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Ethiopia

Energy Assessment

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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 by the World Bank's Industry and Energy Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and 15 bilateral official donors in 1983, it focuses on policy and institutional reforms designed to promote increased private investment in energy and supply and end-use energy efficiency; natural gas development; and renewable, rural, and household energy.

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ETHIOPIA

ENERGY ASSESSMENT

February 1996

PREFACE

The energy sector, like so much else in Ethiopia, is sharply split between the traditional and the modern. As discussed in Chapter I, for the great bulk of the nation's households, wood and traditional biomass fuels are virtually the only source of energy. However, the depletion of Ethiopia's forests has put great pressure on fuelwood supplies and traditional biomass fuels have become more difficult and time consuming to gather in rural areas, and more expensive to buy in urban centers. Much needs to be done to protect and replenish Ethiopia's forests and a comprehensive Forestry Action Plan that focuses, inter alia, on the fuelwood problem has been prepared and is now being implemented. For this reason, and because the pressure on traditional energy supplies can only be alleviated in the near/medium term by measures to increase the efficiency with which they are used and to replace them with modern fuels, Ethiopia's experience in these areas, and how to build on it, is the focus of Chapter V, which deals with household energy.

The modern segment of the energy sector is much the smaller one. Relatively few people have access to modern energy supplies and per capita consumption is among the lowest in the world. However, electricity and petroleum are vital to the functioning of the county's modern agriculture, industry and commerce and a sharp increase in their use is a sine qua non for the accomplishment of Ethiopia's development goals. Supplies are adequate today but electric power, in particular, could soon become a constraint to growth if capacity is not expanded. Avoiding this will call not only for sharply increased investment, but for major policy and institutional changes. Power sector investment, pricing and financing issues are discussed in Chapter II; options for institutional change are considered in Chapter VI. In addition, Chapter IV investigates the prospects for increasing access to electricity in rural areas, particularly through the use of renewable sources of energy and the development of alternative approaches to electrification. With respect to petroleum, all of which must be imported, Chapter III examines the options for increasing efficiency in the supply chain by reducing refining costs, introducing pricing and other market reforms, and improving port, storage and transport facilities.

This report is based on the findings and recommendations of an energy assessment mission that visited Ethiopia, September 5-20, 1994. The mission consisted of Richard Dosik, Mission Leader, Emilia Battaglini, Economist, Kevin Fitzgerald, Household Energy Specialist, Gerald Foley, Rural and Renewable Energy Specialist, Donald Hertzmark, Institutional Specialist, Neil Magrath, Power Specialist, Thomas O'Connor, Petroleum Engineer, Carlo Piccolo, Petroleum Supply Specialist, Keta Ruiz, Pricing Specialist.

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EXECUTIVE SUMMARY

1. The Ethiopian energy sector is sharply split between the traditional and the modern. For the great majority of the population, wood and biomass are the only source of energy (83% of total energy consumption); however, depletion of Ethiopia's forests has put great pressure on fuelwood supplies. With an estimated population of about 55 million, Ethiopia has one of the lowest level of energy consumption per capita in the world, at only 0.30 Toe. Given what Ethiopia has been through, and particularly the much more rapid growth of population than GDP, it is not surprising that energy consumption has grown slowly and that there has been little overall evidence of the shift to modern fuels characteristic of so many developing countries.

2. Relatively few people have access to modern energy supplies and per capita consumption (0.02 toe) is among the lowest in the world. Although supplies of modern fuels are adequate today, electric power could soon become a constraint to growth if capacity is not expanded.

3. Ethiopia has vast hydropower resources, only a small fraction of which have been utilized; substantial but dwindling biomass resources that are inefficiently used; large, although remotely located reserves of natural gas, awaiting a market; geothermal resources, which have been well explored but not yet exploited; and solar and, perhaps, wind energy resources the potential of which has yet to be seriously examined.

4. The Ministry of Mines and Energy (MME) has responsibility for policy formulation and implementation, at least insofar as commercial energy is concerned. The Ethiopian Electric Light and Power Authority (EELPA) and the Ethiopian Petroleum Corporation (EPC) are the parastatals responsible, respectively, for power generation, transmission and distribution and for petroleum procurement. While EPC was recently accorded the status of an autonomous public enterprise, EELPA still functions as dependency of the MME. The Ministry of Natural Resources and the Environment (MNR) is now responsible for forestry and, thus for fuelwood supply, while some demand-side programs, such as the promotion of improved stoves in rural areas, remain the responsibility of the Ministry of Agriculture.

Electricity

5. The main interconnected system (ICS) is supplied by five hydro plants with a total capacity of about 370MW of which some 300MW may be considered "reliable", although some of the older plants now urgently need repair and rehabilitation. Most of the larger population and commercial centers are served by the grid, but many medium-size localities receive only part-time service from diesel generators operated as part of the self-contained system (SCS), while most towns, villages and rural areas lack any access to electricity. Less than 4% of the population is believed to be supplied with electricity.

6. After a long period in which capacity seemed more than ample, Ethiopia's power system is showing increasing signs of strain. In 1993 the load soared by 10.5% as the economy revived; peak demand reached 242 MW. Assuming continued economic growth and political stability, an average annual increase in the demand for electricity during 1993-2005 of 8-10% seems likely. Under five of the six possible scenarios considered in this assessment, the ICS will face both energy and capacity deficits during 1996-99, although the deficits may not come quite as early, or be quite as large, as EELPA expects.

7. Since no significant additions to the nation's hydro capacity are presently under construction, this means that Ethiopia now needs, for the first time, to consider adding a sizable thermal plant to its system if costly load-shedding is to be avoided. It also means that decisions cannot be long postponed about the long term development of the power system including, most importantly, the role of Ethiopia's abundant natural gas resources in helping to meet its power generation needs.

8. If power is not to be a constraint on development, Ethiopia will have to both invest heavily in the sector and to take make a major effort to strengthen its finances and institutions.

Meeting Near-Term Needs: Thermal Plant

9. Because time is clearly of the essence in addressing the prospective deficits, and the construction of hydro plants would take too long, a thermal plant containing several package type units is indicated. A thermal plant not only offers the best hope of averting a near term power shortage, but would also be a valuable permanent addition to the ICS, providing a measure of thermal complementary that would give the system greater flexibility and better balance. Given the magnitude of the prospective deficits, the need for about 60-MW of thermal capacity is indicated[1]. Either simple cycle gas turbines or diesels could be suitable. A comparison of four thermal options (gas and diesel-fueled gas turbines; a single diesel plant and ten separate ones), suggest that diesel-fueled gas turbine and single diesel plant are the most economic options. While there appears to be little to choose between the two in immediate economic terms, the choice of gas turbines would have the advantage of introducing a technology that could play an important role in the future in opening the way for the exploitation of one of Ethiopia's major domestic energy resources.

10. Whether it chooses diesels or gas turbines, EELPA would be well advised to entrust the construction and, at least, the initial operation of the thermal plant to experienced hands.

Meeting Near Term Needs: Other Options

11. EELPA and the MME have considered other options to meet the short term capacity and energy deficit. The principal one involved accelerating the completion of the Gilgel

[1] Acres (Canada) are studying the capacity required and it could exceed 60 MW.

Gibe hydroelectric plant and rehabilitation of some existing hydroelectric plants. This strategy is risky because the capacity from the rehabilitated plants will fall short of that required to meet the deficit, and any delay of Gilgel Gibe would exacerbate the impact of the shortfall. In particular, the resettlement of population from the reservoir area probably will require considerably more time than anticipated in the consultant's plans.

The Long-Term Expansion Program

12. The completion of Gilgel Gibe, whether on an accelerated basis (1998) or as originally scheduled (2000), is likely to provide only a relatively brief respite before additional generation capacity is needed once again. Since completion of a new large hydro project to follow Gilgel Gibe would probably take 7-8 years, there is a need to quickly determine, on a least cost basis, (i) whether there are "small" hydro options that can be brought on line relatively quickly and (ii) which, if any, of the large hydro projects should be next in line for construction.

13. In the former category are the suggested construction of a second plant at the existing Tis Abey site, and the addition of a fourth unit at the Finchaa plant. Tis Abey II appears to merit urgent study but consideration of additional works at Finchaa requires the resolution of technical problems at the exiting facility.

14. Only one large hydro project, Aleltu East, located close to Addis Ababa, has reached a stage of assessment where it can proceed to timely implementation. Aleltu East would produce energy at an estimated $0.078/kWh. Upper Beles, a much larger project, is also considered a contender, although it seems less economic than Aleltu East. EELPA should see to it that Upper Beles is quickly brought to the same level of study as Aleltu so that their relative merits can be more accurately assessed.

15. Since hydro has long been the mainstay of power development in Ethiopia, it is natural to think of system expansion exclusively in terms of the next large hydro project. However, the apparent high cost of large hydro underscores the need to explore other options for long term expansion that may be better attuned to Ethiopia's needs and resources. One such option may be to determine whether there are other, smaller hydro sites that might be developed more quickly and at lower cost than the large projects on which attention has been focused to date. Another option well worth considering in view of Ethiopia's natural gas resources is the possibility of assigning a major role in long term expansion to gas fueled thermal plants. EELPA should prepare a least cost expansion plan that takes all hydro and thermal options fully into account.

Distribution

16. The system presently leaves much to be desired in this area. Losses are high (15-20%), reliability low, and the ability to supply new connections is far short of demand. Technical losses are undoubtedly high because of the dilapidated condition of much of the distribution network. Inability to connect new customers promptly, and to upgrade existing connections when additional service is required, is the other costly weakness of the distribution system. The number of applicants awaiting connections increased from 2000 in 1990 to a reported 70,000 in

1993, a backlog equivalent to a wait time of 4-5 years at the rate at which new connections have recently been made. The preparation of a comprehensive distribution rehabilitation/expansion plan should be given top priority.

Investment Requirements

17. To meet the foregoing expansion and improvement needs, Ethiopia will have to invest on the order of Birr 735million ($118million) annually in its electric power system over the next ten years. During the past five years, EELPA has invested an average of only about Birr 150million annually, little more than 20% of the amount required in the future. If it is to raise its investment sights to the levels suggested, EELPA will have to greatly strengthen both its implementation and its financial capabilities. Given the magnitude of the investment task, it will also need to consider delegating responsibility to outside parties by "contracting out" for project management or other services and/or by offering suitable projects to private investors. The financial challenge to meeting the sector's investment needs is equally formidable. Even assuming that 60% or so of the cost will, as in the past, be financed by foreign donors, Ethiopia will have to provide some Birr 300million annually from its own resources to cover local costs.

Tariffs

18. Last year the government decided on a 60% average tariff increase to be implemented in phases over a five year period. While most welcome, the tariff increase, especially in its first phase (20%), represents only slow progress toward meeting economic and financial requirements. The average first phase tariff of Birr 0.23/kWh is only 50% of LRMC while, even at the end of the scheduled five year implementation period, the average tariff of Birr 0.33/kWh would be no more than 72% of LRMC. Larger and more rapid tariff increases are required if the tariff is to do its economic job of guiding overall consumption and allocating it to the most efficient uses, and its vital financial job of mobilizing adequate domestic resources for investment in the sector.

Private Participation

19. In addition to strengthening its efforts to mobilize resources internally, the government should explore the potential role of the private sector in helping to ease the financial and institutional constraints on power development. The investment program contains two projects --the geothermal and thermal plants-- attractive to private investors. Since Ethiopia has had no experience with facilities of this sort, private investment would be advantageous not only as a source of capital but for the technical know-how and operating experience that would come with it.

Petroleum

20. Although petroleum is Ethiopia's major source of commercial energy, total consumption of petroleum products was only 637,700 tons in 1993, equivalent to just 15kg per capita. However, if the economy continues to improve, demand can be expected to rise quite rapidly (about 6.5% p.a.). All petroleum is imported either as crude to be processed by the

refinery of Assab in Eritrea, which meets less than 60% of Ethiopia's needs, or in the form of refined products. Product distribution is handled by four private oil companies.

21. The supply and distribution system now works reasonably well. Petroleum products are generally in adequate supply in urban centers (although not in rural areas), at prices that in most cases (but not for kerosene and LPG), adequately reflect economic costs. However, underlying institutional rigidities and infrastructure weaknesses raise costs and make the system less responsive to market requirements. Action should be taken to reduce refining costs; introduce market reforms that will free up procurement and prices; provide more adequate facilities for inland transport and storage; and increase the availability of petroleum products in rural areas.

Reducing Refining Costs

22. Because of its age, obsolete design, and relatively small size, the refinery operates at high cost. The cash cost of processing crude at Assab in 1993 was about two-thirds higher than the marginal cost of processing hydroskimming products at larger, more modern refineries in the Mediterranean area. Over-staffing also raises costs significantly; nearly 900 people are on the refinery payroll which is about 3-4 times as many staff as are usually needed to operate a refinery of its size.

23. Using the refinery in 1993 cost the two countries $9.1 million more than if they had purchased all their products from regional export refineries. Thus, the refinery adds more than 6% to the cost of petroleum products. At present, operation of the refinery is clearly an uneconomic proposition that serves to increase the cost of petroleum to both countries, while providing little in the way of added convenience or security of supply. Prospects for changing the economics of the refinery are narrowly constrained by the relatively small size of the market it serves, the lack of indigenous crude oil to serve as a feedstock, and the availability of low cost products from world class refineries in the region. Since prospects for converting the refinery from a cost-increasing to a cost-saving operation seem so dim, closure appears to be the only option for relieving both countries of the economic burden posed by the refinery. If refinery operations are discontinued, Assab would continue to be the entrepot for petroleum product supply for both countries. The existing crude storage facilities could be converted to product storage.

Market Reform

24. Since the refinery is not competitive, it has had to be protected in a number of ways - by granting a procurement monopoly to EPC, allowing EPC until recently to import petroleum at a preferential exchange rate, and maintaining a rigidly regulated pricing system - that prevent the market from functioning as efficiently as it should. Closure of the refinery would open the way for efficiency enhancing reforms in present procurement and pricing practices. The best means of reducing costs would be to introduce competition in procurement by extending the right to purchase and import petroleum products to the private sector oil companies. The continued presence of EPC in the market could serve as a benchmark, ensuring that the private companies are importing at realistic prices.

