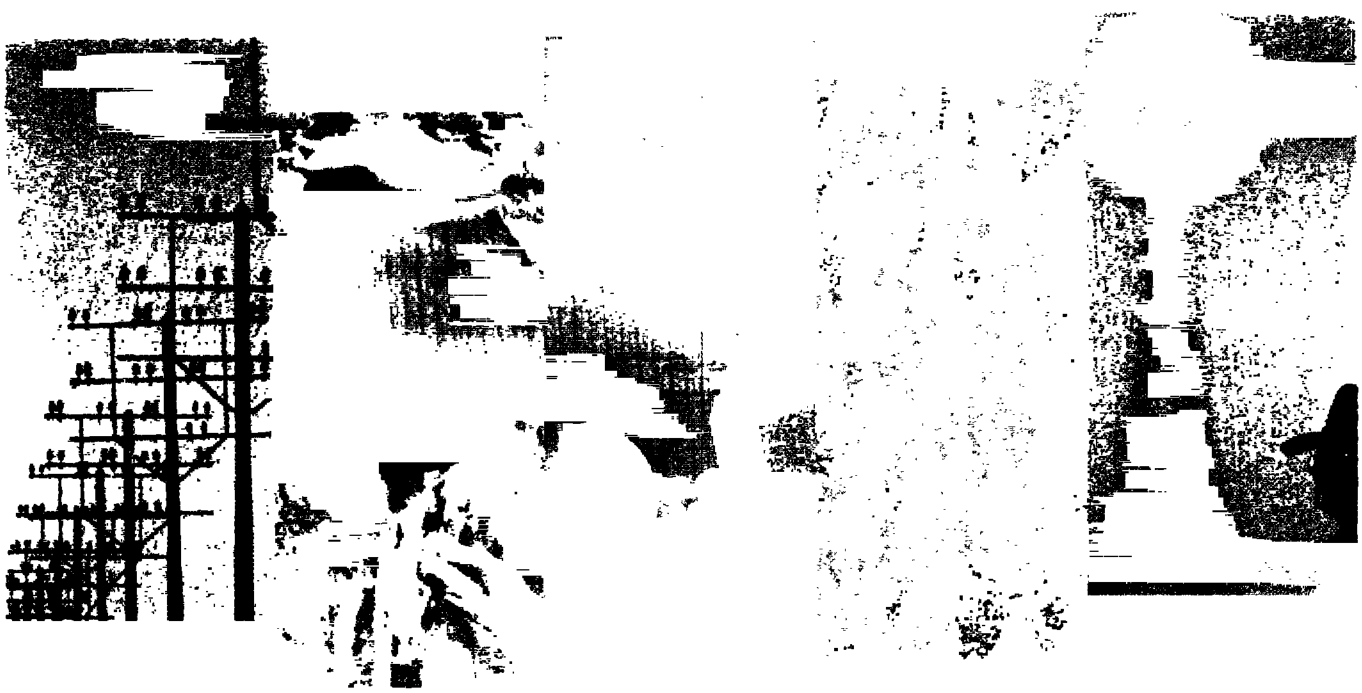
Mongolia

Energy Efficiency in the Electricity and District Heating Sectors

ESM247



Energy

Sector

Management

Assistance

Programme

ESMAP

Report 247/01

October 2001

JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance program run as part of the World Bank's Energy, Mining and Telecommunications Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and bilateral official donors in 1983, it focuses on the role of energy in the development process with the objective of contributing to poverty alleviation, improving living conditions and preserving the environment in developing countries and transition economies. ESMAP centers its interventions on three priority areas: sector reform and restructuring; access to modern energy for the poorest; and promotion of sustainable energy practices.

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Mongolia - Energy Efficiency In The Electricity And District Heating Sectors

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ESMAP Management"

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Currency Equivalents

Exchange Rate Effective December 2000:

Local Currency Unit = Tugrik (Tg)
US$1 = Tg 1080
Tg 1000 = US$0.93

MONGOLIAN FISCAL YEAR
January 1 - December 31

Abbreviations and Acronyms

ADB	Asian Development Bank
CHC	City Housing Company
CHP	Combined Heat and Power
DANIDA	Danish International Development Agency
DH	District Heating
DHC	District Heating Company
DHS	District Heating System
DHW	Domestic Hot Water
EA	Energy Authority
ESMAP	Energy Sector Management Assistance Program
ESW	Energy Sector Work Strategy
GOM	Government of Mongolia
MDBs	Multilateral Development Banks
MID	Ministry of Infrastructure and Development
PCOS	Production Controlled Operation Strategy
SPC	State Property Committee
TD	Transmission and Distribution
TES	Thermal Electrical Station
TOR	Terms of Reference
UBEDO	Ulaanbaatar Electricity Distribution Office

Executive Summary

Purpose

1. The purpose of this Activity Completion Report is to summarize the results of support from the Energy Sector Management Assistance Program (ESMAP) to Mongolia in the rehabilitation of its electricity and district heating systems during the period 1994 to 1998. This support was undertaken by the Joint United Nations Development Programme (UNDP)/World Bank ESMAP, in coordination with the Government of Mongolia (GOM), donor agencies, and the Asian Development Bank (ADB). Danish and Swedish trust funds provided co-financing.

