballasted mercury vapor lamps), electronic ballasts (assuming Mostafa Ali's price estimates hold true), reduced wattage incandescent lamps (assuming 15% energy savings as a result of reducing lamp life to 750 hours) and reflector lamps. I suspect improved recessed incandescent fixtures will also fall into this category. These measures have a levelized cost of approximately .05 EL/kWh -- less than half of the long-run marginal electricity cost. In the third tier are compact fluorescent lamps and efficient magnetic ballasts. While these measures are cost-effective based on long-run marginal costs, they are lower priority items for pursuit in the near-term.

Program and policy options to promote these measures are numerous. I list some of the options here and include a brief discussion.

Improved Education. Training seminars should be offered to energy and facility managers on retrofit opportunities and to design architects and engineers on lighting design and lighting conservation opportunities. This material should also be incorporated into engineering and architectural training programs. Similarly, trained staff should meet one-on-one with energy and facility managers and lighting designers to provide technical assistance and encouragement to pursue lighting efficiency measures.

Testing and Labeling. Many products are not labeled with the lumen output and rated life, which makes it difficult to compare products. Testing standards for lumen output and watt input should be established and all products labeled. Rated life standards already exist in Egypt. It is possible that Egyptian test standards already exist for lumen output and watt input, but we were unable to get information on them. In the near-term, testing would most likely be done by the manufacturers, with oversight provided by the Organization for Testing and Quality Control (e.g. witnessed tests of randomly chosen products). In the long-run, the Organization for Testing and Quality Control may need its own testing equipment.

Utility Programs. In the U.S., Europe and Brazil, utilities are encouraging customers to implement energy conservation measures through technical assistance, rebates and other programs. The Egyptian Electricity Authority should consider offering similar programs. These programs could be based on the experience in other countries, but customized to meet specific Egyptian requirements.

Power Factor Requirements. Egypt is plagued with a low power factor, resulting in considerable wasted resources. Low power factor ballasts are a major contributor to the problem. Minimum power factor requirements should be considered. The next step would be preparation of an in-depth cost-benefit analysis.

R&D on New Products. A number of promising products are not presently produced in Egypt such as electronic ballasts, reduced-wattage incandescent lamps, and high efficiency, low-cost, fluorescent and recessed incandescent fixtures. Technical assistance should be provided manufacturers in the design of these products. Financial assistance should also be considered.

Import Duties. According to Mostafa Ali, Egypt presently charges an import duty on lighting products of approximately 20-45%, with duties on incandescent lamps at the high end of this range and duties on fluorescent and HID lamps at the low end of this range. Egypt should consider modifying its duties to encourage efficient products. Specifically, duties on high efficiency products which are not presently produced in Egypt could be lowered while duties on inefficient products could be raised. Examples of efficient products to encourage include circular and compact fluorescent lamps, and high pressure sodium lamps and ballasts. Examples of inefficient products to discourage include 38 mm fluorescent lamps and mercury vapor lamps (particularly the unballasted mercury vapor lamps).

Minimum Efficiency Standards. Minimum efficiency standards eliminate inefficient products from the marketplace. In the short-term, an efficiency standard which eliminated 38 mm fluorescent lamps might be desirable (although the same effect could be achieved by restricting imports of 38 mm lamps and by convincing Canal Electric to switch to 26 mm lamps). In the long-term, when electronic ballasts and high pressure sodium lamps and ballasts are produced in Egypt, minimum efficiency standards could be used to encourage use of these products.

Building Code Requirements. Egyptian building codes, to my knowledge, do not include any energy efficiency requirements. Even if requirements are included in the building code, my understanding is that building code requirements are largely ignored. If the government is confident that energy code requirements would be enforced, development of commercial building energy guidelines would be useful. Such guidelines could also be useful as a voluntary standard, particularly if technical assistance or financial incentives could be offered to encourage their use.

Electricity Prices. Adoption of lighting conservation measures is hindered by the fact that consumers pay less than half the cost of producing electricity. The government is committed to price reform. Such reform would be a major step in promoting lighting conservation measures.

E. REFERENCES

Principal contacts:

Eng. Nader Mostafa Aly, Factories General Director, Mostafa Ali Co. for Modern Lighting, 36 Rushdy St., Cairo, Tel. 3910795, 3910796, 3900211.

Eng. Ahmed Ragaei, Projects Director, Alsharif Projects Co., 10th of Ramadan City, 1 St. Quarter Center, Bldg. 1, Entrance 3, Flat 4, Tel. 666258.