25. While most products prices are now set at economic levels, the regulatory regime has three major deficiencies: price competition is precluded, price/cost relationships are seriously distorted in some cases, and regulation is excessively rigid. Kerosene and LPG are under priced and there is no mechanism for regularly reviewing and adjusting prices in line with changes in international prices and the exchange rate. Deregulation would enable prices to reflect actual procurement and distribution costs and adjust automatically to changes in import parity, thereby providing correct signals to consumers. If the refinery is closed and procurement opened to all, it would be possible to free prices all along the supply chain. However, even if the refinery remains open, prices still could be deregulated at the retail level to obtain some of the benefits of competition. The establishment of a monitoring system would enable the government to detect any signs of collusion or other failures in the market that may distort prices.

Transportation and Storage Improvement

26. At the present time, all petroleum products are trucked 950 km inland on the winding, two lane Assab-Addis Ababa road in an expensive, time-consuming process. Dependence on a single road, coupled with limited storage capacity, makes Ethiopia's petroleum supply vulnerable to disruptions of either a natural or man-made nature. Moreover, forecast annual consumption increases will further exacerbate inland supply, storage and distribution problems. In view of this, Ethiopia should critically review the supply and distribution situation. The focus of this review should be on expanding the Assab port unloading and storage facilities; strengthening transportation links; and augmenting inland storage facilities. Preliminary calculations suggest that construction of a products pipeline may be an economic option; a pre-feasibility study should be conducted to firm up the cost and throughput estimates, and examine the competitiveness of the pipeline vis-à-vis upgrading the highway to international standard and other options for increasing transport capacity and reducing costs.

Increasing Rural Supplies

27. Petroleum products are often in short supply and available only at high prices from informal sector suppliers in rural areas. The private companies have shown little interest in moving significant amounts of product into the rural areas, notwithstanding the subsidy included in the pricing structure and an informal distribution system has developed in which local entrepreneurs truck products from Addis into the rural areas and sell them on the local economy for whatever price the market will bear. Incentives for the efficient distribution of products in rural areas can be provided either through deregulation, or by rationalizing the price control system so that prices adequately reflect differences in transport and other distribution costs. Product availability would be greatly improved and, while prices would be higher than the present regulated ones, they might well be less than what many farmers now actually have to pay.

Rural and Renewable Energy

Rural Electrification

28. Only about 4% of the population is connected to the electricity supply and virtually all EELPA's consumers are concentrated in the main urban areas.

29. "Rural" electrification in Ethiopia consists of the extension of utility supplies to smaller cities and towns using grid extensions (ICS) or isolated generating plant (SCS). It is carried out by EELPA as part of the normal and continuing expansion of the supply system. Progress has been slow, mainly because existing tariffs make it impossible for EELPA to cover the cost of rural electrification. Under these circumstances, prudent management requires EELPA to proceed slowly with the expansion of rural services where every consumer connected and kWh sold leads to a worsening of the utility's financial position.

30. A recently completed long-range planning study of rural electrification called the Ethiopia National Rural Electrification Project (ENREP), found that 67 projects, involving the electrification of about 460 communities, would be economically justified during 1994-2011. This would mean a connection rate of around 15,000 new consumers per year, about three times greater than that presently being achieved outside the base ICS, and an investment rate of around $15 million (90 million Birr) per year.

31. While ENREP provides a useful overall framework for planning rural electrification, its actual implementation is well beyond EELPA's present capabilities. There are a variety of institutional, financial and other reasons for this. EELPA does not appear to have the technical or administrative capacity required for a major expansion of its activities in this area. The necessary funds are not available within EELPA at present and, given the tariff policy, are not going to be internally generated in the foreseeable future. It is essential that the detailed ENREP programme be viewed with considerable caution and that no project is implemented without being independently analyzed and justified by EELPA on the basis of up-to-date information. Implementation of the programme should, moreover, be carried out in balance with the overall rehabilitation and development of the distribution system.

32. Even if the full ENREP programme were implemented, some 96% of the rural population would remain without a conventional electricity supply in the year 2011. The great majority of rural Ethiopian families thus have no prospect of obtaining a conventional electricity supply within their lifetime. In other countries in similar circumstances, the use of small scale electricity supply systems (such as small diesel or gasoline generators for private or public supplies; car batteries to provide small amounts of electricity for lighting, radio, and even TV; and the use of PV systems for domestic and other small scale uses) helps to meet the gap. Such systems enable rural businesses and families to obtain some of the key benefits of rural electrification in areas which cannot presently be reached by conventional rural electrification. As such, these approaches deserve to be encouraged by the government as part of its efforts to improve rural living standards. The government should establish a positive and encouraging legislative framework for the provision of small scale public electricity supplies by private

suppliers which allows suppliers to set their own tariffs and remove bureaucratic obstacles. It should, at the same time, provide for minimum safety standards and a reasonable degree of consumer protection. The Energy Studies and Research Center (ESRC) should carry out a tightly focused and limited amount of field investigation concentrating on a small number of the more prosperous urban centres and peri-urban areas where the emergence of small scale electricity markets is likely to be most rapid. The aim should be to identify measures which can facilitate the development and servicing of any such emerging markets.

Small Scale Renewable Energy Resources

33. Ethiopia is well endowed with renewable energy sources. These include solar, wind, mini-hydro and geothermal. There are also large quantities of cattle dung which might be used for biogas production. ESRC has overall responsibility for renewable energy development and promotion in the country; although some renewable energy activities are also carried out at EELPA (small hydro) and the Ministry of Agriculture (biogas and PV pumping).

34. One of the most important weaknesses in the work carried out to date is an almost complete lack of analysis of the economic viability of renewable energy applications and their competitiveness relative to their conventional alternatives. Nor has there been any significant amount of investigation into whether potential markets exist for the technologies or how such markets might be developed.

35. PVs and solar energy. The most promising way forward for self-sustaining dissemination of PV systems in Ethiopia is through private sector promotion of solar lanterns and solar home systems (SHSs) as has happened in Kenya and other countries. Such systems usually employ 10-50 Wp PV modules to provide electricity for household lighting, radios and other small power needs. Their initial cost is high, but they can be economically competitive with other rural energy sources (kerosene lanterns, car batteries) and provide a better quality of service. The ESRC should, in conjunction with potential private sector suppliers, carry out a limited study to determine whether and where markets exist.

36. Wind. Wind speeds do not seem adequate for the generation of electricity but there appear to be many areas with sufficient wind for water pumping. The primary task is therefore to identify applications in which water pumping is economically justifiable and affordable to the local community.

37. Mini-Hydro. In addition to its role in conventional rural electrification in the EELPA framework, mini-hydro can, in principle, provide a local source of supply for private or community operated generation. Successful implementation of such projects requires a willingness to pay for electricity on the part of a sufficient number of local people to cover the costs, as well as the existence of the skills and commitment to build and operate the plant. Nevertheless, once there is a clearer picture of electricity markets in rural areas, ESRC should conduct an assessment of the potential role of mini-hydro.

38. Geothermal. Preliminary assessments of the country's total firm geothermal electricity generating capacity are about 700 MW. Detailed feasibility studies have been carried out in the Aluto-Langano area in the Lakes District, where EELPA now intends to build a 5MW pilot plant and to install 30MW of capacity. There may also be some possibility of using small-scale low-temperature geothermal plants in the 0.1-1 MW range as a means of providing electric power to isolated communities. These possibilities should be borne in mind during future geothermal exploration. The aim should be to establish whether there are resources which are suitable for low temperature small scale applications as well as the more conventional larger and higher-temperature developments presently being considered.

39. Biogas. Ethiopia has around 27 million cattle. The amount of dung produced is, in principle, sufficient to provide feedstock for over two million family-size biogas digesters. But technical, institutional, and cost constraints mean that, at best, only a very small proportion of this potential can practicably be realized in the near to medium term future. The assessment recommends that 20-30 of the existing properly functioning digesters should be assessed, and if this review indicates that biogas is economically, technically and socially feasible, a limited program for the construction of, perhaps, 20 prototype digesters in typical target rural households should be considered.

Household Energy and Demand Management

40. Woody biomass fuels consumed in rural households continue to dominate Ethiopia's energy balance. Nearly 90% of Ethiopia's population live in rural areas. Rural dwellers collect and consume the vast majority of the biomass fuels used nationwide (dung, crop residues, and woody biomass - wood and branches, leaves, and twigs) as they have little access to or disposable income for conventional fuels. With population growth, demand for biomass fuels can be expected to increase, thus worsening biofuels scarcities in the absence of effective initiatives to manage the woody biomass resource base.

41. Substitution of conventional fuels has made a major difference in the household energy economy of Addis Ababa since the mid 1980s. Rapid penetration of electric *injera mtads* and kerosene stoves along with a liberalized policy on kerosene imports have reduced woody biomass consumption in Addis Ababa considerably. 91% of households in Addis own a kerosene stove thereby completing the transition from no use of kerosene as a household cooking fuel in 1980 to complete penetration of the Addis Ababa residential market in 1994. 62% of homes own an electric *mtad*, while the share of households cooking with LPG remains relatively constant at 17%. Fuel substitution has reduced the consumption of woody biomass and charcoal by some 50%. Since 1990, efforts in Addis Ababa to improve the efficiency of charcoal use in households have also made major progress. Improved charcoal stoves disseminated by the private sector have achieved impressive market shares in Addis Ababa. After 3 years of well designed dissemination efforts, 22% of Addis Ababa households have at least one Lakech improved charcoal stove and 7% of households say they intend to buy a Lakech as their next charcoal stove. This rapid dissemination which is driven entirely by consumer demand met by

private sector producers can be characterized as no less than a stunning success relative to most stove programs that never attain double digit penetration rates even after many years of effort.

42. Since 90% of the population lives in rural areas, efforts to improve the efficiency of woodfuels use in urban households and to substitute conventional fuels will not have much of an impact on the overall, national biomass supply/demand situation. However, they raise the welfare of urban dwellers by reducing the financial burden of cooking and are a sound investment for the country. As such, the Lakech charcoal stove dissemination efforts should be extended to other urban areas and initiatives to develop and disseminate an improved biomass *mtad* and a low cost electric *mtad* should be continued and expanded. Such efforts would cost some $1.2 million annually between 1995 and 2000 and would likely yield a 35% rate of return.

43. Since methods used by small informal private charcoal producers are very inefficient, there is a large potential to raise the efficiency of charcoal transformation in traditional earthen kilns by improving kiln construction, firing, and tending practices. Previous efforts were aimed at improving kiln technology, but a reoriented effort to train charcoalers in better management practices for traditional kilns stands a much better chance of succeeding in the Ethiopian context.

44. Finally, the role of the private sector in supplying urban household fuel needs should be recognized and included in policy reform. The charcoal and woodfuel trade should be legalized. The experience of individual entrepreneurs in briquetting operations has been far more encouraging than efforts sponsored by the State. As such, the private sector should play a lead role in moving forward with the stalled agricultural residues briquetting project.

Institutional Issues

45. The energy sector faces severe challenges in almost every area; it is power, however, that poses the greatest challenges owing to the need to simultaneously and quickly improve operations, restore financial health and undertake an investment program of unprecedented magnitude. These challenges call for basic institutional changes that will provide incentives for improved performance, establish accountability, increase domestic resource mobilization, and make it possible to draw on the technical and financial resources of the private sector. These changes can best be accomplished by: (a) changing the MME's relationship to EELPA from one of command and control to one of arm's length regulation; (b) commercializing or corporatizing EELPA so as to enable it to function as an autonomous public utility; and (c) opening the way for private participation in the sector as a provider of technical and management services and as owner/operator of capital facilities. It is recommended that a comprehensive study be made of the legal, organizational and policy changes necessary to establish an institutional framework consistent with the above objectives.

46. Because EELPA functions, de facto, as an operating arm of the MME, the Ministry as regulator is in the unenviable and impracticable position of trying to regulate itself. A clear separation of the MME's role as regulator from EELPA's role as operator would benefit both institutions. It would not only put the Ministry in a position to effectively regulate the

power sector, but also enable it to devote a greater share of its attention and resources to its primary policy-making responsibilities, and to its related planning and research functions.

47. Developing a regulatory framework consistent with the objectives of adequate supply of electricity, efficient power generation, transmission and distribution, adequate revenues, open entry to the sector, and increasing access to electricity, should be the principal focus of the newly created Energy Operations Departments (EOD). Regulation should aim at influencing the performance of the operating enterprises, by setting targets and providing incentives, and reviewing and adjusting tariffs in accordance with sound economic and financial criteria.

48. EELPA's present organizational status deprives management of real control over and responsibility for vital operational and organizational decisions. Conflicting objectives and interference from the political sphere have undermined EELPA's ability to earn its way, influenced investment decisions, imposed low salaries, induced overstaffing and, at the same time, weakened the accountability of management. If EELPA is to operate efficiently its organizational status and institutional culture will have to be changed, in order to transform it from a government department providing a service to a commercially oriented utility producing and selling a product. And for this to happen, EELPA will have to be granted a high degree of managerial and financial autonomy. Commercialization along these lines can probably best be achieved in the Ethiopian context by converting EELPA from a public "authority" to a public "enterprise", as was recently done with EPC. This would be consistent with the government's overall policy of commercializing state owned economic undertakings.

49. The first, and most important, step toward enhancing EELPA's financial autonomy would be the establishment of a regulatory regime that would ensure adequate tariffs. In addition, EELPA should be permitted to retain the bulk of its earnings, paying only such taxes as are due from other public (and private) enterprises. This would place greater control of the budget in EELPA, thus enabling management, rather than the government process, to allocate resources.