2. ESMAP has been involved in Mongolia through two distinct periods:

- From 1994–95, ESMAP assisted the Government in developing an Energy Sector Work Strategy (ESW). The strategy prioritized policy actions and investments over a 6-year period in the coal-power-heat supply chain and laid out the foundation for future policy and lending activities of donor agencies and multilateral development banks (MDBs). The ESW had two main outcomes: (i) It helped shift attention from emergency aid to stabilization efforts and promoted the sector's institutional transformation to a more commercial approach, thus paving the way for sector reform. (ii) It identified investment priorities, beginning with the rehabilitation of the coal sector (which was subsequently financed by the World Bank), and then focusing on increasing the reliability of the main combined heat and power (CHP) plants and the district heating system (DHS), which were subsequently financed by the ADB and donor agencies.

- From 1995–2000, ESMAP facilitated technical assistance to improve the efficiency of heating stoves in low-income areas (gers) around Ulaanbaatar and focused on energy efficiency improvements in the capital city of Ulaanbaatar. This report covers only the latter involvement, and summarizes the main conclusions and recommended investment priorities on the basis of energy efficiency assessments of the capital's electricity and district heating distribution systems. Some of these recommendations will be carried out through a World Bank loan that is currently being prepared.

Background

3. Mongolia's DHS caters to a large portion of the urban population in one of the coldest climates in the world. Its electric power system supplies energy to core mining activities and to industrial, commercial, public, and household consumers. The central system is based on five coal-fired CHP plants with an installed electricity capacity of 793.5 MW and a heat capacity (steam and hot water) of 4873 MWth. This system, which is connected to Russia's Siberian grid by a 220-kV line, services Ulaanbaatar, Darkhan, Baganuur, Erdenet, and six surrounding aimags. This area as a whole accounts

for about 90 percent of the total electricity use and for most of the country's district heating. Small towns (aimag centers) beyond the central system are either serviced by small coal-fired CHP plants and DHSs or by various combinations of coal-fired, heat-only boilers and diesel-fueled, power generation sets.

4. The Energy Department of the Ministry of Infrastructure and Development (MID) is responsible for the formulation of energy policy and for monitoring its execution. The central system and the aimag systems are managed by the Energy Authority (EA), a state-owned umbrella institution for a number of subsidiary energy enterprises. One of these subsidiaries is the Ulaanbaatar Electricity Distribution Office (UBEDO), which is responsible for the distribution of electricity in the capital. UBEDO sells about 604 GWh annually, compared with countrywide electricity sales of about 1837 GWh in 2000. Another subsidiary is the District Heating Company (DHC), which is responsible for the generation and transmission of power, heat, and steam in Ulaanbaatar. DHC sells heat to industrial, institutional, and commercial end-users as well as to residential consumers. In year 2000, EA's total revenues came close to US$77 million (80 percent from electricity and 20 percent from heat).

5. Problems associated with the operation of the CHP system include: (i) low availability of power generating units (close to 60 percent in 1994–95); (ii) lack of operational flexibility to follow and meet peak load demand; (iii) growing losses in the distribution of electricity and heat; and (iv) financial shortages resulting from low tariffs, low collections of billed electricity, and large inter-company arrears. All of these issues are being tackled, but sustainable solutions will require a long-term partnership between the GOM and donor agencies, to attract private sector participation while establishing a sound regulatory framework.

Main Conclusions

6. ESMAP had two main objectives: (i) ascertain the level and sources of losses in the electricity and district heating distribution systems in Ulaanbaatar, and (ii) propose a set of actions and investments to lower these losses to economic levels. To take measurements and develop reliable data over a prolonged period, the Mongolian counterparts at the DHC and UBEDO formed teams to draw up the TOR, discuss the interim results, and review and approve the final reports. The organizations also arranged study tours to gain insight into the operation and regulation of DHS in other countries that might have relevance to Mongolia.

7. ESMAP's research resulted in three main conclusions:

- In the power distribution system in Ulaanbaatar, overall energy losses[1] on the transmission and distribution (TD) system are following an upward trend, increasing from about 27 percent of the net energy supplied in 1995 to 30 percent in 2000. Of these losses, about 14 percent are estimated to be technical losses and 16 percent are estimated to be non-technical losses. The major problems are occurring in the low-voltage system, as opposed to the mid-voltage system. Ger areas pose the greatest problem for UBEDO because of high non-technical losses and difficult bill collection. Overloaded transformers and excessively long and thin low-voltage lines are the top priorities for rehabilitation. Such lines are most frequent in ger districts, which are suburban residential communities of 60 or more small houses or tentlike structures. UBEDO customer relations and sales functions have not yet changed to match commercial practices and are fraught with problems that contribute to high non-technical losses. The current setups with consumers, which originated in the previous centrally planned system, must be changed for the company to act on a commercial basis and for future privatization. For example, meters are still owned and controlled by customers rather than by the power utility.
- In the DHS, water loss constitutes the major problem, with leakage rates well beyond internationally accepted standards. The current water loss amounts to about 6 million tons a year, averaging around 1,000 ton/h during the heating season (October to April). The total annual water loss equals 310 GWh. The heat loss resulting from transmission and radiation is estimated at about 340 GWh, or 14 percent of the total supply. This rate is still high compared with the international standard of 5 to10 percent, but is not as serious as the water leakage.
- A more subjective conclusion is that Mongolia should approach efficiency improvements and sector reform with a CHP frame of mind, that is, in an integrated way rather than addressing the problems of power supply and district heating reform separately. Given the nature of the CHP system in Mongolia and the effects of heat demand on electricity supply, the studies forming the basis for this report indicate that integrating the analyses of the two sectors would achieve higher returns. The Government agrees with this conclusion and is preparing an Energy Law that will allow the separation of policy, regulatory, and operational roles in the energy sector.