Eng. Abd elrahman Taalab, General Manager TL Factory, Philips, Alexandria, Egypt.

Publications:

Brookhaven National Laboratory, 1987, "Analysis and Technology Transfer Annual Report - 1986", Upton, New York, USA.

Electricity Distribution Authority, 1989, "Annual Statistical Report - 1988", Ministry of Electricity and Egypt, Cairo, Egypt.

Geller, Howard, 1990, "Electricity Conservation in Brazil: Status Report and Analysis (draft), American Council for an Energy-Efficient Economy, Washington, D.C., USA.

General Electric, 1988a, "General Lighting Cost Analysis", GE Lighting Information Center, Nela Park, Cleveland, Ohio, USA.

General Electric, 1988b, "Selection Guide for Quality Lighting", GE Lighting, Cleveland, Ohio, USA.

Illuminating Engineering Society of North America, 1985, IES Lighting Ready Reference, New York, New York, USA.

Lovins, Amory, and Robert Sardinsky, 1988, The State of the Art: Lighting, Rocky Mountain Institute, Snowmass, Colorado, USA.

Marques, Marcos Jose, 1989, "A Conservacao de Energia Electrica - Linhas e Instrumentos para sua Viabilizacao, Diretoria De Coordenacao, Elctrobras, Rio De Janeiro, Brazil.

Miller, Eto and Geller, 1989, The Potential for Electricity Conservation in New York State, N.Y. State Energy Research and Development Authority, Albany, New York, USA.

De Moraes, Gambirasio and Lima, 1985, "Conservacao de Energia Eletrica - Motores Eletricos e Sistemas de Acionamento", Fundacao para o Desenvolvimento Tecnologico de Engenharia, Sao Paulo, Brazil.

Nadel, Geller, Davis and Goldstein, 1989, Lamp Efficiency Standards for Massachusetts: Analysis and Recommendations, prepared for Massachusetts Executive Office of Energy Resources, American Council for an Energy-Efficient Economy, Washington, D.C., USA.

O'Farrell, Paul, 1988, "Residential Electricity: Consumption, Rate Structure and Subsidy", U.S. Agency for International Development, Cairo, Egypt.

Philips Lighting, 1988a, Compact Lighting Catalogue 1987/88, Netherlands.

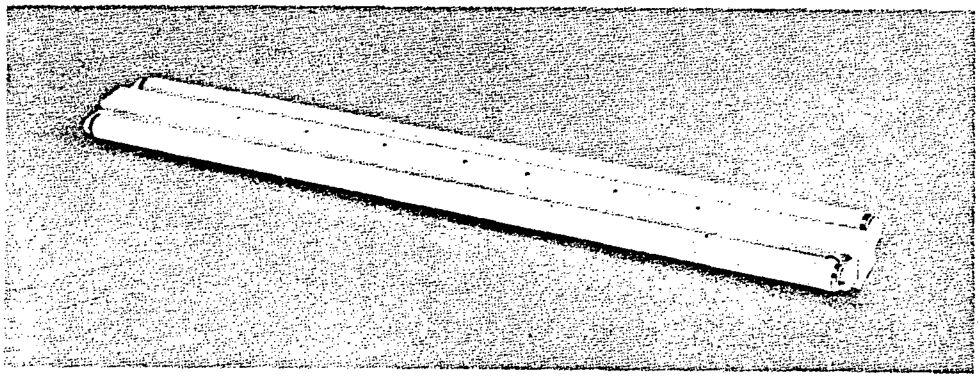
Philips Lighting, 1988b, "Lamp Specification Guide, SG-100", Somerset, NJ, USA.

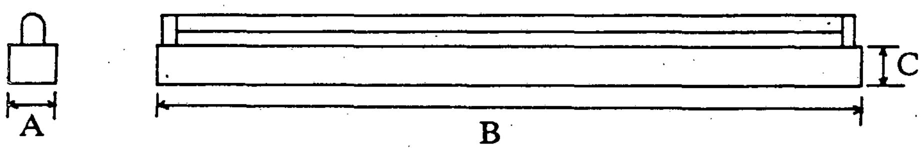
APPENDICES

1. Typical Egyptian fluorescent strip fixture.
2. Examples of decorative fixtures for circular fluorescent lamps.
3. Lamp test sheets used by Philips and Alsharif.
4. Spreadsheet for levelized cost per kWh calculations.
5. Ballast comparison.