50. EELPA's human resources need to be upgraded and its organization practices and procedures improved in key areas. An intensive and well-targeted training effort is clearly required if EELPA is to have the capability to implement the expansion program that lies ahead of it. It is, therefore, recommended that a study be undertaken to identify EELPA's principal training needs and formulate an action plan for meeting these needs by enhancing in-house training capabilities and through carefully structured programs for training abroad. On the organization side, the Corporate Planning Department's mission should be re-defined to make it responsible primarily for planning at the "macro" or enterprise level, and for setting system standards that meet technical and economic efficiency criteria. It would work to ensure that resources are allocated according to senior management's investment priorities and that the operational plans of the generation, transmission and distribution departments are coordinated to this end and are consistent with established system standards.

51. Given the severity of the distribution problem - high losses, low reliability and inability to keep up with the demand for service, mainly due to lack of resources or failure to use them efficiently - consideration should be given to the basic institutional strategy to be adopted in rebuilding the function. While the range of possibilities is wide, three options can be suggested: (a) strengthening the management of the distribution function within EELPA through intensive technical assistance and/or by contracting out for services; (b) decentralizing distribution; or (c) separating distribution from generation and transmission, putting it in the hands of a new public or private enterprise. Each of these options has its advantages and drawbacks. The creation of a separate distribution enterprise would, for example, provide the most direct approach to dealing with the twin problems of institutional priority and resource allocation that are at the heart of the present difficulties, but would probably be the most difficult option to implement. The options for institutional change should be carefully evaluated as part of the recommended distribution study.

52. Ethiopia not only needs private capital to help finance its power sector investment program but also is about to embark on the construction of thermal and geothermal plants with which it is not familiar and where private expertise would be indispensable. Independent power projects (IPPs) - in which private investors, either alone or in conjunction with existing public utilities, finance, build, own and operate generating plants - are becoming an important phenomenon in many developed and developing countries. While the necessary institutional arrangements need not be fully in place before trying to attract IPPs, certain minimum conditions must be established and, even when this is done, the process of stimulating investor interest, negotiating project arrangements and raising financing is likely to be time consuming. With its transition to a market economy still incomplete, whether Ethiopia can in the near term attract private investment in the power sector is very much open to question. However, given the pressing need for private capital, technology and management, this is a process well worth initiating. To do so, Ethiopia will need, first, to clearly and explicitly commit itself to private participation in the sector. The present investment law is ambiguous, at best, on this subject; new legislation that will clearly open the door to all private investors should be put in place. While such legislation may contain minimum conditions for IPPs (e.g., concerning project feasibility and the credentials of the sponsors), it probably should not go beyond this since the government will need a maximum of flexibility to gauge private sector interest and to negotiate financial and other terms on a project-by-project basis.

Ethiopia Energy Assessment
Summary of Main Recommendations

Priority Issues	Recommended Strategy	Follow-up Measures and Activities
Electricity Sector		
Near-Term Requirements	Quickly install a package-type thermal plant of approximately 60MW to avert possible shortages and provide complementary	Undertake a feasibility study to determine best plant size, configuration, technology, fuel, location.
Medium/Long-Term Expansion	Study Upper Beles to feasibility level. Examine generation options other than expensive large hydro, e.g. smaller hydro and large gas fueled thermal plants	Prepare a least-cost expansion plan, with all hydro and thermal options taken into account
Distribution	Increase resource allocation. Improve planning and implementation capability	Prepare a comprehensive rehabilitation and expansion plan
Investment and Financing Requirements	Increase domestic/foreign resource mobilization Strengthen project implementation capability	Raise sector self-financing capacity Open door to private investment Expand technical assistance
Tariffs	Raise levels to reflect costs Revise structure to reduce subsidies, encourage efficiency	Adopt plan for more adequate/rapid tariff adjustment
Petroleum Sector		
Refining Costs	Close Assab refinery	Initiate discussions with Eritrea
Market Reforms	Introduce competition in procurement to reduce cost of supply Introduce price competition	Extend the right to purchase and import petroleum products to the private sector Study options of deregulation or rationalization of pricing regime
Petroleum Product Supply and Distribution	Improve ports Reduce inland transport costs Increase storage capacity	Study port improvement costs/benefits; examine road improvement options; prepare pre-feasibility study of products pipeline
Rural Supply	Increase product availability in rural areas	Deregulate prices or rationalize price control system to provide adequate incentives for distribution in rural areas
Rural and Renewable Energy		
Conventional Rural Electrification	Rationalize extension of rural distribution system Improve implementation capacity	Give priority to rehabilitation of existing rural distribution system; Using ENREP as basis, prepare 5 year plan for distribution system extension including systematic monitoring and evaluation

Priority Issues	Recommended Strategy	Follow-up Measures and Activities
Complementary Rural Electrification	Promote use of small scale private electricity supply systems (diesel generation; battery recharging)	Establish legislative framework enabling private provision of these systems and setting standards. Carry out field investigation on emerging markets for small scale electricity supply systems
Renewable Energy	Encourage private sector to take lead in commercialization Focus government support on selecting economic applications and identifying viable markets	Identify economic applications especially for PV (e.g. domestic lighting). mini-hydro and wind pumping. Investigate, in conjunction with the private sector, the existence, size and location of potential markets.
Household Energy Biomass Fuels Substitution/Utilization	Expand successful efforts to encourage fuel substitution and improve efficiency of biomass fuels use	Extend improved charcoal stove dissemination to urban centers other than Addis Ababa. Expand development and dissemination of improved biomass mtad and low cost electric mtad
Charcoal Production	Increase efficiency of charcoal transformation	Permit private charcoal production Improve kilns construction, firing and tending practices. Train charcoalers in management practices for traditional kilns
Biomass Fuels Supply	Promote the role of the private sector in supplying urban household biomass fuels needs	Legalize charcoal and woodfuel trade Encourage briquetting operations by individual entrepreneurs
Institutional Reforms Role of the Government in the Power Sector	Change MME's relation to EELPA to that of arm's length regulator, responsible for establishing and maintaining operational and financial performance standards Focus MME's attention on its central policy making, planning and research functions	Carry out a comprehensive a study of the options for the restructuring of the power sector and the legal, organizational and policy changes necessary to establish a suitable institutional framework. Develop the Energy Operations Department's ability to carry out the regulatory function, especially with respect to tariffs
Commercializing EELPA	Allow EELPA to operate as a commercially viable public utility with a high degree of operational and financial autonomy. Strengthen EELPA internally	Convert EELPA from public authority to public enterprise. Ensure adequate tariffs and enable EELPA to retain the bulk of its earnings. Develop a comprehensive training and technical assistance plan
Restructure Distribution Function	Raise institutional profile of distribution function and its access to resources	Carry out a comprehensive study on institutional options for rebuilding the distribution function
Role of the Private Sector	Enable the power sector to draw on private capital, technology and management wherever possible	Make clear government commitment to private participation. Enact legislation enabling domestic and foreign private investors to undertake large and small projects. Take advantage of all opportunities for contracting out for private management and other services.

I. ENERGY AND THE ECONOMY

Economic Setting

1.1 Ethiopia is one of the poorest countries in the world, with a per capita GDP of only $125, and social conditions that are among the worst in Africa, with much of the population lacking access to even rudimentary health care, safe water or sanitary facilities. Although 80% of the population are agricultural, more than half suffer chronic food insecurity; unemployment is widespread and over 30% of the population have incomes below the absolute poverty level. Ethiopia's economic and social woes are deeply rooted in rapid population growth (3.4% p.a.), the shortage of arable land, rapid environmental degradation, inadequate and crumbling infrastructure, and years of under-investment in human resources. Today, these constraints to economic growth are compounded by the legacy of the civil war, ethnic rivalries and the distortionary policies of the previous regime.

Table 1.1: Selected Social Indicators of Development

	15-20 years ago	Most Recent Estimate	Sub-Saharan Africa
GNP per capita US$	90	125	520
Total Population, million	40	54.8	546.4
Population Growth Rate	2.8	3.4	2.9
Urban population, % of pop.	9.5	12.7	29.5
Access to Safe Water, % of pop.	8	18	41.1
Access to Health care, % of pop.	-	44	45
Illiteracy, % of pop.	-	75	51

Source: World Bank, IEC.

1.2 Before the political change which brought the Transitional Government of Ethiopia (TGE) to power in May 1991, the massive state control of the productive sectors, trade, financial services and infrastructure severely restricted the country's productive capacity. An overvalued Birr, lack of foreign exchange, limited access to credit, discriminatory policies and high profit taxation suffocated the initiative of the private sector and discouraged export-oriented production. The TGE's macro-economic stabilization and reform program has improved the fiscal situation and corrected key price distortions. Taxes and subsidies were rationalized, positive real interest rates were introduced and the devaluation of the Birr in October, 1992 from 2.1 to 5.0 per US dollar was followed by the introduction of a limited foreign exchange auction system under which the currency has been moving toward a market determined rate.

1.3 The economy has responded positively to these reforms. GDP grew by 12.3% in FY 1993 (compared to -3.2% in 1992) and the rate of inflation dropped to 10% in FY 1993 from 20% in the previous year. Severe droughts slashed agricultural production in FY94, with a negative impact on GDP, which grew only by 1.3%, and on the overall fiscal deficit, which increased to 16.9% of GDP (from 11.2% in FY93). GDP is expected to grow by about 6% in FY95. The narrowing gap between parallel and official foreign markets supported exports with a positive effect on the balance of payments and foreign exchange reserves. The country's external debt situation and creditworthiness also improved significantly with the debt service/export ratio dropping from 82% in FY92 to 46% in FY94.

1.4 Agriculture, which accounts for about 54% of GDP, 80% of employment and 75% of exports, will remain the major source of growth in the medium term. Industry, mainly ago-processing, accounts for about 12% of GDP, mostly through large state enterprises. The agricultural sector cannot sustain the country's growing population. Meanwhile, industrial expansion is constrained by the weakness of the domestic private sector. The TGE's long-term strategy of "agricultural development-led industrialization" (ADLI) aims at increasing agricultural production by improving sector productivity; expanding the manufacturing sector to absorb labor and meet the increasing demands of the domestic market; and increasing and diversifying exports. Last year, the TGE reached agreement with the Fund and the Bank on a policy framework, which established targets for a next phase of reform based on continued prudent economic management, commitment to social sector investments, and a shift of resources to the private sector. If executed as planned, it is expected to result in a 5.5-6% annual GDP growth rate and inflation rate below 10% during 1994-96.

Table 1.2: Selected Economic Indicators

	1991/92	1992/93	1993/94	1994/95	1995/96
GDP growth rate (1)	-3.2	12.3	1.3	5.5	6.0
Consumer price index growth rate	21.0	10.2	10.0	8.0	6.0
Exports (volume) growth rate	-47.5	83.9	6.9	13.6	5.7
Imports (volume) growth rate	-16.0	19.9	1.7	27.8	6.0
Investments as % of GDP (1)	9.3	12.5	14.4	16.4	17.8
Domestic savings as % of GDP	3.0	-0.2	-0.4	0.3	4.8
Govt. revenue (exc. grants) % GDP	10.7	11.9	13.7	16.4	17.5
Govt. expenditure as % of GDP	20.3	23.2	30.8	29.3	30.4
Overall fiscal deficit as % of GDP	9.2	11.2	16.9	12.8	12.9
Exchange rate (2)	2.07	5.0	6.0		

1. Constant prices.
2. Birr devaluated on October 1, 1992 from 2.7 to 4.98 Birr to the dollar.

Source: World Bank, AF2CO.

1.5 The TGE commitment to shifting the weight of investment in the productive sectors from the state to the private sector has resulted in a reduction in the allocation of the total capital expenditure to industry to 8% in FY 1994 (from 19% in 1989) and a major drop in contributions to state farms. However, the TGE regards its main task as managing the political transition to a new, decentralized political structure under which much of the responsibility for government will be vested in ethnically based regions. It also fears that the private sector is, after years of repression, simply too weak to be relied on as the engine of growth. Thus, while the private sector is allotted an important role in the government's ADLI strategy, the TGE seems to feel that the government will need to maintain a controlling hand on the economy and that the public sector will need to take the investment lead, particularly in strategic sectors such as infrastructure.

The Energy Sector

1.6 Like so much else in the country, the Ethiopian energy sector is sharply split between the traditional and the modern. For the great majority of the population wood and biomass are the only source of energy (93% of total energy consumption). However, the depletion of Ethiopia's forests has put great pressure on fuelwood supplies. Although no fuelwood crisis in the sense of absolute shortage has materialized, traditional biomass fuels have become more difficult and time consuming to gather in rural areas, and more expensive to buy in urban centers. The modern segment of the energy sector is a very small one. Relatively few people have access to modern energy supplies and per capita consumption (0.02 toe) is among the lowest in the world. However, electricity and petroleum fuels are vital to the functioning of the country's modern agriculture, industry and commerce and a sharp increase in their use is crucial for the accomplishment of Ethiopia's development goals. Supplies of modern fuels are adequate today, but electric power could soon become a constraint to growth if capacity is not expanded.

Energy Resources and Consumption

Energy Resources

1.7 Resources are not the constraint on the role of energy in the development process. To the contrary, Ethiopia has vast hydropower resources, only a small fraction of which have been utilized; biomass resources remain substantial, but are inefficiently used; and Ethiopia has large, but remotely located reserves of natural gas, awaiting a market. In addition, there are substantial geothermal resources that have been well explored; coal deposits that are believed to be mostly small but may be commercially exploitable; and solar and, perhaps, wind energy resources the potential of which has yet to be seriously examined. Oil is, so far, lacking despite a considerable amount of exploration. However, Ethiopia is still regarded as highly prospective and exploration continues.

Table 1.3: Ethiopia's Energy Resources

	Total Resources		Primary Use (1992/93)	
Source	Toe x 10^6	%	Toe x 10^3	%
Hydropower	55.5	23.2	261	1.6
Natural gas	71.8	30.0	-	-
Petroleum	-	-	868	5.3
Coal	10.0	4.2	-	-
Geothermal	0.5	0.2	-	-
Fuelwood	93.5	39.1	12,440	76.3
Bagasse	0.1	0.0	165	1.0
Other organic residues (1)	7.7	3.2	2,563	15.8
TOTAL	239.1	100.0	16,297	100.0

1. Dung and crop residues.

Source: World Bank, Calub Gas Development Project, SAR, February 1994 EEA, National Energy Balance, 1992/93.