8. The following chapters provide more technical details on the sources of energy losses and recommended actions. The Mongolian and consultant team, however, shares the view that the current institutional organization does not provide incentives for improvements. This is one of the problems that will be tackled by the Energy Project to be supported by the World Bank (see details below). This report does not consider

[1] Technical losses are those that result from the transformation of electricity into other forms of energy (primarily heat) as current flows from the generating stations to the end-user. Non-technical losses represent energy supplied to the end-consumer but not billed for by the utility.

reforms of the institutional and legal structure of the electricity and district heating systems.

Main Actions

9. Following up on ESMAP assistance, the GOM and the World Bank are preparing a US$35 million Energy Project that should (i) improve the efficiency and reliability of the power distribution system in Ulaanbaatar, (ii) improve revenue collection and reduce losses, and (iii) assist UBEDO to become a modern and commercialized electric power distribution company on a more sound financial footing. A reduction in distribution losses from 30 percent to close to 14.5 percent is expected to result from the implementation of this project.

10. In parallel, the Danish International Development Agency (DANIDA) and the ADB are undertaking investment projects in the district heating sector that are aimed at improving the overall operation of the system and, in particular, achieving a substantial reduction in heat and water losses. As is the case in the energy sector as a whole, the district heating sector still needs action to move it toward a more commercial structure. This means that, after current rehabilitation investments to stabilize the system take place, institutional reform must be undertaken.

1

District Heating System In Ulaanbaatar: Sources Of Losses

1.1 The summary in this chapter is supported by nine technical papers[2] of the working team, which consisted of staff from the Ministry of Infrastructure and Development (MID), the District Heating Company's (DHC) General Manager, local and international consultants, and World Bank staff. Fieldwork was carried out during 1996 and 1997, and the team has also taken into account the various investments undertaken by the Government of Mongolia (GOM), the Danish International Development Agency (DANIDA), and the Asian Development Bank (ADB) (Loan 1492-MON and TA-2610).

1.2 The working team decided that the following four tasks deserved the highest priority, constituting an agenda for further work:

- Stop rapidly increasing water losses within the power plants and create a basis for a sustainable operation of the internal heating systems in the future.
- Minimize the negative impact of the increased transmission pressure level in terms of increased leakage.
- Improve the situation in the distribution system currently owned by the City Housing Company (CHC) to reduce losses in the service line to the end-users of heat and hot water.
- Further commercialize the DHC.

1.3 The team estimated that about US$17 million in investments over a 5-year period would be required to approach these tasks in a sustainable manner while complementing current investments that are being supported by the ADB in particular. The benefits should include reduced energy production at the combined heat and power (CHP) plants, reduced water consumption at the level of both Energy Authority (EA)/DHC and CHC, and reduced electricity requirements for pumping.

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2 Technical papers: Water Loss Analysis; Heat Loss Analysis; Heat Production Capacity; Water Treatment System Analysis; Status Assessment of Transmission System; Overview Hydraulic Conditions; Distribution System Analysis; Organization of UB District Heating Company; and Overview Tariff Structure and Contractual Issues Related to Supply and Purchase of Heat.

Background

Institutional Framework

1.4 The district heating (DH) system includes:

- three power plants [thermal electrical station (TES) 2, 3, and 4] owned and operated by the EA;
- the transmission network, owned and operated by the DHC; and
- the distribution systems, owned and operated by different parties, of which the municipality-owned CHC is the most important.

1.5 The DHC is a subsidiary company under the EA. It is responsible for the generation and transmission of power, heat, and steam in Ulaanbaatar (and beyond), selling heat to industrial, institutional, and commercial end-users and to residential consumers. The EA is owned by the State Property Committee (SPC), which supervises and audits state-owned enterprises. The MID's Energy Department is responsible for formulating energy policy and monitoring its execution.