كشافات اضاءة بدون وجه بلاستيك لتوضع فى خطوط مستقيمة

Fluoresecnt Units Without Plastic Cover To be Adapted On Direct Line

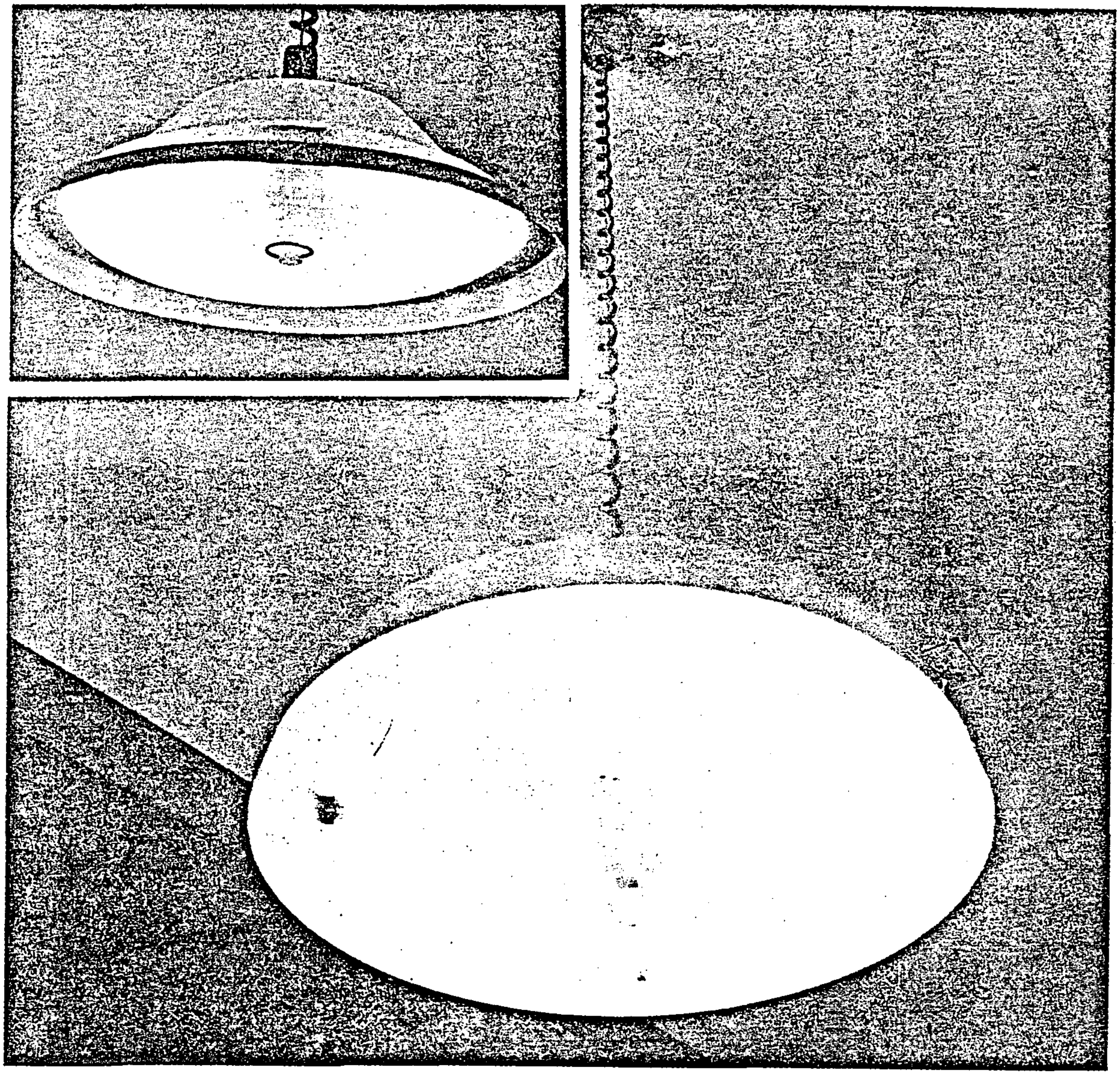




	A	B	C
M1 /40	45	1220	37
M2 /40	155	1220	40
M3 / 40	155	1220	40
M4 /40	280	1220	40
M1 /20	45	610	37
M2 /20	155	610	40
M3 /20	155	610	40
M4 /20	280	610	40