1.8 Ethiopia's abundant hydropower resources - with an estimated potential of 15,000 to 30,000 MW have traditionally been seen as the major source of power generation. However, other options for long-term power development should be considered, in particular the possibility of using natural gas. Large reserves of natural gas have been identified in the remote Ogaden Basin region and reserves at Calub have been estimated at 2.7 trillion cubic feet. The Calub field is currently being developed and the natural gas liquids (kerosene, LPG and gasoline) will be commercialized. Only a small quantity of natural gas will be used for electricity generation at the Calub plant (the remaining being reinjected) and the potential uses for larger scale electricity generation, as an industrial fuel and as feedstock for chemical fertilizer production will be studied under the project. Woody biomass resources, although severely depleted by intensive deforestation, are still available in significant quantities in some areas. However, population growth and limited access to or disposable income for conventional fuels will worsen biomass scarcities, particularly in certain areas of the north and central regions. A forestry action plan has been developed with the support of the Bank and aims at improving the management of the woody biomass resource base and reversing the growing depletion of the country's forests.

Energy Consumption

1.9 Final energy consumption amounted to 16.3 million Toe in 1992/93. With an estimated population of about 52.7 million, Ethiopia has one of the lowest level of energy consumption per capita in the world, at only 0.30 Toe (the average for Africa in 1989 was about 0.47 Toe). Total energy consumption has increased at less than 3% per annum since 1985/86, in line with the population growth. Consumption of electricity and petroleum fuels has been quite erratic over the last few years: consumption of kerosene for example has grown at an annual rate of 20% over the last several years, while the demand for other petroleum products has remained constant, mostly because of supply constraints. However, on average, consumption of commercial energy has increased slightly more slowly than traditional biomass fuels; as a result, commercial energy continues to account for only about 7% of total energy supply. Per capita consumption of commercial energy is 0.02 Toe which is extremely low even for African standards (the average for Africa in 1989 was 0.28, for Kenya 0.07). Given what Ethiopia has been through, and particularly the much more rapid growth of population than GDP, it is not surprising that energy consumption has grown slowly and that there is little evidence of the shift to modern fuels characteristic of so many developing countries. However, this state of affairs is clearly incompatible with Ethiopia's need for progress toward environmentally sustainable economic growth and poverty alleviation.

1.10 Consumption by sector has changed little over the years. The household sector continues to dominate, accounting for 87.5% of total energy consumption, while industry accounts for 5%, the commercial sector for about 4% and the transport sector for 3.5% of consumption. The household sector relies overwhelmingly on fuelwood and other traditional biomass fuels, which are used mainly for cooking. Better off urban households use electricity and petroleum products: electricity is unavailable outside the larger towns and the supply of petroleum products is limited and uncertain in rural areas. Also the industrial and commercial sectors depend heavily on biomass and other traditional fuels (71% and 77% respectively) for energy. 21% of commercial energy is consumed by the industrial sector, mostly medium and large scale industries; 17% is consumed by the household sector and 10% by the commercial sector. The transportation sector depends entirely on petroleum products and consumes 65% of the total petroleum fuel supply. The level and composition of energy consumption (approximately equal to net supply) is summarized in the following table.

Table 1.4: Ethiopia National Energy Balance Summary, 1992/93
(000 TOE)

	Woody Biomass	Crop Residue	Bagasse	Dung	Charcoal	Electricity	Petroleum Fuels	TOTAL	%
Net Dom. Consumption	12,263	1,179	165	1,384	177	261	868	16,297	
	75.2%	7.2%	1.0%	8.5%	1.1%	1.6%	5.3%	100%	
Consumption by sector									
Household	11,444	1,127		1,326	172	107	86	14,262	87.5%
Agriculture							20	20	0.1%
Transport							562	562	3.5%
Industry	355	30	165	34	2	120	118	823	5.1%
Services and Other	464	22	0	25	2	34	81	628	3.9%

Source: EEA See also Annex 1

Forecast Energy Demand

1.11 Overall energy demand is expected to grow at approximately 3.2% per year for the period 1994-2005. Economic growth (5.5%) and population growth in urban and rural areas (3.1) are the main driving forces. The demand for each type of energy has been forecast and aggregated to obtain the overall energy demand (modern + traditional). Electricity demand is expected to grow at 8% per year, on the assumption that both domestic and industrial demand will show a fast growth pattern in the next several years; growth in petroleum products consumption will average 6.4% per year, with LPG and kerosene (which are subsidized) growing much faster than the average (31% and 10% respectively). Demand for traditional energy is expected to increase at an annual rate of 2.9%, in line with rural population growth.

1.12 At these rates, modern energy demand in Ethiopia will double in the coming decade and will create pressure for an expansion of supply. However, given the very small share of modern fuels in overall energy demand, the expected high rates of growth in the demand for electricity and petroleum products will not substantially affect Ethiopia's very low level of energy consumption per capita. Woodfuels will continue to play a critical role in the country's energy supply for many years.

Table 1.5: Energy Demand Forecast (% annual growth, 1994-2005)

	1994	1994-2000	2001-2005	1994-2005
Total Energy Demand	3.2	3.2	3.2	3.2
Electricity	6.6	7.7	8.4	8.0
Petroleum Products	7.4	6.4	7.4	6.4
Woodfuel	2.9	2.9	2.9	2.9

See also Annex 2.

Energy Pricing

1.13 Petroleum product and electricity prices are regulated by the Government. Electricity tariffs, which had not been adjusted since 1986, were increased by 12% in October, 1994, but the average tariff is still no higher than 50% of LRMC. Petroleum product prices are tightly controlled and kept uniform throughout the country. Until the devaluation, prices of most petroleum products were far below international levels; now, only LPG and kerosene are priced substantially below import parity. Fuelwood prices, being largely market-determined, are high enough to make cooking with wood much more expensive than with kerosene, LPG or electricity which provides an incentive for substitution where such fuels are available.

Sector Institutions

1.14 Ethiopia's energy sector is organized in accordance with what has been the "standard" model in most African and other developing countries, in which a ministry exercises tight central control and direction while operations in the principal sub-sectors are in the hands of parastatal corporations with limited autonomy. The Ministry of Mines and Energy (MME) is the dominant institution, with clear responsibility for policy formulation and implementation, at least insofar as commercial energy is concerned. However, the MME's writ does not run to energy pricing, which is under the control of the Ministry of Trade. The recent reorganization of MME has put in place a Planning and Programming Department (PPD) with policy making responsibilities, and an Ethiopian Energy Studies and Research Center (EESRC) which took over most of the tasks of the previous Ethiopian Energy Authority (EEA), including coordinating efforts to improve household energy efficiency and develop new and renewable sources of energy. Responsibility for petroleum exploration and regulation has been given to the Petroleum Operation Department. All other tasks, including regulation of the power sector, are to be performed by the Energy Operation Department (EOD). The Ethiopian Electric Light and Power Authority (EELPA) and the Ethiopian Petroleum Corporation (EPC) are the parastatals responsible, respectively, for power generation, transmission and distribution and for petroleum procurement. EPC purchases all imported crude and products; has the crude processed at the refinery in Assab, now owned by Eritrea; and sells refined products to the four international companies that market them throughout the country.

1.15 As regards traditional biomass fuels, the Ministry of Natural Resources and the Environment (MNR) is now responsible for forestry and, thus for fuelwood supply, while some demand side programs, such as the promotion of improved stoves in rural areas, remain the responsibility of the Ministry of Agriculture. Its programs also include the operation of a scheme intended to provide poorer city dwellers with fuelwood at low prices. However, the bulk of the fuelwood used in the cities actually comes from the private suppliers who charge market prices.

Sector Policy

1.16 In the past, government policy sought to manage the sector through tight controls and to address the fuelwood/forestry problem and to develop the country's power, petroleum and other energy resources primarily by means of public sector programs and projects using public resources, and relying heavily on the contributions of aid donors. These policies not only proved ineffective, but saddled the sector with a host of price and other distortions some of which are yet to be corrected.

1.17 The TGE's energy policies are set out in the Letter of Sector Policy submitted to the Bank in January, 1994 in connection with the Calub Gas Development project, and in the Energy Policy Statement dated April, 1994 that was supplied to the assessment mission. The latter is the more comprehensive document. It states the government's intentions in each of the sub-sectors - e.g., to attack the household energy problem by promoting agro-forestry, increasing the efficiency with which biomass fuels are utilized, and facilitating the shift to greater use of modern fuels; to rely mainly on hydropower to increase the electricity supply but to take advantage of Ethiopia's geothermal, solar, wind and other renewable energy resources where appropriate; and to further explore and develop oil and gas reserves. It also refers to the need to encourage energy conservation in industry, transport and other energy-using sectors; to ensure that energy development is environmentally sustainable; and to provide appropriate incentives to the private sector. However, there is only scant mention of the need for pricing and institutional reforms.

1.18 The sector policy letter does much to fill this gap insofar as the petroleum sector is concerned. It establishes the principle of import parity pricing and the steps for its implementation; outlines the institutional changes to be made in the sub-sector; and sets out the measures to be taken to encourage private sector investment in exploration and development. Concerning the power sector, however, the letter states only that tariff reforms will be based on the results of a forthcoming study and notes that, except for small projects undertaken by Ethiopian investors, power production and supply are reserved for the public sector.

II. THE ELECTRICITY SECTOR

2.1 After a long period in which capacity seemed more than ample, Ethiopia's power system is showing increasing signs of strain. The main interconnected system (ICS) is supplied by five hydro plants with a total capacity of about 370MW of which some 300MW may be considered "reliable", although some plants urgently need repair and/or rehabilitation Most of the larger population and commercial centers are served by the grid, but many medium-size localities receive only part-time, unreliable service from diesel generators operated as part of the self-contained system (SCS), while most towns, villages and rural areas generally lack any access to electricity. All told, less than 4% of the population is believed to be supplied with electricity and expanding electrification is, for social as well as economic reasons, an important element in the TGE's strategy. Prospects for doing so are discussed in Chapter IV.

2.2 During the '80s, generation grew by some 8.0% per annum before falling off sharply in 1991-92 because of the turmoil in the country. In 1993, however, the load soared by 10.5% as the economy revived; peak demand reached 242 MW. If the load continues to grow rapidly over the next several years, as expected, a substantial amount of additional capacity will be required in the near term if costly load-shedding is to be avoided. Since no significant additions to the nation's hydro capacity are presently under construction, this means that Ethiopia now needs, for the first time, to consider adding a sizable thermal plant to its system . It also means that decisions cannot be long postponed about the long term development of the power system including, most importantly, the role of Ethiopia's abundant natural gas resources in helping to meet its power generation needs.

2.3 The strains on the power system are already evident on the distribution side. Distribution has long been a weak point, with system losses averaging 15-20% over the past 10 years, largely due to inadequate maintenance and chronic under-investment in the distribution network. The recent resumption of rapid load growth has further overloaded the network, leading to a deterioration in the quality of service marked by more frequent outages and voltage reductions. The distribution system's inability to cope has also been reflected in a rapid increase in the backlog of applicants waiting for connections.

2.4 If power is not to be a constraint on development, Ethiopia will have to both invest heavily in the sector and to take make a major effort to strengthen its finances and institutions. After reviewing likely trends in the demand and supply of power, this chapter examines the principal thermal and hydro options for system expansion, and the needs of the distribution system. The sector's investment and financing requirements are than explored with emphasis on the tariff and other financial reforms necessary if these requirements are to be met. The institutional changes necessary to improve sector finances, raise investment planning and implementation capabilities, and improve operating efficiency are discussed in Chapter VI.

Load Forecast

2.5 Assuming continued economic growth and political stability, an average annual increase in the demand for electricity during 1993-2005 of 8-10% seems likely. The higher figure is EELPA's forecast. It posits a very rapid growth in sales to both domestic and industrial consumers and may be taken to indicate the maximum likely rate of increase in the total load. The lower end of the range depicts a "slower growth" scenario that takes into account prevailing constraints on domestic sales resulting from EELPA's distribution problems and the likelihood of less exuberant industrial growth than EELPA expects.

2.6 The evolution of the domestic market, which has been Ethiopia's fastest growing one, will be critical. Over the past twenty years, domestic sales, rising from a very low base, have grown by more than 10% per annum to account by 1993 for some 40% of the power market. About half the growth has been due to increased consumption per customer, the rest due to new connections. However, in recent years EELPA has experienced increasing difficulty in keeping up with the demand for new connections, with the result that a reported backlog of some 70,000 applicants, mainly domestic, has accumulated. Thus, in the short term, domestic sales of electricity will be influenced more by EELPA's ability to provide connections and other improvements to its distribution systems than to the ability of its would-be consumers to utilize the electricity. Much will depend on how rapidly EELPA can strengthen its distribution efforts. The company sees domestic sales rising sharply during 1995-99 as it rapidly catches up on the backlog, and forecasts a 10% average growth rate for the 1993-2005 period as a whole. If, as seems more realistic, EELPA needs more time to work through its distribution problems, domestic sales may be expected to rise only slowly over the next several years. On this assumption, the slower growth scenario envisages a domestic market growth rate of about 9% for the period.

2.7 Industrial consumers as a whole constitute about as large a market as domestic ones, with the larger establishments served at high voltage accounting for the bulk of sales. After consultation with the Department of Industry and with the newly established Investment Bureau responsible for the private sector, EELPA anticipates sales to large industry increasing by more than 20% annually for the next five years. However, there appears to be little concrete evidence for expecting an industrial boom of this magnitude and it should be noted that, historically, the forecasts of industrial growth presented by the Ministry have never been approached, never mind fulfilled, while the Investment Bureau's views appear to reflect the euphoria characteristic of a new organization. The slower growth scenario assumes 7% annual growth in sales to all industrial consumers, a much higher figure than in the past but one that appears to be within the bounds of sober optimism.

2.8 The slower growth scenario also omits service to electric boilers, which accounted for 3% of sales in 1993 but which EELPA forecasts will grow to 6% by 2005. EELPA promoted the use of these boilers at a time when it had substantial excess hydro capacity. They are supplied at a low tariff on an interruptible basis --i.e., on the express understanding that they will be served only when power surplus to the needs of full paying customers is available. Because of this, their needs should not drive the investment program[2].