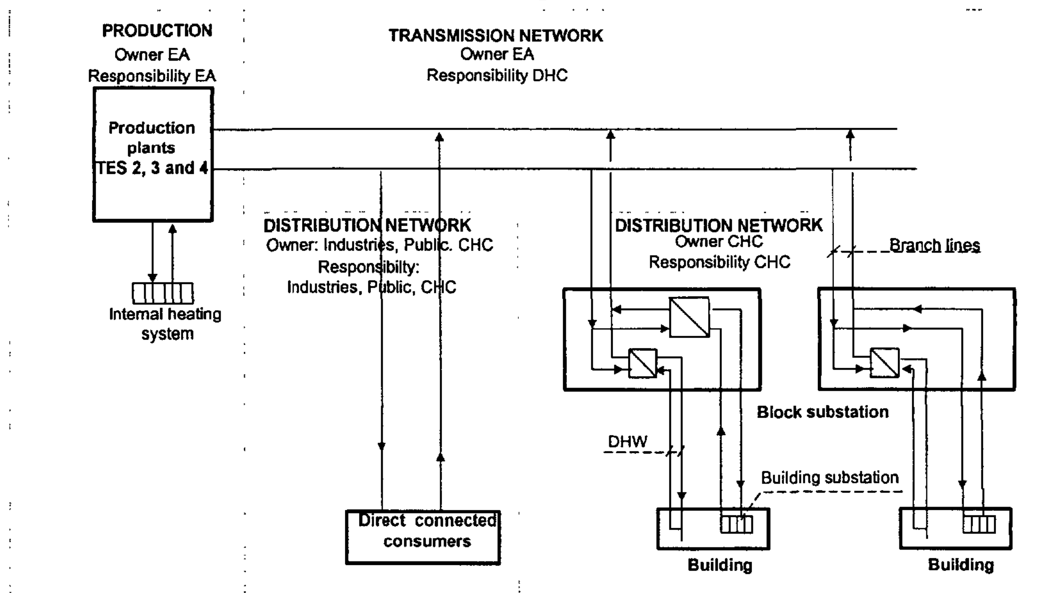
1.6 Heat tariffs are set by the MID, after consultation with the EA. There are separate tariffs for tenants, industries, domestic hot water (DHW), and process water. The tariffs are revised once or twice a year, according to a variable adjustment formula. The DHC is operated as a company with its own separate accounts and balance statement. Its assets include nearly all main transmission lines and most of the branch lines. The DHC transfers all of its gross sales revenues to the EA. In return it receives 10 to 15 percent of the revenues from heat and DHW sales to cover operating expenses.

1.7 The current district heating system (DHS) is designed in accordance with the Production Controlled Operation Strategy (PCOS). One effect of this design is that usually more energy than necessary is pumped into the system to ensure that sufficient heat is always available for the majority of consumers. PCOS also prevents the introduction of a tariff structure based on actual use, because it leaves little possibility for individual customers to control and affect heat consumption.

Main Elements and Technical Features

1.8 To create a common understanding about the kind of installations referred to in this chapter, typical components of a normal DH vocabulary system are explained below. The diagram also shows the general division of responsibility and ownership of the DHS.

Figure 1.1



1.9 Following are main definitions of vocabulary items in the above diagram:

- ***Transmission network:*** the main pipe network between production plant and consumers. The transmission system is normally a two-pipe network, with one supply pipe and one return pipe. The pipelines are either over ground (aerial) or underground (with the pipes placed in concrete ducts).
- ***Branch lines:*** connect the main transmission lines with the block station or with directly connected consumers.
- ***Distribution network:*** normally a four-pipe network, with one supply and one return pipe for DHW and a similar set for radiator water (for heating). The DHW not used by the tenants is re-circulated to the block substation. About 50 percent of the block substations have a heat exchanger for radiator water, thus providing a hydraulic separation between transmission and distribution systems. The pipelines either run underground between the buildings or are located in the basements.
- ***Block substation:*** the building or cabinet that forms the border between the transmission and the distribution system. It houses installations for the control, distribution, and preparation of DHW and of water for space heating.
- ***Building substation:*** normally located in a special cabinet that contains equipment for the radiator circuit. If there is a heat exchanger for DHW production, it is in the same room. If the building is connected to a four-pipe system, the substation for DHW cannot be strictly defined, but the shut-off valves in the string can be said to be the dividing line.

Sources of Losses

Technical Losses by Source

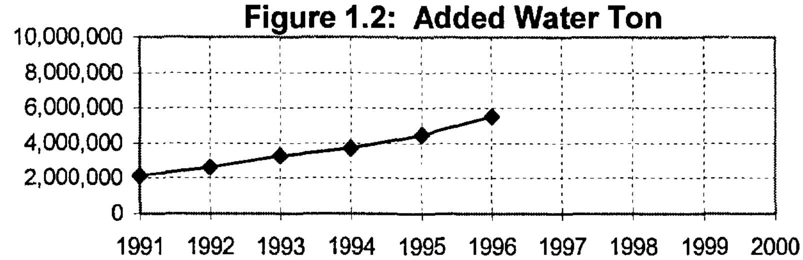
1.10 The approach used to assess water and heat losses included:

- Evaluation of operating statistics.
- On-site status assessments, including the recording of visible leaks.
- Flow measurements to verify recorded data.
- Flow measurements to identify leakage or so-called water theft.
- Follow-up statistics.

1.11 By far the greater part of the research was performed during November and December 1996, when most of the measurements took place. The consultants and the management of DHC agreed on a plan of action for additional measurements, to be carried out by the Mongolian party and subsequently presented at the evaluation conference in July 1997. The results of these additional measurements were considered in this report.

1.12 Water Losses. Water losses have been gradually increasing over recent years, as shown below. The figures come from DHC reports and reflect actual measurements at the TES plants. "Added water ton" refers to the amount of water that is added to compensate for losses.

Figure 1.2: Added Water Ton



1.13 The situation is critical and seems to be gradually getting worse. The average flow of water added to the systems is shown below for six consecutive heating seasons, which last from October to April.