وحــدة اضـاءة نجفــة بلمبــة فلورسنت

Pleaides Circulare Units With Fluorescent Lamp 32/40 Wattt

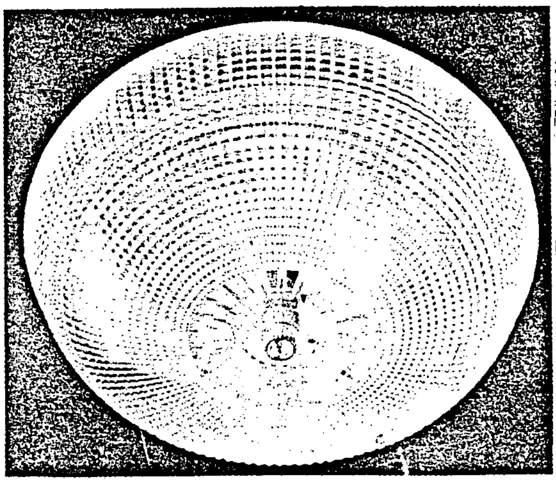


Lighting unit with fluorescent lamp 32/40 watt variable coulours , the invert from steel painted Electro-static , plastic face from pyramid crystal or rounded crystal , the unit had a spring for upper and down , manufactured as per internations suitable for offices, houses, restauwants stores different calour.

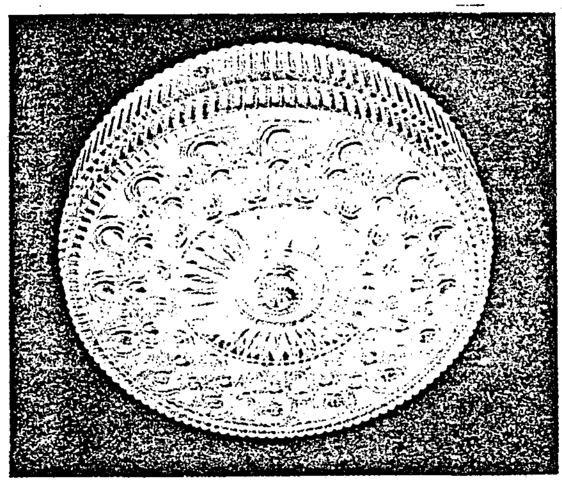
وحـدات اضاءة بلمبـة فلورسنت ٣٢ وات و٤٠ وات بـالوان جـذابـة والعـاكس من الصـاج المـدهـون بـويـه الكتـروستـاتيـك Electro — static والـوجـه من البلاستيك طـراز الكزيستـال الهرمى أو الكـريستال ذات الحلقات . والوحدات مزودة بسوسته خاصة للتحريك الى اسفـل أو الى اعلى ومصممـة طبقا لاحـدث المـواصفـات وتصلح لجميع الاغـراض للمكــاتب والمنـزل الحــديث والمطاعم والمحلات بألوان مختلفة .

وحدات الاضاءة الفلورسنت المستديرة

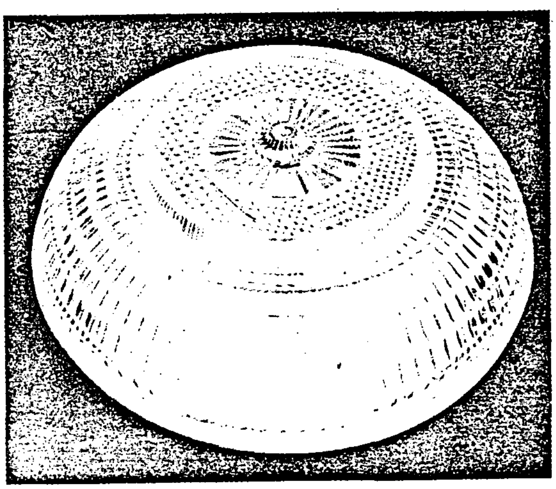
Circular Flourescent Unit



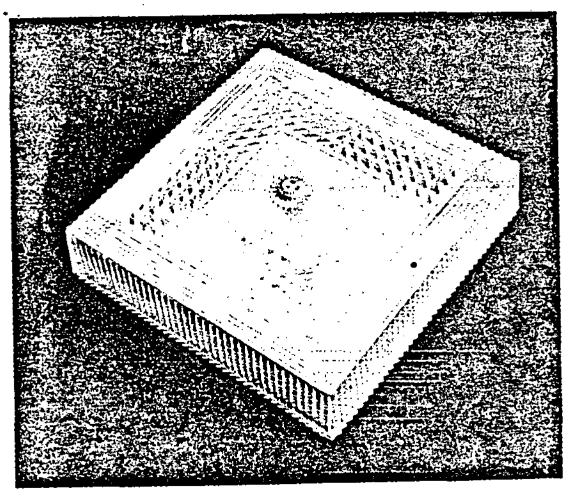
1/ 32/ S1/S



1/32/S1/BS



1/32/S1/B



1/ 32/ S1/ SQ

Philips

Date : FEB. .90

FINISHING LAMPS

(T.L , T. L. D)