Power System Capability

2.9 The total capacity of the ICS hydro plants is as follows:

	Installed	At Min Head
Koka, 3x14.33-MW	43-MW	26-MW
Awash I, 2x16-MW	32-MW	32-MW
Awash II, same	32-MW	32-MW
Finchaa, 3x33.3-MW	100-MW	97-MW
Malka Wakana, 4x38.25	153-MW	148-MW
Tis Abey, 3x3.83-MW	11-MW	7-MW
	371-MW	342-MW

2.10 The total "reliable" capacity, calculated for a condition in which all four reservoirs are near minimum levels and the largest single unit, operating at reduced head if appropriate, is out of service, can be put at about 305MW. However, several plants in the system are in need of rehabilitation and repair. Koka, which is now 34 years old, and Tis Abey both require extensive electrical and mechanical rehabilitation. In addition, there appears to be a potentially serious problem with the penstock at Finchaa requiring repairs the nature and extent of which are still to be determined.

2.11 The firm energy capability of the hydro system, if operated optimally, is estimated by EELPA's consultants, Acres International Limited, (ACRES) to be 1645GWh during a 30-year drought. Ensuring the availability of the full firm energy requires careful co-ordination of the operation of all plants, especially of those that control the three major reservoirs. This is especially so in Ethiopia because both Finchaa and Malka Wakana have sufficient storage capacity that they are able to store water from one year to another, thus complicating the rules for their operation to ensure firm capability in the face of a drought lasting more than one year. Diversity of inflow regimes of the three drainage basins results in their firm energy combined being greater than the sum of their individual levels of firm energy. However, in operating its system, EELPA appears to see each of the reservoirs separately; it thus considers the capability of its system to be only 1314GWh, 20% less than the consultants' estimate[3].

[2] For similiar reason, no account is taken of possible export sales. Interconnections with the Sudan and/or Djibouti have long been entertained as a means of exporting hydropower when it is in surplus and obtaining supplies from its neighbors' thermal plants when it is not. EELPA no longer has surplus hydropower and will in all likelihood soon be installing thermal capacity of its own.

[3] In calculating reliable capacity, EELPA also uses a worst case scenario in which the three river basins are simultaneously struck by drought.

2.12 The difference between the capability estimates indicates that there is an opportunity for EELPA to extract considerably more energy from its system than it now believes possible. To exploit this potential, EELPA needs to obtain and utilize effectively the computer software necessary to optimize its operations.

Generation Projects Pending

2.13 EELPA's presently plans to complete the following new projects by the year 2000:

Chara Chara Weir
Aluto Lugano Geothermal I & II
Gilgel Gibe Hydro I & II

2.14 Of these projects only the Chara Weir is already under construction. It will raise the level of Lake Tana and firm up the capacity of the Tis Abey hydro plant until flows are diverted for the Upper Beles project. The weir is scheduled for commissioning by 1997. It will increase the firm energy available from Tis Abey from 55 to 100-GWh/a. The estimated cost is approximately $10 million, so the additional energy will cost about $0.027/kWh, well below the currently estimated long-run marginal cost of production.[4]

2.15 The geothermal resource at the Aluto Lugano site in the Rift Valley consists of eight wells with an average depth 2500-meters, five of which are productive with water at about 330C, good for about 2 MW each. Consultants are being selected for the development of a 5-MW pilot plant to be completed by 1997. This is likely to lead to the installation of two 15-MW units, which would utilize the full potential of this field as currently estimated by the Ethiopian Geological Institute, who were responsible for the initial development program. No further geothermal generation is anticipated at this stage although exploration continues at Tendaho, near the Assab-Awash road about 200-km south-west of Assab. Since the initial 5-MW installation is in the nature of a pilot plant its production is not included in our estimates of firm power and energy. However, it is assumed that the two 15-MW units will be completed successfully, in 1999 and 2000, as the thermal capability has been proven and the intent of the pilot development is to define more accurately the quality of the steam and the treatments required for its use and subsequent disposal.

2.16 EELPA is committed to the completion of the Gilgel Gibe hydro project as the major element in its medium term system expansion plans. The preliminary design of Gilgel Gibe, completed in 1985, included a rockfill dam 37.5-m high and 1717-m in length to create a reservoir with a live storage volume of 717-million cubic meters (40% of the average annual inflow), a power tunnel 9.5-km in length leading to a single powerhouse to contain six 54-MW units. During excavation of the tunnel near the projected powerhouse geological conditions were encountered that rendered impossible the completion of the tunnel. At the same time a landslide removed some 5-km of the construction access road. The design was consequently revised in

[4] Redevelopment of Tis Abey site possibly could lead to more efficient-use of the additional water from Chara Weir.

1990-91. The dam and intake were unchanged as was the upstream section of tunnel except that it was diverted to supply a new powerhouse only 3.3-km from the intake where half the head would be developed by two 45-MW turbine-generators discharging back into the Gilgel Gibe River. At minimum reservoir elevation the two units would deliver 85-MW. To develop most of the head as originally conceived a weir is planned about 700-m downstream from the first powerhouse. This will create a headpond for the 2nd stage. The water will be conveyed by a surface conduit, 2.4-km long, that will approximately follow the contour on the right bank before entering a 490-m long tunnel to supply the 2nd powerhouse which, like the first, will contain two 45-MW units. EELPA estimates that some 12,000 people will have to be resettled to make way for the project.

2.17 More than half of the project has had to be redesigned; the new designs were reviewed by an Austrian consulting engineering company in 1992. In preparing their estimates EELPA have used the unit costs developed for the original project in 1984, escalating them to 1990 at 4.46% annually. Based on these estimates and excluding as sunk costs the approximately $121 million already spent on the project,[5] Gilgel Gibe is expected to cost some $306 million to complete. Stage 1 is estimated to produce about 400-GWh/a of firm energy at a cost of $0.066/kWh On completion the project is estimated to produce 775-GWh/a of firm energy at a cost of $0.052/kWh. Both of these figures are substantially below the approximately $0.075-0.090/kWh estimated in 1992 dollars for the next two hydro projects.

2.18 Consulting engineers have been appointed to review the existing designs, revise them as necessary, recalculate costs and prepare tender documents. Since the project has been extensively re-designed, and the present cost estimates are scaled up from the original ones, this task is critical. The consultants are expected to complete this phase of their work by the end of December, 1995. In the expectation that the consultant's findings will not appreciably effect the technical feasibility or economic viability of the project, their terms of reference also include assisting EELPA in selecting bidders, evaluating the bids, and then carrying out the functions of an Owner's Engineer until completion of the project.

2.19 While both the Aluto Lugano pilot plant and Gilgel Gibe appear to be worthwhile projects that EELPA should seek to implement as quickly as possible, much remains to be done before work can get underway on either of them. In both cases, studies need to be completed, designs and cost estimates prepared and/or carefully reviewed, and financing found and negotiated. Once construction begins, completion of a large hydro project like Gilgel Gibe could be expected to take four to five years, even in the best of circumstances. Given the project's difficult history, it might be realistic to expect a longer construction period.

System Requirements

2.20 The forgoing discussion suggests that system expansion requirements be considered in the framework of two load forecast and three system capability options. The load

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[5] The transmission lines have already been erected and most of the major electrical equipment is either committed or already purchased.

forecast options are the "high growth" one prepared by EELPA and the "slower growth" alternative suggested above. The capability options are the "limited" capability one used by EELPA, the "enhanced" capability one based on Acres estimates and a "construction delayed" version of the latter that assumes that the projects now in EELPA's medium term investment program will be completed two years late.[6] Under five of the six possible scenarios resulting from the combination of these options, the ICS will face both energy and capacity deficits during 1996-99. This is depicted in Figure 1 and summarized in Table 2; details are provided in Annex 3.

2.21 While none of the six possible scenarios may be discarded, three appear particularly useful as reference cases for defining system requirements. The first of these is the high load growth/limited capability scenario used by EELPA. It is in some ways a worst case. The energy deficits come earlier (1996) than in any other scenario and range between 152 and 846GWh, equivalent to 10% to 35% of forecast system load. Capacity deficits appear in 1997 and fall in the 23-138MW range. The second reference scenario is the slower load growth/enhanced capability combination. It can serve as a best case, since there are no energy deficits until 2005 and only modest capacity deficits. Thirdly, the slower load growth/delayed construction scenario provides something of an intermediate case. It assumes load growth will be somewhat slower than forecast by EELPPA and that the capability of the existing system will be enhanced through improved operation, but that currently planned projects will not be completed on schedule. Under these assumptions, both energy and capacity deficits appear later (1999 and 1998) and are less onerous than in the first scenario, falling in the 21-209GWh and 13-85MW ranges, respectively.

2.22 Since it would be imprudent to assume all is for the best, it seems reasonable to conclude that the ICS is likely to be significantly short of energy and capacity in the next few years but that the deficits may not come quite as early, or be quite as large, as EELPA expects.

Meeting Near-Term Needs: Thermal Plant

2.23 Be this as it may, because time is clearly of the essence in addressing the prospective deficits, the installation of a thermal plant containing several package-type units is indicated since the installation of large thermal units or the construction of hydro plants would take too long. A thermal plant not only offers the best hope of averting a near term power shortage, but would also be a valuable permanent addition to the ICS, providing a measure of thermal complementarity that would give the system greater flexibility and better balance. The choice of thermal plant size and configuration, technology, fuel, location, etc. can only be definitively considered in the context of a full feasibility study, which is urgently required. Until then, however, it may be worthwhile to consider some of the basic parameters of the thermal plant and the principal options available.

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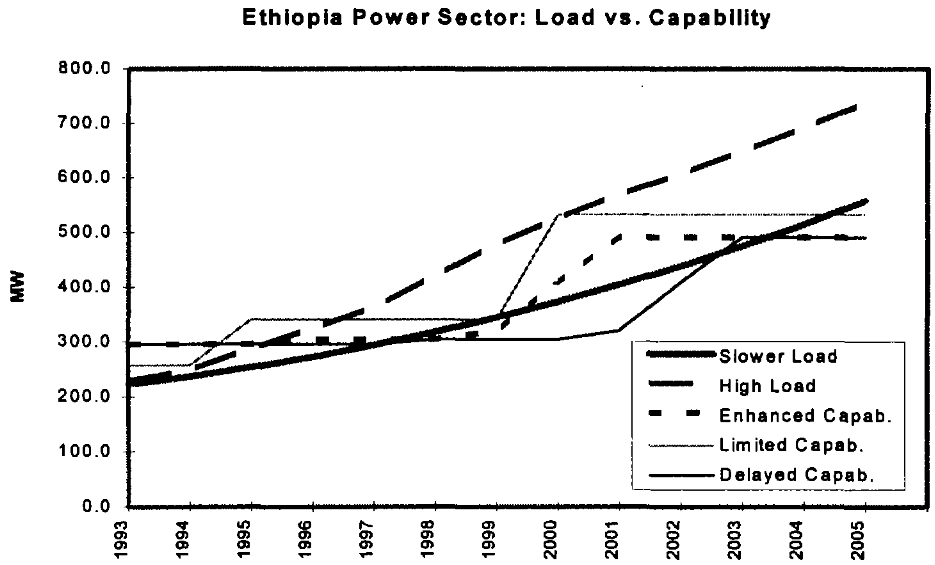
6 In addition to the new projects mentioned above, the latter two capability estimates include rehabilitation of the Koka hydro plant.

Figure 1



N.B. Capability does not include Upper Beles

Table 2.1: Ethiopia - System Requirements Scenarios

Energy Deficit Years (GWh)

	Capability	Limited	Enhanced	Delayed
Load				
	High		1997-2005	1997-2005
	Slower	1997-99; 2003-05	2005	1999-2001; 2005

Capacity Deficit Years (MW)

	Capability	Limited	Enhanced	Delayed
Load				
	High		1996-2005	1996-2005
	Slower	1999; 2005	1998-99; 2004-05	1998-2002; 2004-05

	Worst Case
	Best Case
	Intermediate Case

N.B. Capability does not include Upper Beles.

2.24 Given the magnitude of the prospective deficits, the need for about 60-MW of thermal capacity is indicated. Since the energy deficits are based on drought production they approach the maximum the plant could be required to produce. In 2001, the year of greatest energy deficit under the intermediate scenario, the average thermal production during a drought would be only 16% of the thermal plant's capacity. In the worst case, the maximum energy deficit be about 845GW.h in 1999 so fuel consumption would be significant, but for that year only.[7] A peaking plant for which the expected fuel consumption is sufficiently low that capital cost can be minimized with little regard for fuel efficiency, is therefore indicated.

2.25 Either simple cycle gas turbines or diesels could be suitable. Gas turbines are increasingly used for such applications because of their lower capital and operating costs. Several manufacturers produce gas-turbine generators in which the prime mover is a modified aircraft jet-engine. Generators are sized to match the aircraft engine so manufacturers offer specific sizes of machines "packaged" for installation on a concrete pad with a bare minimum infrastructure. These packages cannot be tailor-made to deliver a specific output determined by the purchaser. The smallest currently available is about 4-MW, and the largest about 33-MW. Packaged gas turbines in the middle of this range, installed at a single plant, would cost about $800/kW, including shipping, insurance and site costs.

2.26 Either Awash or Dire Dawa would appear to be suitable locations for a thermal plant. Both are connected to the grid and both would have good access to fuel deliveries since they have road connections to Assab and Djibouti respectively and the Djibouti-Addis Ababa meter-gauge railway passes through both towns. However, in both locations the gas turbines would have to be de-rated to take account of their altitude and high ambient temperatures. A standard packaged unit with a base rating of 22-MW, would deliver 16-MW in Dire Dawa which is located at an elevation of 900m and has a an average temperature of 30C. Four such units would be appropriate at this location. At Awash, with its 1600-m elevation and average 25C air temperature, the package would deliver a little less than 16-MW but four units would still be recommended.