Table 1.1

Heating season	1990–91	1991–92	1992–93	1993–4	1995–96	1996 Autumn
Ton/h	304	529	500	656	754	900

1.14 The water losses in the total system are summarized below:

Table 1.2: Division of Water Losses

	Added flow ton/h	TES internal system	Transmission network	Branch lines, sub-stations	Block stations, distribution system
TES 2	20	Marginal			
TES 3 HP	360–400	100–150			
TES 3 LP	70	30			
TES 4	490–570	200			
Total	**940–1,060**	**360–410**	**180–240**	**250–275**	**160**
Total average	**1,000**	**385**	**210**	**250**	**160**
Division in %	100	38	21	25	16

1.15 The particularly high water loss in the internal heating system at TES 4 is due to its deteriorated condition. It should further be noted that, when the additional water demand is beyond the capacity of the treated water installations, raw water is used to make up the balance. This practice increases the corrosion in old and rehabilitated pipes. The overall water loss requires an extra supply of heat of close to 310 GWh a year.

1.16 Heat Losses. Heat losses were estimated on the basis of status assessments and the network documentation, supplemented by the actual operating data. These results are listed in the table below in Table 1.2:

Table 1.3

Annual losses	Ducts	Aerial pipes	Total	Percent of heat con-sumed	Percent of heat produced
	MWh	MWh	MWh	%	%
Radiation losses, main line	110,000	170,000	280,000	11.4	9.0
Radiation losses, branch lines	60,000		60,000	2.4	2.0
Total radiation losses	**170,000**	**170,000**	**340,000**	**13.8**	**11.0**

1.17 In general, the heat losses are within acceptable limits, although they can still be reduced if certain parts of the system, marked in the status assessments, are rehabilitated. Some of the rehabilitation measures will be implemented under the DANIDA-financed project and under the ADB-financed Energy Conservation Project (see details below).

Areas for Improvement

1.18 A strategy to reduce losses to economic levels will have to include at least the following components:

- Better incentives to reduce losses at their sources, through reform of the current institutional and regulatory structure. The current arrangement does not enable the DHC to address the main sources of water losses, which are occurring in the internal system of the power plants and in the service lines to the end-users of heat and DHW.

- Investments in (i) rehabilitation of the distribution systems, (ii) rehabilitation of the internal systems of TES 3 and TES 4, (iii) replacements in the transmission system, (iv) installation of sectioning valves and compensators, (v) differential pressure controllers, (vi) maintenance and repair equipment; and (vii) support for the commercialization of the distribution companies.

1.19 The purpose of this study was to focus only on the physical source of losses; however, the current institutional setup is not conducive to sustain any reduction in losses. Therefore, along with a loss reduction program, there ought to be a component that enables the DHS to transform to a more commercial orientation.

1.20 Regarding priority investments, the team reviewed ongoing and planned support by donor agencies, particularly DANIDA and the ADB. This support is focused as follows:

- DANIDA: Replacement of 3.1 km of pipeline (3 percent of the total) and of 36 compensators in the transmission system. The replacement of pipelines will have a positive impact on the reduction of both water and heat losses (the latter will be at least halved for the network section concerned). The reduction of water losses is more difficult to estimate, but losses related to repair work on the sections concerned would be eliminated, while the water losses from compensators will also be reduced.
- ADB Energy Conservation loan, 1492-MON: Replacement of 6 km of district heating pipeline and 39 sectioning valves. Furthermore, a large part of the overground piping will be furnished with new insulation and coverings. The new valves will facilitate leak detection, making repair work easier to perform. The pipe replacement will bring the same benefits as in the case of the DANIDA project. The insulation work on overground pipelines will effectively reduce the heat losses on those sections, since the current insulation is damaged and in some places is missing entirely.
- ADB Heating Rehabilitation Project, 1548-MON: This project will set the stage for the rehabilitation and conversion of the DHS to a variable flow operation, including:
  - Installation of variable speed-controlled pumps at the power plants, which will make it possible to run the three TES plants in one common network. This step will facilitate leak detection.
  - Installation of a new pressure holding system, increasing the pressure.
  - Separation of the internal TES heating systems from the transmission and distribution system. Water losses will be easier to

detect and it will facilitate a commercial relationship between the EA and the DHC in the future.

- Addition of water treatment capacity. This step will remove the need to resort to raw water and thus will minimize the corrosion process.
- Improvement of block substations, with hydraulic separation and installation of control equipment. This measure will clearly divide the responsibilities for water losses between the DHC and the CHC, making losses more easily detectable. The installation of control and metering equipment will most likely reduce losses from water theft.
- Separation of directly connected consumers by means of heat exchangers. As in the case of the block substations, this measure will clearly divide the responsibilities between the DHC and its clients, thus facilitating leak detection.

1.21 Pending the completion of the above investments, the next generation of investments required, estimated at about US$17 million, should include:

- Radical reduction of water losses within the power plants and creation of a basis for a sustainable operation of the internal heating systems in the future.
- Minimization of water losses in the transmission system as a result of the high pressure levels.
- Improvement of the situation in the distribution system currently owned by the CHC to reduce losses in the service line to the end-users of heat and hot water

1.22 A reduction of losses in the DHS will also have a positive effect on electricity generation resulting from reduced water pumping requirements.

2

Electricity Distribution In Ulaanbaatar

2.1 The summary in this chapter was prepared by a team that consisted of staff from UBEDO and local and international consultants during 1997–97. Although this team focused its investigations on the capital, the national relevance of the study has not suffered unduly, because Ulaanbaatar consumes about 33 percent of the energy that is distributed annually by the national interconnected grid, and the characteristics of the power system in the capital are typical of those in Mongolia's other cities, including Darkhan.