A

T. L Production Line

T. L Factory

Q. D. L

group type	G. Pr	P. wt	T/B	Em. wt	Em. wt Pump.	Em. wt drop.	V. D			2 nd Control		Euro Store test				Poto Measurement,						
	2.8 ± 0.3	6.7 ± 0.5	90 %	8 ± 0.8	6.4 ± 0.6	5.3 min	0	0.4	1.5	Prod.	no light	0	0.4	1.5	Score	V 103 ± 5	I 430	W 40 ± 3	L / pct	Lm 2520	X 317	Y 342
T. L 40 / 20 w / 54	2.85	5.4	79.1	7.68			0	1.3	3	149938	911+226	0	0.15	0.8	940	109.8	428	40.2	102%	2576		
	0.04	0.3	4.2	0.35							0.6 0.15					0.05	1.8	0.2		6.5		

group type	G. Pr	P. wt	T/B	Em. wt	Em wt Pump.	Em. wt drop	V. D			2 nd Control		Euro Store test				Poto, Measurement						
	2 ± 0.3	4.6 ± 0.4	90%	6.4 ± 0.6	5.1 ± 0.4	4 28 min	0	0.4	1.5	prod.	no light	0	0.4	1.5	Score	V 103 ± 5	I 440	W 36 ± 5%	L / pct	Lm 2500	X 313	Y 337
T. L. D. 36 / 18 w / 54	1.76	3.61	80.6	5.94			0.25	1.98	1.3	85691	415 117	0	0.25	0.4	945	108.7	431	36.6	104%	2603		
	0.02	0.18	3.1	0.29							0.48 0.13					0.05	0.2	0.25		38.8		

Copy, Dr, Loutfy
Mr, Polder Vaart
General manager,
Production manager

Eng: Ahmed Younis

Q. D. L manager

Alsharif

THE EGYPTIAN INDUSTRIES FOR ELECTRIC LAMPS

QUALITY CONTROL DEPARTMENT

IN - PROCESS QUALITY CONTROL (IV)

Date :					Sheft :				FL-Line (fluorescent)			
Photo and Electric Data of Fl. Lamp												
hr	No.	No. of head	C^o	Vs	Vm	Vb	mA	W	Lm	Lm/W	m-Bar	Nots

Alsharif

THE EGYPTIAN INDUSTRIES FOR ELECTRIC LAMPS

QUALITY CONTROL DEPARTMENT

IN - PROCESS QUALITY CONTROL (IV)

Date : Sheft : GLS -Line (Incandescent)

Photo and Electric Data of FL. Lamp

hr	No	Vm	Vb	A	W	Lm	Lm/W	Comment
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								
	1.							
	2.							
	3.							
Average								

Report :

Checked By :

Haggag/.

LEVELIZED COST FOR EGYPTIAN LIGHTING IMPROVEMENTS

Measure	W Saved	Cost	Life	EL/kWh
26 mm fluor. lamps	4	0.45	3	0.015
Effic. magnetic ballast	3	6.5	15	0.095
Electronic ballast	5	6.5	15	0.057
Reflector incand. lamp	15	1.6	0.67	0.057
Circular fluorescent	54	6	3	0.015
Compact fluorescent	45	25	3	0.074
High pressure sodium lamp	155	105	8	0.042
Reduce watt incand. lamp	9	0.3	0.25	0.047

Note:
EL/kWh = Cost/PV[(W saved * 3000 hrs per yr/1000 W per kW),
10% discount rate, measure life]

Ballast Comparison

Ballast Type	Power (W)	PF*	Lifetime (yrs)	Price (LE.)
Egyptian, poor quality	50+	0.5	10	6.0
Egyptian, good quality	47-48	0.57	10	6.5
European, improved efficiency	45	>0.9	20	13.0
Electronic	43	>0.9	30	7-13.0
Electronic, designed for 26mm lamp	37	>0.9	30	7-13.0

* PF equals ballast factor.

LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
INFORMATION RESOURCES DEPARTMENT
BERKELEY, CALIFORNIA 94720