2.27 Gas turbines can be either operated on liquid fuel or fueled with natural gas. The latter seems an option well worth considering since petroleum products must be imported, while Ethiopia has large reserves of natural gas at Calub in the remote Ogaden region. The Calub field is currently being developed under a World Bank assisted project under which liquids (kerosene, LPG and gasoline) will be extracted and trucked to market, while the gas will be reinjected since no viable market for it presently exists. Unfortunately, the thermal plant alone seems unlikely to provide such a market. Bringing the gas to the plant would require the construction of a 6 inch pipeline from Calub to Dire Dawa, the nearest point on the grid. This would cost an estimated $72 million[8] which, even if the opportunity cost of the gas delivered to the pipeline is put at zero, would be uneconomic if the plant is operated for peaking at, say, 15% load factor (see below).

2.28 A likely diesel option would be a plant housing ten 6 MW units. The operation of units of this size would be a large step for EELPA whose largest diesels are presently 1.5MW units. Machines of the suggested size require solid foundations and a powerhouse with an overhead crane for their assembly and subsequent maintenance. The installed cost of 5 to 7-MW diesel units is estimated to be about $880/Kw ($920/kW for the first unit in a 4-6 unit plant, with the additional units costing $840/kW).

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7 A 60 MW plant would be insufficient in this instance, suggesting there would be severe load shedding.

8 A power transmission line would probably cost no more, but would be a single-purpose investment while the gas delivered by the pipeline could serve a number of purposesin addition to power generation.

2.29 Rough calculations based on the foregoing discussion of the four thermal options (gas and diesel-fueled gas turbines; a single diesel plant and ten separate ones), suggest that they compare economically as follows:

Table 2.2: Ethiopia - Thermal Power Plant Options: Cost Estimates*

	Gas-fueled Gas Turbine (a)	Oil-fueled Gas Turbine (b)	60 MW Diesel Plant (c)	Ten 6-MW Diesel Units (d)
		$ million		
Capital Cost	120	48	53	58
Total Cost, with IDC	155	67	63	68
Fixed Annual Costs	23.3	10	9.5	10.3
		c/kWh		
Variable O&M	0.25	0.25	0.45	0.45
Fuel	0	5.079	4.644	5.036
Unit Cost @ % load factor		c/kWh		
15%	30.05	18.25	17.19	18.58
20%	22.6	15.02	14.17	15.3
25%	18.13	13.08	12.35	13.34
30%	15.15	11.79	11.14	12.03
40%	11.42	10.17	9.63	10.4
60%	7.7	8.56	8.12	8.76

* See Annex 4 for key assumptions.
(a) A $72-million pipeline to Dire Dawa supplying four packaged gas turbines.
(b) Same gas turbine as (a), supplied with oil from Djibouti.
(c) A diesel plant containing ten 6-MW diesels, at Dire Dawa, supplied with oil from Djibouti.
(d) Ten separate plants each with a 6-MW diesel unit.

2.30 While the gas-fueled gas turbine and separate diesel plant options appear to be out of the running for the reasons already mentioned, there appears to be almost an economic dead heat between the diesel-fueled gas turbine and single diesel plant options. If the feasibility study confirms that the choice between these options is too close to call on economic grounds alone, non-economic factors will have to be carefully considered. In particular, EELPA's preference for the "familiar" diesel technology will have to be balanced against the attractions of becoming familiar with gas turbines, a new technology that could have a bright future in a country with Ethiopia's gas resources. While EELPA will undoubtedly be more comfortable with diesels, its diesel operating experience has been none too happy, and the 6MW units are much larger and more elaborate than any it has installed or operated. Thus, whether it chooses diesels or gas turbines, EELPA would be well advised to entrust the construction and, at least, the initial operation of the thermal plant to experienced hands.

2.31 Looked at in a longer term perspective, a gas turbine plant could easily be converted to using natural gas as a fuel if this becomes available.

Meeting Near term Needs: Other Options

2.32 Fearing that thermal plant would require expensive fuel, EELPA and the MME, in November 1995, were still considering other options for meeting the short term need for capacity. The principal option included completing the Gilgel Gibe plant on an accelerated schedule, and rehabilitating some existing hydroelectric plants. Thus, the consultants employed by EELPA were developing a construction schedule under which the first two units would be brought on-line by mid-1998, or within two years of the assumed contract signing in mid-1996, as compared with the four year construction period originally envisioned. The consultant's report will need to be carefully reviewed to determine whether this is, in fact, realistic. In addition, the scheduling of the project will have to take account of the time required to prepare and respond to environmental impact studies; to plan and implement an adequate resettlement program; and to negotiate and put into place the requisite financial package.

2.33 The strategy adopted also calls for the rapid completion of rehabilitation works at existing hydroplants in order to strengthen EELPA's capabilities prior to the inauguration of Gilgel Gibe. This would include rehabilitation works at the Tis Abey and Koka plants, estimated by EELPA to restore 7 and 10-20MW, respectively, of reliable capacity to the system. Also under consideration was the possibility of reopening an old, long-abandoned hydro plant (Abu Samuel) near Addis Ababa, from which an additional few MW might be obtained. Of these rehabilitation projects, only the works at Tis Abey are ready for implementation when financing becomes available; technical and cost studies are required to determine the scope and feasibility of the other proposed projects.

The Long-Term Expansion Program

2.34 The completion of Gilgel Gibe, whether on an accelerated basis (1998) or as originally scheduled (2000), is likely to provide only a relatively brief respite before additional generation capacity is needed once again. If Gilgel Gibe comes on line in 2000, the ICS would, under "worst case" assumptions, be short of capacity in 2001; in both the "best case" and "intermediate" scenarios, additional capacity would be needed by 2004 (assuming no thermal plant is built). Since completion of a new large hydro project to follow Gilgel Gibe would probably take 7-8 years, there is a need to quickly determine, on a least cost basis, (i) whether there are "small" generating options that can be brought on line more quickly and (ii) which, if any, of the large hydro projects should be next in line for construction.

2.35 Two hydro options that have been suggested for consideration include the construction of a second plant at Tis Abey, and the addition of a fourth unit at the Finchaa plant. The idea of a second Tis Abey plant is one which has not been recently studied. However, it seems most attractive, *a priori*, offering as it does the possibility of developing upwards of 100MW of new capacity at relatively low cost. Pending the undertaking of the necessary studies, it seems that the project could be completed in four years. A fourth unit at Finchaa has been contemplated for some time and the plant was constructed with provision for an additional unit.

However, the present problems with the penstock (see above) would have to be definitively corrected before this could become a realistic proposition.

2.36 Of the potential "next" large hydro projects, only one, Aleltu East, located close to Addis Ababa, has reached a stage of assessment where it can proceed to timely implementation. A feasibility and system expansion study completed by Acres in 1994[9], concludes that a hydro plant with 174MW (3X58) of reliable capacity, capable of generating 767 GWh in a drought year, could initially be installed at the Aleltu site at an estimated cost, including transmission, of some $378millon. Aleltu East would produce energy at an estimated $0.078/kWh and Acres recommend it be developed next as Ethiopia's least cost hydro project.

2.37 Upper Beles, a much larger project, located in the Lake Tana region in the northern part of the country, is also considered a contender. The project is seen as having some 380MW of firm capacity and generating an estimated 1600GWh/pa. Its cost is put at approximately $900 million, including transmission. Although it has only been studied to the pre-feasibility level, Upper Beles presently seems less economic than Aleltu East. However, its economics will be improved by the construction of the aforementioned Chara Weir, which would serve as an essential element of the project. Moreover, whereas considerable resettlement is involved for the creation of the Aleltu East reservoir, none appears to be required for Upper Beles. Also, while Aleltu East is closer to the ICS load center at Addis Ababa, thus reducing its cost of transmission, Upper Beles, being near Bahir Dar and the long weak connection to the north, would add to the stability of that operation. EELPA is inclined to favor Upper Beles; it should see to it that Upper Beles is quickly brought to the same level of study as Aleltu so that their relative merits can be more accurately assessed.

2.38 Since hydro has long been the mainstay of power development in Ethiopia, it is natural to think of system expansion exclusively in terms of the next large hydro project. Indeed, where "cheap hydro" is available there is usually little point in considering other options. However, hydro in Ethiopia appears to be far from cheap. As just noted, electricity from the cheapest hydro project would cost $0.078/kWh according to Acres, which found costs ranging up to $0.09/kWh in the other hydro projects it considered. While other factors (e.g. reserve margins) need to be considered in comparing hydro and thermal, the apparent high cost of large hydro underscores the need to explore other options for long term expansion that may be better attuned to Ethiopia's needs and resources. One such option may be to determine whether there are other, smaller hydro sites that might be developed more quickly and at lower cost than the large projects on which attention has been focused to date. Another option well worth considering in view of Ethiopia's natural gas resources is the possibility of assigning a major role in long term expansion to gas fueled thermal plants. A Bank study found that large gas-fueled combined cycle gas turbines could generate electricity at $0.046-0.069/kWh with gas priced at an economically reasonable level.[10] It is important that this option be explored in depth.

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9 Aleltu Hydroelectric Project Feasibility Study/Power System Planning Study, Acres International, August, 1994.

10 Prospects for Gas-Fueled Combined Cycle Gas Power Generation in the Developing Countries, World Bank Energy and Industry Department, May, 1991. Capital Cost $600/kW; plant factor 40-75%; gas price $2.50/MMBTU.

2.39 EELPA should adopt a least cost expansion plan that takes all hydro and thermal options fully into account. An updated version of the Acres study, scheduled for completion by March, 1996, should provide a major input for the preparation of such a plan.

Distribution

2.40 If the needs of a growing economy are to be met, it not only will be necessary to significantly expand generating capacity but also to greatly improve the power system's ability to efficiently and reliably deliver electricity to its customers. As previously noted, the system presently leaves much to be desired in this area. Losses are high, reliability low, and the ability to supply new connections is far short of demand.

2.41 System losses, measured as the difference between generation and sales, have long been in the 15-20% range but there is no firm information on the their breakdown between transmission and distribution, or on the extent to which the losses in distribution are due to technical or non-technical factors. However, the relatively heavy investments in recent years appear to have substantially strengthened the transmission system, making it seem likely that that the bulk of system losses occur on the distribution side. Here, technical losses are undoubtedly high because of the dilapidated condition of much of the distribution network. Many of the lines, transformers and other system components are old, inadequate and/or poorly maintained. Frayed and sagging conductors, with inadequate clearances, are commonplace and apparently the main cause of frequent short circuits. Transformers are often badly overloaded, not so much, it seems, because of inadequate capacity in the system, but because loads have been so poorly distributed.[11] Unequal loading leads to frequent overheating of lines and transformers and to voltage and other problems.

2.42 The technical weaknesses of the distribution system are a cause not only of high system losses but of low quality service to consumers. Outages are frequent, and sometimes of long duration. Voltage can fluctuate widely; power spikes as well as lengthy periods of low voltage are frequent occurrences. In the absence of hard data on reliability, it is difficult to say just how poor service is and whether it is getting worse. However, informal interviews with consumers indicate that service is regarded as poor and deteriorating. Industrial consumers complain of lost production during outages and machinery damage due to voltage fluctuations. Domestic and commercial consumers are not only inconvenienced when the lights go out, but suffer damage to household appliances and office equipment.

2.43 Inability to connect new customers promptly, and to upgrade existing connections when additional service is required, is the other costly weakness of the distribution system. Shortages of distribution materials and equipment appear to be at the root of the problem. While the number of new customers connected to the ICS dropped in 1992-93 from the levels of the preceding years, the demand for new connections has risen sharply. The result has been an increase in the number of applicants awaiting connections from 2000 in 1990 to a reported

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[11] The total rating of distribution transformers in Addis Ababa is 450 MW while peak demand in 1993 was 144 MW.

70,000 in 1993, a backlog equivalent to a wait time of 4-5 years at the rate at which new connections have recently been made. While most of those in the queue are waiting for domestic service, the backlog also includes those wishing to establish new commercial or manufacturing establishments, or to expand existing businesses. For example, one manufacturer interviewed reported that imported equipment with which he planned to double production had been standing idle for more than a year pending the installation of a long-promised new transformer.

2.44 The problems of the distribution system stem primarily from inadequate funding for investment and maintenance and from planning and implementation practices that have not been adequate to make best use of the funds available. During the past 5 years only about 5.5% of total power sector investment expenditure has, on average, gone to distribution. Investment in distribution has been held more or less constant during a period of inflation and currency devaluation, with the result that there has actually been a sharp reduction in the domestic and foreign exchange resources going to distribution. Thus, the approximately Birr 6.5 million spent on distribution in 1993/2 was equivalent to little more than $1.0 million. Partly owing to the lack of funds, spending on distribution has tended to take place on an ad hoc, squeaky-wheel-gets-the-grease basis, rather than being directed where technically and economically most needed. Low voltage lines have, for example, been extended to unreasonable lengths, and consumers connected to them without much regard for transformer or line loading.

2.45 To restore and expand the distribution system will require both money and an institutional commitment to giving distribution the high profile and high priority it merits. The preparation of a comprehensive rehabilitation program is clearly the first order of business. Since information on system conditions is sparse, it will first be necessary to conduct comprehensive surveys to identify where reconductoring and/or the renovation of transformer substations is most needed to reduce losses and improve reliability. Then, the necessary rehabilitation works will have to be designed; material requirements and costs estimated; and the organization, manpower and other requirements for implementation worked out. Finally, the rehabilitation program will have to be carefully coordinated with EELPA's system expansion plans. The preparation of an integrated investment program for distribution is a major undertaking which will require the assistance of consultants. Consultants may also be required to assist in the implementation of the program.