2.2 Fieldwork, measurements, and discussions with the local counterpart led the team to the same broad conclusion that applied to the DHS, namely, that the increasing level of losses in the electricity distribution system can be attributed to both technical and non-technical causes. The study team focused on estimating the level of these losses, identifying their main sources, and drawing up a plan of action to reduce the losses to economic levels.

2.3 Preliminary estimates as well as measurements taken throughout the study indicate that total losses are increasing: they were 27 percent in 1995 and went up to 30 percent of the net energy supply in 2000. About 14 percent are estimated to be technical losses and 16 percent are estimated to be non-technical losses. This loss level means that about 300 GWh a year is supplied without receiving any payment for it. The main sources of technical and non-technical losses are as follows:

- Non-technical losses:
  - Un-metered (but authorized) consumer supplies;
  - power theft; and
  - lack of transparent billing procedures for those apartment buildings that are metered as single units, the bills for which are being submitted to the building management. UBEDO customer relations and sales functions have not yet changed to match commercial practices and are fraught with problems that contribute to high non-technical losses.

- Technical losses:
  - major problems were found to be in the low-voltage system, as opposed to the mid-voltage system. Overloaded transformers and excessively long and thin low-voltage lines (mostly in ger areas) are the highest priority for rehabilitation.

2.4 Following up on the work conducted by the study team, the GOM and the World Bank are preparing a loan to focus on the main problems identified in the study and to address simultaneously those institutional areas that must be reformed in order to put the sector on a commercial footing.

2.5 The next section summarizes the study team's fieldwork, conducted during the 1996–97 period. The figures have been updated to year 2000.

Background

2.6 The Ulaanbaatar supply system operates at voltages of:

- 110 kV for transmission,
- 35 kV for subtransmission and some distribution lines, especially in rural areas,
- 6 and 10 kV for primary (medium-voltage) distribution in the urban areas, and
- 400 V for three-phase low-voltage consumer supplies.

2.7 The 6-kV feeders emanate primarily from Power Stations 2 and 3, in which generators operate at 6 kV and are directly connected to distribution busbars. But a few 6-kV feeders originate in substations not belonging to Power Stations 2 and 3. Some of the physical characteristics of the supply network in Ulaanbaatar City itself (not the entire UBEDO supply area) are shown below:

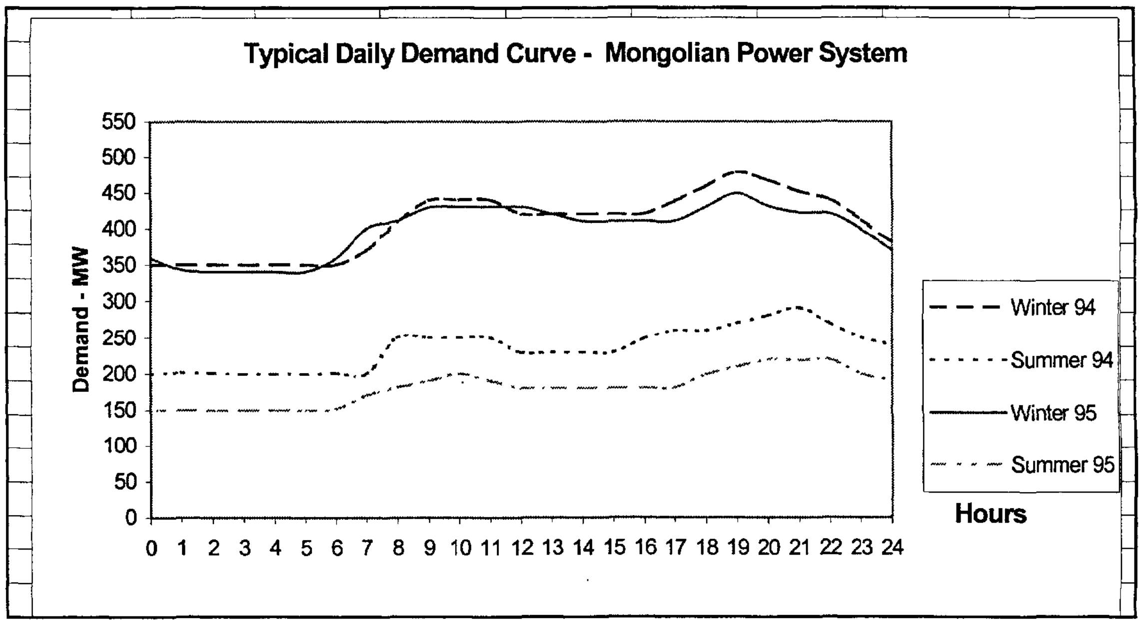
Table 2.1: Ulaanbaatar City Power Supply System

SUBSTATIONS		LINE LENGTHS	
Voltage kV	No.	Voltage kV	Length km
220	1	220	285.8
110	13	110	207
35	50	35	753
6/10	549 pole-mounted	6/10	3908 overhead
6/10	590 indoor	6/10	678 underground
		0.4	965 overhead
		0.4	514 underground

2.8 The loads in Ulaanbaatar City are roughly divided into three areas. In and around the city center is a densely concentrated area in which consumers are predominantly industrial and commercial. Surrounding this central area and extending into the suburbs, the loads are primarily residential. Out in the suburbs themselves, residential dwellings are often grouped into communities consisting of 60 or more small houses and tent-like structures. These communities, generally referred to as the ger districts,[3] are characterized by dense population and relatively low consumption, averaging about 180 kWh/month per house during the winter, when space heating is required.