Investment and Financing Requirements

2.46 To meet the foregoing expansion and improvement needs, Ethiopia will have to invest on the order of Birr 735 million ($118millon) annually in its electric power system over the next ten years. As the table shows, some three quarters of the total would be for new generating plant. This assumes, as previously discussed, that four major projects will be constructed: Gilgel Gibe ($306 million), the Aluto Lugano geothermal plants ($65 million), a 60 MW thermal plant ($67 million) and the Aleltu East hydro electric project ($378 million). Investment in transmission should include the expenditures necessary to complete ongoing and committed projects, principally the proposed northern extension of the grid beyond Bahar Dar, estimated to cost some $80-85 million; completion of the 230kV ring around Addis Ababa required to firm up the bulk supply to the city and to increase the stability of the entire 230kV system; and the transmission links required for Aleltu East and other new generating plant. Estimates prepared by EELPA, the Planning Commission and Acres indicate that an annual average of some Birr 90 million would be required for transmission. Since pending the completion of a careful survey of rehabilitation requirements, little can be said about the investment required in distribution, a notional amount of Birr 100 million per year has been included for this purpose. The estimate of distribution requirements also assumes that spending on rural electrification will rise gradually, averaging some Birr 35 million per year over the period. There would thus be a sharp increase over the level of investment in distribution in recent years, raising its share of power sector investment from 5% to 18%.

Table 2.3: Estimated Power Sector Investment Requirements, 1995-2004

	Birr million	$ million
Generation	5,100	822
Transmission	900	145
Distribution	1,340	216
Total	7,340	1,183

2.47 While the amount of investment required can only be roughly estimated, two things are abundantly clear: the task ahead is one of unprecedented magnitude and that it is unlikely to be accomplished on a "business-as-usual" basis. During the past five years, EELPA has invested an average of only about Birr 150 million annually, little more than 20% of the amount required in the future. If it is to raise its investment sights to the levels suggested, EELPA will have to greatly strengthen both its implementation and its financial capabilities. EELPA's implementation performance has not been good. According to Planning Commission data, it was actually able to implement less than 50% of its planned annual investments during the past five years. If it is to carry out the much more onerous investment tasks ahead, EELPA will need to greatly increase its planning, design and project management capabilities. Given the magnitude of the investment task, it will also need to consider delegating responsibility to outside parties by "contracting out" for project management or other services and/or by offering suitable projects to private investors. The need for these and other basic institutional changes in the sector is discussed in Chapter VI below.

2.48 The financial challenge to meeting the sector's investment needs is equally formidable. Even assuming that 60% or so of the cost of the investment is in foreign exchange and will, as in the past, be financed by foreign donors, Ethiopia will have to provide some Birr 300 million annually from its own resources to cover local costs. As the table below indicates, this would be about five times the average amount domestically financed over the past five years.

Table 2.4: Investment Expenditure by Source of Funds
(Ethiopian fiscal years - Birr million)

	1993/92	1992/91	1991/90	1990/89 & 1989/88
Domestic Financing	66.5	70.2	19.2	93.6
EELPA	31.8	44.3	4.2	59.1
Budget	34.7	25.9	15.0	34.5
Foreign Financing	26.6	94.6	144.8	233.4
Total	93.1	164.8	164.0	327.0

2.49 EELPA's ability to contribute to investment has been eroding rapidly in recent years. Inflation and devaluation have sharply boosted costs while tariffs had been unchanged since 1986, with the result that in the 1991/92 and 1993/94 fiscal years EELPA began to experience net losses on current account. It has thus had to rely on the its cash flow from depreciation and, increasingly, on contributions from the government budget to finance its investment program. While government contributions have always been an important source of finance, they have usually amounted to only a partial return of the "capital charges" the government collects from EELPA. In 1992/93, however, the government for the first time in many years had to contribute more to EELPA than it received in capital charges. Thus, investment in power became a true charge on the budget and, while the amount involved was a relatively modest Birr 9.6 million, the net burden on the budget was expected to rise to about Birr 52 million in 1993/94. Given the pressures on the budget and the government's other development priorities, this served to underscore the need for action to mobilize a much larger share of the necessary investment financing within the sector.

Tariffs

2.50 A tariff increase was evidently long, long overdue not only on financial grounds, but for economic reasons as well. With the average tariff standing at just Birr 0.21/kWh ($0.03/kWh), there was clearly a need to restore a reasonable relation between the price of electricity and the economic cost of supply in order to remove an artificial stimulus to the growth of the load and other distortions. To determine the extent of the tariff increase, EELPA undertook a thorough in-house study of both the economic and financial requirements. It concluded that, while an increase of about 25% would suffice to bring the average tariff in line with EELPA's own estimate of LRMC, the tariff would have to be approximately doubled in order to raise earnings to the point where it could finance some 25% of projected investment. This proposal naturally led to a great deal of debate within the government, which eventually decided on a 60% average tariff increase to be implemented in phases over a five year period. The first phase, equivalent to 20% of the proposed increase, or a 12% increase in the average tariff, was implemented last October. The second phase of 35% is scheduled to take effect in twenty months and the last increase at end of the five year period.

Table 2.5: EELPA Tariff Increase
(Birr cents)

	A Previous Tariff	B New Tariff	C New Tariff First Phase	D % Increase B/A	E % Increase C/A
Domestic	0.15	0.29	0.18	91	18
General	0.34	0.45	0.37	32	6
Industrial LV	0.22	0.39	0.26	71	15
Industrial HV	0.20	0.28	0.22	62	7
Street Light	0.33	0.34	0.33	3	0
Average	0.21	0.33	0.23	60	12

2.51 While most welcome, the tariff increase, especially in its first phase, represents only slowly progress toward meeting economic and financial requirements. As Table 7 shows, an analysis prepared for the assessment on the basis of the best available indicators of supply cost and conservative exchange and interest rate assumptions, indicate that LRMC can best be estimated as averaging Birr 0.46/kWh ($0.075/kWh).[12] The average first phase tariff of Birr 0.23/kWh is, thus, only 50% of LRMC while, even at the end of the scheduled five year implementation period, the average tariff of Birr 0.33/kWh would be no more than 72% of LRMC. Larger and more rapid tariff increases are required if the tariff is to do its economic job of guiding overall consumption and allocating it to the most efficient uses, and its vital financial job of mobilizing adequate domestic resources for investment in the sector.

2.52 The new tariff falls short of LRMC for all consumers, with domestic customers being the most heavily subsidized. Even with the full five year increase, they would be paying only about 55% of LRMC while the tariffs for other categories of consumers would be 80-90% of LRMC. The maintenance of such a large subsidy to domestic consumers appears to reflect the government's concerns with keeping electricity affordable to low income households and sustaining the substitution of electricity for biomass cooking fuels. While these are valid concerns they need to be seen in context. Concern about affordability should be tempered by the realization that it is Ethiopia's better off households, not its poorest ones, that have electricity. As regards fuel substitution, although electricity would become the most expensive fuel for non-injera cooking in Addis Ababa if it were priced at its full economic cost, this would be unlikely to induce many households to forego the convenience of electricity, and electricity would remain cost-competitive for cooking injera (see Chapter V).

[12] See Annex 5.

Table 2.6: New Tariff and LRMC

	LRMC Birr cents	New Tariff % LRMC	New Tariff First Phase % LRMC
Domestic	0.53	55	34
General	0.50	90	74
Industrial LV	0.44	89	59
Industrial HV	0.35	80	63
Street Light	0.34	103	100
Average	0.46	72	50

2.53 Although the level of the new tariff is not what it should be, two important changes to enhance its economic utility have been made in the tariff structure. Declining block tariffs for domestic consumers, which were an invitation to over-consumption, have been replaced by a domestic tariff under which the rate increases with the amount consumed. This should assist in tempering domestic demand, although the lowest block appears to be so high (50kWh/month) as to cover more than the poorest consumers actually requiring a "life-line" rate, and the price signal being sent to consumers is likely to be diffused by the excessive number of blocks (seven) in the domestic tariff. The metering and billing activities are also complicated by this cumbersome block tariff structure. The other major structural change is the introduction of time-of-day pricing for high and low voltage industrial consumers, which should encourage peak-shaving. The introduction of a similar tariff scheme for the larger domestic consumers, whose use of electric injera cookers adds considerably to the peak in Addis Ababa, would also have this effect and should be considered. On the negative side, the separate tariff for the SCS has been eliminated, although its supply costs are much higher, and the special, very low promotional tariff for electric boilers has been retained, although its justification is long gone.

2.54 In addition to the increased energy charges and changes in the tariff structure discussed above, steep increases in EELPA's service charges were also authorized. The numerous changes make it difficult to estimate the financial impact of the new tariff, but EELPA believes that the overall result will be to increase its revenues by about 28%. In addition, it is understood that the government also agreed to waive the capital charge in order to boost EELPAs earnings. If this is so, the broad effect of the tariff package would be to substantially reduce EELPA's pre-tax loss in 1994/95 and 1995/96 (see Table 8). Together with the cash flow from depreciation, this would enable EELPA to contribute some Birr 65-70 million to the financing of its investment program. While a marked improvement over the situation in recent years, contributions of this magnitude would be equivalent to only about 10% of the average annual level of investment foreseen above and would leave more than Birr 200 million per year to be financed from the budget.

Table 2.7: Tariff Increase: Possible Impact on EELPA's Finances
(Ethiopian fiscal years, Birr billion)

	Actual 1993/94	With new tariff first phase 1994/95 est.	1995/96 budget
Revenue	219	290	356
Operating expense incl. depreciation	183	188	237
Gross profit	36	102	119
Non-operating expense	78	93	134
Capital charge	25	13	0
Net profit (loss)	(67)	(4)	(15)
Add depreciation	65	68	86
Available for investment	(2)	64	71

Collections

2.55 While inadequate tariffs have been the principal cause of EELPA's financial weakness, poor collections have also played an important role. As Table 9 shows, in 1992/93 EELPA's receivables rose sharply to some Birr 171 million, a level equivalent to nearly 10 months' sales. This mainly reflected a more than doubling of the amounts due from both domestic and industrial customers; receivables from commercial and government customers were little changed. These trends were, fortunately, reversed in 1993/94, when the receivables of all categories of consumers fell, reducing the total outstanding to Birr 128 million. While most welcome, receivables were still equivalent to 7 months' sales, more than double the 3 months to which EELPA agreed they should be reduced under the Energy I project.

Table 2.8: EELPA: Outstanding Bills
(Birr million)

	< One Year	> One Year	Total	Months' Sales
1991/92	92	42	134	8.2
1992/93	127	44	171	9.7
1993/94	87	41	128	7.0

Private Participation

2.56 In addition to strengthening its efforts to mobilize resources internally, the government should explore the potential role of the private sector in helping to ease the financial and institutional constraints on power development. In many industrial and developing countries alike, private power producers are now playing an important role in financing, building, owning and running generating facilities under a wide variety of financing and operating arrangements. While the large hydro schemes that have traditionally been the mainstay of EELPA's expansion plan would not be attractive to private investors, the investment program does contain two projects --the geothermal and thermal plants-- of the type they have found attractive elsewhere. Since Ethiopia has had no experience with facilities of this sort, private investment would be advantageous not only as a source of capital but for the technical know-how and operating experience that would come with it. In view of these advantages, Ethiopia would be well advised to test the interest of the private sector by creating the conditions necessary to open such projects to their participation. What this might involve is discussed in Chapter VI.

III. PETROLEUM SECTOR

Introduction

3.1 Although petroleum is Ethiopia's major source of commercial energy, accounting for some 5% of the total energy supply compared with 1.5% for electricity, total consumption is very low. In 1993, consumption of petroleum products was 637,700 tons, equivalent to just 15kg per capita. However, if the economy continues to improve, consumption can be expected to rise quite rapidly, as shown in the following table.

Table 3.1: Ethiopia Petroleum Demand Forecast
(Kilo tons)

Products	1993	1994	1995	2000	% Growth Rate
LPG	4	4	5	26	30.7
Gasoline	106	109	111	125	2.3
Jet Fuel	49	50	60	102	11.0
Kerosene	95	108	115	185	10.0
Gasoil	298	314	323	402	4.5
Fuel oil	81	73	92	126	6.6
HSFO	-	-	-	-	0.0
Bitumen	6.7	8	9	15	12.6
Total	637	666	714	982	6.4

3.2 All of Ethiopia's petroleum is imported.[13] Crude and finished products procurement for Ethiopia and Eritrea is handled by the Ethiopian Petroleum Corporation (EPC). In February, 1995, EPC was given the status of a public enterprise which provided it with considerable managerial and financial autonomy, and a mandate to conduct its operations on a commercial basis. EPC undertakes procurement on the basis of the distribution companies' requirements and joint planning with the Petroleum Corporation of Eritrea (PCE). All imports currently transit via Assab. Crude refining is handled by PCE, which owns the refinery at Assab, and refines the crude owned by EPC in exchange for a processing fee and foreign exchange availability for the acquisition of maintenance materials. The Assab refinery covers less than 60% of Ethiopia's needs due to its low operating rate and a product slate which is not in line with the internal consumption pattern. As a result, large amounts of gas oil and kerosene need to be imported as products, while significant quantities of high sulphur fuel oil (HSFO) must be re-exported at prices lower than production cost. Product distribution is handled by four private oil

[13] Ethiopia has never had commercial oil or gas production, although the Calub field, which was discovered in 1972, and developed through a bilateral agreement with the Former Soviet Union, is being brought into production with the assistance of Bank Credit Cr-2588-ET. This credit also contains a Petroleum Exploration Promotion component designed to advertise the existence of several other discoveries within the Ogaden which appear sufficiently large to warrant commercial development, as well as to promote additional exploration within the country.

companies (Shell, AGIP, Mobil and Total). Details of product supply for both countries are shown in the table below:

Table 3.2: Petroleum Supply and Demand Balance - 1993
('000 tons)

Products	Demand			Supply		
	Ethiopia	Eritrea	Total	Refinery	Imports	Exports
Crude				605	622	
LPG	4	0.6	4.6	4.6		
Gasoline	106	10.6	116.6	76	32	
Jet fuel	49	4.9	53.9	-		
Kerosene	95	13.1	108.1	48	118	
Gasoil	296	104.9	400.9	150	237	
Fuel oil	81	26.1	107.1	92		
HSFO	-	12.2	12.2	174		161.8
Bitumen	6.7	3.3	10	10		
Total	637.70	175.70	813.40	550.00	387.00	161.80

3.3 The supply and distribution system now works reasonably well. Petroleum products are generally in adequate supply in urban centers (although not in rural areas), at prices that in most cases (but not for kerosene and LPG), adequately reflect economic costs. However, underlying institutional rigidities and infrastructure weaknesses raise costs and make the system less responsive to market requirements than it needs to be. If the needs of a growing economy are to be effectively served, action should be taken to reduce refining costs; introduce market reforms that will free up procurement and prices; provide more adequate facilities for inland transport and storage; and increase the availability of petroleum products in rural areas.