2.9 Major industrial loads include municipal water pumping from deep wells, pumping installations for the central DHS, the abattoir, bakeries, wool processing factories, and carpet factories. As a result of the severe winters in Ulaanbaatar, the system must cope with a high peak in electricity consumption during half of the year, when electric space and water heaters are used and when additional energy is needed to pump water into the central DHS. The figure below shows the seasonal differences for two consecutive years.

Figure 2.1



2.10 Very few substations, including those within the power stations, are equipped with meters that can directly indicate the power factor or even the reactive power demand. Measurements on a number of feeders showed that many of these operate at very low power factors (less than 75 percent). UBEDO itself has not installed any capacitors, but there is power factor correction equipment in a number of consumer-owned substations.

3 The number of people coming to Ulaanbaatar, mostly to the ger area, has grown at an average of 12.7 percent per year since 1999. In 2000 alone, the number of families in gers grew by 8.4 percent while the number of new businesses in the city has grown by an average of 11 percent over the 1999–00 period.

2.11 Electricity demand in the Ulaanbaatar area has grown from 570 GWh in 1998 to 604 GWh in year 2000, while energy purchases by UBEDO—to satisfy that demand—have grown from 810 GWh in 1998 to 911 GWh in year 2000. Thus overall losses have grown from 29.6 percent to 33.7 percent in 2000, a compounded annual loss rate of 13 percent.

Transmission and Distribution Losses

Non-technical Losses

2.12 Non-technical losses account for about 16 percent of the energy annually supplied to the UBEDO transmission and distribution systems. By international standards, this is a very high level. Non-technical losses, which represent energy supplied to consumers for which no bills have been issued, are the result of errors or inadequacies in the metering, meter reading, or billing systems of the utility. Common contributors to non-technical losses are:

- *Un-metered supplies to registered consumers.* Only about one-third of UBEDO's residential consumers are provided with company-installed meters. A very large percentage of the residential consumption is therefore estimated, at a time when annual residential growth in the ger districts in year 2000 was 8.5 percent.
- *Power theft.* Unauthorized connections to UBEDO's system are a major contributor to non-technical losses. In the ger districts it is not difficult to find examples of illegal diversion of power. The problem is more pronounced in winter, when many householders are unable or unwilling to purchase coal for space heating. These households connect directly to UBEDO's system in order to run poor-quality resistance heaters. Power theft is also a factor in technical losses, since the illegal connections are most easily made to the lowest phase of the utility's low-voltage feeders. As a result, this phase becomes too heavily loaded and the resulting imbalance between phase currents increases the technical losses in the system.
- *Faulty meter installations.* This category includes wiring defects, mismatch of instrument transformers, and tilted meters, etc.
- *Metering defects.* Meters may be incorrectly calibrated, or may lose accuracy with age, or may suffer from deliberate tampering with the mechanism.
- *Meter-reading errors.* Many apartment buildings are equipped with only a single UBEDO meter and the bills are submitted to the building management companies. These companies resort to sub-metering the individual apartments, but the meters concerned are not owned by UBEDO and are not read by its personnel. In many cases, the management companies dispute the readings of the single official meter and pay instead for what they claim is the actual total consumption, based on summing the readings of the individual meters. UBEDO is not allowed to check this

procedure and has so far (reluctantly) accepted the position of the management companies. It is difficult to find other examples in the world of a utility that allows the customer to decide what his or her consumption has been, despite the existence of an official meter.

2.13 The study team concluded that each of the above five factors contributes to some extent to the high level of UBEDO's non-technical losses, but decided that the following three factors most urgently require attention: (i) un-metered but authorized consumer supplies, (ii) power theft, and (iii) regularization of billing and payment procedures for single-meter apartment buildings.

Technical Losses

2.14 During the next few years, work should focus on the following five priority areas in order to reduce technical losses to economically acceptable levels:

- *Overloaded low-voltage distribution transformers.* Routine checks showed a large number of such units to be highly overloaded, some up to more than 230 percent of their rated capacity. In general, a transformer that operates frequently at or above its rated capacity should be replaced in order to ensure system reliability and to keep losses at an acceptable level. Preliminary estimates indicate the need to purchase and install about 200 MVA low-voltage distribution transformers.
- *Overloaded medium-voltage distribution transformers.* Based on the load-flow analysis performed during its fieldwork, the team recommends the reinforcement of seven medium-voltage distribution transformers.
- *Voltage upgrading of 6-kV feeders.* An evaluation of the economics of upgrading those 6-kV substations and feeders that are too heavily loaded indicates that upgrading to 10 kV would produce a marked benefit. Since it is not possible to tackle all of the 6-kV substations and transformers on emanating feeders within one simultaneous exercise, the team recommends starting with substation Dornod 1 and the transformers on its 12 feeders.
- *Reconductoring low-voltage feeders.* Calculations have made it clear that the low-voltage feeders produce the highest share of the total conductor losses. A very large number of these low-voltage feeders are of the 25-mm^2 bare aluminum steel conductor type, but the poles, insulators, and related hardware will support 35-mm^2 conductors without modification. An evaluation of the economics in upgrading 40 km of low-voltage feeders from 25 mm^2 to 35 mm^2 showed a favorable benefit.
- *Capacitor installation for power factor improvement.* Measurements, presented in the main report, have shown that many medium-voltage feeders operate at very low power factors. Sample calculations of the economics of capacitor installation for loss reduction in these feeders show a good benefit.

Table 2.2: Ulaanbaatar City Power Supply System

GWh	1997	1998	1999	2000
Energy purchases	796	810	867	911
Energy sales	559	570	603	604
Losses: %	29.8	29.6	30.4	30.7

Source: EA's statistics, December 2000.

Conclusions

2.15 Experience in other countries around the world over the past decade has shown that competitive private sector participation in the distribution sector has a greater probability of reducing losses in a sustainable way, while reducing inter-company arrears. Mongolia is not an exception. A recent World Bank-sponsored study[4] shows the need for an enabling environment to increase the chances of a successful privatization, including:

- establishment of an effective industry model prior to privatization;
- establishment of a well-functioning industry and regulatory model in advance of asset sales;
- a well-administered sales process; and
- management control.

2.16 None of these conditions has been established in Mongolia yet. However, first steps are being taken to establish a new electricity and heating law.

2.17 In the interim, as a minimum, there is a need for a total investment package of about US$15 million. This investment package includes (i) new installation and replacement of distribution transformers, (ii) mid-voltage step-up in Dornod I substation area, (iii) reconductoring of low-voltage lines (which also will contribute substantially to non-technical loss reduction), (iv) spare parts, safety equipment, and measurement tools, (v) installation of new UBEDO meters and reconfiguration of service drop wires, and (vi) re-engineering and commercialization of UBEDO customer business procedures. The team also recommends the purchase of software for distribution system analysis and for the production of digital maps.

2.18 All of these investments are economic and will assist in reducing technical losses to realistic economic levels, while complementing structural reforms in the energy sector. The actual volume of the investments and the priority that should be given to each of the various recommendations will also depend on the amount of capital available and on the results of more rigorous investigations than were possible within the scope of this study.

4 "An Analysis of Electricity Distribution Privatization in Developing Countries," The World Bank, February 2000.

Joint UNDP/World Bank
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
	Commercilizing Natural Gas: Lessons from the Seminar in Nairobi for Sub-Saharan Africa and Beyond	01/00	225/00
	Africa Gas Initiative – Main Report: Volume I	02/01	240/01
	First World Bank Workshop on the Petroleum Products Sector in Sub-Saharan Africa	09/01	245/01
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
	Africa Gas Initiative – Angola: Volume II	02/01	240/01
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cameroon	Africa Gas Initiative – Cameroon: Volume III	02/01	240/01
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessement (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94

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Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
	Africa Gas Initiative – Congo: Volume IV	02/01	240/01
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95
	Africa Gas Initiative – Côte d'Ivoire: Volume V	02/01	240/01
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
	Africa Gas Initiative – Gabon: Volume VI	02/01	240/01
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87

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Madagascar	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	--
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	--
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95

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Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution SystemTechnical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--

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Zimbabwe	Rural Electrification Study	03/00	228/00
	EAST ASIA AND PACIFIC (EAP)		
Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/999
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Mongolia	Energy Efficiency in the Electricity and District Heating Sectors	10/01	247/01
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Energy Strategy Paper (English)	--	--
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
	Strengthening the Non-Conventional and Rural Energy Development Program in the Philippines: A Policy Framework and Action Plan	08/01	243/01
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87

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Thailand	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
Western Samoa	Energy Assessment (English)	06/85	5497-WSO
	SOUTH ASIA (SAS)		
Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector (English)	06/98	205/98
	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
	Clean Fuels	246/01	10/01
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84

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Sri Lanka	Industrial Energy Conservation Study (English)	03/86	054/86

EUROPE AND CENTRAL ASIA (ECA)

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Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
Central Asia and The Caucasus	Cleaner Transport Fuels in Central Asia and the Caucasus	08/01	242/01
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
	Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union (English and Russian)	08/00	234/00
	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
Turkey	Energy Assessment (English)	03/83	3877-TU
	Energy and the Environment: Issues and Options Paper	04/00	229/00

MIDDLE EAST AND NORTH AFRICA (MNA)

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Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

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	LATIN AMERICA AND THE CARIBBEAN (LAC)		
LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
	Introducing Competition into the Electricity Supply Industry in Developing Countries: Lessons from Bolivia	08/00	233/00
	Final Report on Operational Activities Rural Energy and Energy Efficiency	08/00	235/00
	Oil Industry Training for Indigenous People: The Bolivian Experience (English and Spanish)	09/01	244/01
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
	Rural Electrification with Renewable Energy Systems in the Northeast: A Preinvestment Study	07/00	232/00
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Minihydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91

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Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comision Nacional para el Ahorro de Energia (CONAE) (English)	04/96	180/96
	Energy Environment Review	05/01	241/01
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
	Rural Electrification	02/01	238/01
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

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	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93

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Global	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon Backcasting Exercise (English)	02/99	212/99
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