3.4 Action along these lines would be consistent with the MME's policy objectives in the sub-sector. As set out in the Letter of Sector Policy for the Energy Sector submitted to the World Bank in connection with the Calub Gas Development Project, these objectives include: the elimination of entry barriers to private participation; improving the infrastructure and policy and regulatory framework in order to facilitate petroleum supply and distribution; reorganizing sectoral institutions to improve their efficiency; and basing petroleum product prices on import parity.

Reducing Refining Costs

3.5 The Assab refinery is a Soviet-designed and constructed hydroskimming refinery, which was completed in 1967. It has a processing capacity of about 17,000 bpd. Ownership and management of the refinery passed to Eritrea in May 1991 as part of a comprehensive peace settlement between the two countries.

3.6 The refinery's product output is fixed, based on the type of crude which it is designed to process, and is significantly skewed towards black products, as shown in the following table. White product yields are very low and losses and auto consumption are very high. Without major technical reconfiguration of the refinery, there is little possibility of product variation. In addition, product quality in terms of octane and sulphur content are well below world standards. This is also a function of the refinery's design configuration; in particular, the existing Soviet bimetallic reformer catalyst (aluminum and platinum) limits the refinery to producing gasoline of 79-80 octane. Annex 6 provides additional information on the refinery and its operation.

Table 3.3: Assab Process Unit Design Capacity
(tons/day)

Topping	2,400 (2,100 is max. op cap.)	
Reforming	260	
Vacuum	430	
Refinery Yields (per cent)	**1993 actual**	**1994 plan**
LPG	0.8	0.8
Gasoline	12.6	13.8
Jet Fuel/kerosene	7.9	7.6
Gasoil	24.8	28.2
Fuel oil	15.2	15.0
High sulphur fuel oil	28.8	23.0
Bitumen	1.7	3.0
Losses and Autoconsumption	8.2	8.7
Total	100.0	100.0

3.7 Because of its age, obsolete design, and relatively small size, the refinery operates at high cost. As the table below shows, the cash cost of processing crude at Assab was about $14 per ton in 1993.[14] This is about two-thirds higher than the marginal cost of processing hydroskimming products at larger, more modern refineries in the Mediterranean area, which is about $9 per ton. While high costs are intrinsic to the operation of a refinery like the one at Assab, over-staffing also plays an important role. Nearly 900 people are on the refinery payroll; this is about 3-4 times as many staff as are usually needed to operate a refinery of its size. In addition, because of Assab's remote location, the refinery must pay staff a 40% "desert allowance" and provide them with housing, schools and other facilities.

[14] EPC reports that unit cash processing costs were much lower in 1994, when the refinery's throughput was 23% higher, and the average value of the Birr 20% lower, than in 1993.

Table 3.4: Assab Refinery Processing Costs - 1993

Accounting Center	Cost ($/ton of processed crude)
Variable costs	2.6
Direct materials	0.8
Steel drum sheet	1.8
Fixed costs	11.1
labor	4.7
prod overhead	4.2
Gen & Administ.	2.2
Total cash cost	13.7

3.8 The refinery's finances are simplicity itself. As agreed between Ethiopia and Eritrea, the actual operating and maintenance costs of the refinery are covered by a processing fee paid by EPC to PCE. The fee is renegotiated annually on the basis of the refinery's proposed expenditure budget. The refinery itself, which is organizationally part of PCE, takes no margin and makes no profit. While its operating costs are covered, depreciation is not.

3.9 The refinery provides all of Eritrea's product requirements, plus nearly 60% of Ethiopia's requirements; the remaining products must be bought on the open market. Since the refinery's costs are considerably higher than those elsewhere in the region, its use increases Ethiopia's and Eritrea's petroleum products bill. The total economic (opportunity) cost to the two countries can be estimated by comparing what they currently pay for crude and products with what the total cost would be if all of their requirements were met by importing products (i.e., the total value of their consumption at import parity prices). This is done in the following table; the calculation of import parity prices is detailed in Annex 7.

Table 3.5: Assab Refinery Opportunity Cost of Operation (1993, in Millions of Dollars)

Product	Total Value of consumed product at import parity prices	Actual Cost of crude plus purchased product
Crude oil		75.1
Processing		8.3
LPG	1.4	
Gasoline	22.0	7.5
Jet/Kero	31.8	22.3
Gasoil	73.5	46.1
Fuel Oil	11.7	1.6
HS Fuel Oil		(9.7)
Bitumen	1.7	
Total value	142.1	
Total cost		151.2
Opportunity cost		(9.1)

3.10 As the table indicates, in 1993 using the refinery cost the two countries $9.1 million more than if they had purchased all their products from regional export refineries. Thus, the refinery adds more than 6% to the cost of petroleum products; this is the premium that was paid to keep it in operation. The added expense is equitably shared between the two countries in the ratio of their respective offtake of product, 62/38 (Ethiopia/Eritrea), making the net cost to Ethiopia $5.7 million.

3.11 At present, operation of the refinery is clearly an uneconomic proposition that serves to increase the cost of petroleum to both countries, while providing little in the way of added convenience or security of supply. It is likely to continue to be an expensive luxury since the prospects for changing the economics of the refinery are narrowly constrained by the relatively small size of the market it serves, the lack of indigenous crude oil to serve as a feedstock, and the availability of low cost product from world class refineries in the region. Nevertheless, since proposals for upgrading and/or expanding the refinery have been considered for some time, two possibilities that bracket the range of investment options were examined for the assessment. The first, rehabilitation, would aim at optimizing the operation of the present refinery, without a basic change in technology; the second, revamping, would involve a major expansion and technological updating of the refinery.

3.12 The rehabilitation investment would focus on improving efficiency through utilities refurbishment, the reduction of losses and autoconsumption, and enhancements in LPG and diesel recovery. The cost of these optimizations would be approximately $20 million over a two year period. This would marginally improve yields but leave the refinery operating margin still negative, although less so than now. As a result, the net present value at 10% of this $20 million investment over a ten year period, would be on the order of a negative $50 million. Moreover, rehabilitation would do little to solve the increasingly severe problem posed by the non-availability of parts from the former Soviet Union, where refineries of this type are no longer in use. Revamping would involve doubling of refinery throughput capacity, and the introduction of a vis breaking/thermal cracking unit. It would take three years and $200 million to accomplish. As a result of such a major technical upgrading, the present negative refinery operating margin would become slightly positive. However, the present value of the revamping investment at a 10% discount rate over a twenty-year period would be approximately a negative $194 million.

3.13 While major investment appears to be ruled out, operation of the refinery could be improved at little or no cost by converting it from a government department to an autonomous corporate entity able to act commercially. A corporate management, responsible for financial results, would have incentives for improving efficiency that do not exist under the present system in which the refinery's costs are simply reimbursed through the processing fee. If "corporatized" the refinery should be able to purchase its crude throughput requirements on its own account, or to accept toll processing contracts from EPC and the private companies on commercially competitive terms. An autonomous management, able to hire and fire as necessary, should also be able to eliminate unnecessary staffing and other costs. Commercial operation would also involve allowing the refinery to retain any earnings, and reinvest them in improvements in plant and related facilities. While corporatization along these lines would enable the refinery to be managed with greater efficiency, it could do little to alter the refinery's basic lack of economic competitiveness, and it would still require subsidy/protection.

3.14 Since prospects for converting the refinery from a cost-increasing to a cost-saving operation seem so dim, closure appears to be the only option for relieving both countries of the economic burden posed by the refinery. If refinery operations are discontinued, Assab would continue to be the entrepot for petroleum product supply for both countries. The existing crude storage facilities would be converted to product storage and, as discussed below, both the unloading facilities and the storage depot would be enlarged to take advantage of economies of scale in shipping, transportation and storage of product. Some 150-200 employees would be required to operate the port and storage depot. The 700-750 or so present staff who would be made redundant by the closure of the refinery could be provided with severance, early retirement, relocation and/or retraining benefits which, however generous, would require only a faction of the prospective cost savings.

Market Reform

3.15 In addition to the important direct savings on petroleum product costs, closure of the refinery would open the way for efficiency enhancing reforms in present procurement and pricing practices. Since the refinery is not competitive, it has had to be protected in a number of ways --by granting a procurement monopoly to EPC, allowing EPC to import petroleum at a preferential exchange rate, and maintaining a rigidly regulated pricing system-- that prevent the market from functioning as efficiently as it should. Dismantling these protections would lower costs and make the supply and distribution system more responsive to the needs of the economy.

3.16 Opening procurement to the private sector: To ensure the refinery of a crude supply and a market for its products, the previous government granted EPC the exclusive right to purchase the nation's requirements of crude oil and finished products. EPC's procurement practices are professional. Tenders are undertaken through newspaper advertisements for six-month forward contracts for crude and for specified finished products. Purchase requirements are customarily met through agents, who charge an agency fee. Payments are made within 30 days through electronic transfer of funds. As the table shows, EPC now manages to procure crude and products, except for gasoline, at prices that are only slightly above import parity.

Table 3.6: Actual Procurement Prices and Potential Savings, 1993

	Actual CIF cost ($/ton)	CIF Import Parity Price ($/ton)	Imports ('000 tons)	Potential Savings ($'000)
Crude	121.7	120	622	1,171
Gasoline	204	183	32	667
Jet Fuel	196	191	118	598
Gasoil	180	177	237	629
		Total Potential Savings		3,065

3.17 However, the fact that EPC still spent some $3.1 million more on procurement in 1993 than would have been necessary at import parity, suggests that there is considerable scope for reducing procurement costs. The best means of accomplishing this would be to introduce competition in procurement by extending the right to purchase and import petroleum products to the private sector oil companies, The transaction costs of private companies are likely to be less than those of EPC, due to the economies of scale which the companies use in their global purchasing agreements, and the equally likely absence of agency fees. With all companies, including EPC, competing on equal commercial terms, incentives for securing the best prices would be maximized. The continued presence of EPC in the market also would serve as a benchmark, ensuring that the private companies are importing at realistic prices.

3.18 Opening procurement to the private sector should also help to reduce financing costs such as the 2.5% telegraphic transfer charge currently paid by EPC that added an estimated $3.1 million to the cost of its crude and product purchase in 1993. These fund transfer charges appear to be made by the Ethiopian banks involved in these transactions, rather than the foreign banks into which these funds are transferred. These costs are excessive; a rate of 0.2% is more common in the international banking world. It is quite likely that they are a result of EPC being required to make its transactions through Ethiopia's government controlled banking system. It is reasonable to expect that these excessive transaction charges would disappear should the fund transfers be made through ordinary commercial banks, by EPC or the private sector companies making the purchases.

3.19 Elimination of Preferential Exchange Rate: The Ethiopian government maintains a two-tier foreign exchange system. Most transactions are made at the market rate, which is set in frequent treasury auctions. The market rate floated downward before stabilizing in mid-1994 at the $1.0=Birr 6.2 level. For strategically important expenditures, such as the procurement of crude oil and refined products, pharmaceuticals, fertilizers and the payment of debt service, the Government made foreign exchange available to state companies at a preferential rate that averaged 5.55 Birr/$ in 1993. For petroleum purchases, this amounted to an expensive subsidy to EPC which, as the table shows, cost the government Birr 67.6 million ($11 million) in 1993.

Table 3.7: Ethiopian Foreign Exchange Subsidy
(1993 figures)

	$ million	Birr million
Ethiopia/Eritrea oil bill	148	
Eritrea estimated oil bill	35	
Ethiopia Export of fuel oil	9	
Ethiopia net oil bill (@6.2 Birr/$)		644.8
Ethiopia net oil bill (@5.55 Birr/$)		577.2
Total Forex Subsidy	10.9	67.6

3.20 Foreign exchange is now freely available through the auction process, and EPC should have no difficulty meeting its foreign exchange needs on the market. Recognizing this, the government decided in July, 1995 to eliminate the preferential exchange rate and EPC now purchases foreign exchange at the auction rate.

3.21 Pricing: Prices are tightly controlled. Since there is only one source of products, EPC, the Assab ex-refinery price is the wholesale price. As the table below shows, under the price structure set after the devaluation in October 1992, ex-refinery prices for the major products consumed, gasoline and diesel fuel, were above import parity while the ex-refinery prices of LPG and kerosene were well below international levels.

Table 3.8: International Market Product Prices Versus Ex-Assab Refinery Product Pricing 1993 $/ton

Product	FOB	CIF	Import Parity Price (IPP)	Actual Ex-Refinery Price
LPG	157	284.0	292.4	158
MoGas	175	183.3	189.2	275
Jet/Kero	183	190.8	196.9	130
Gasoil	169	177.3	183.0	201
Fuel Oil	89	96.7	100.4	119
HSFO	59	66.5	69.9	-
Asphalt	54	165.6	171.0	204
Crude	112	119.9	124.1	-

3.22 In May, 1994, the ex-refinery prices of kerosene and LPG prices were raised, in dollar terms, by 5% and 32% respectively, moving them closer to import parity, while other product prices were largely unchanged. Retail prices are controlled by the Ministry of Trade, which fixes transportation charges and distribution margins. From the point of sale at the refinery, the following regulated costs are added: EPC's profit margin, taxes, transport to Addis Ababa, and distributor and retailer margins, to yield a retail price at the pump. All retail prices were significantly increased in Birr terms in May, 1994, as the following table shows:

Table 3.9: Retail Price Structure (Birr/liter)

	October,1992	May, 1994	Percent Increase
Gasoline	1.85	2.00	8%
Gasoil	1.42	1.50	6%
Kerosene	.90	1.00	11%
Fuel Oil	.95	1.00	5%
LPG	2.00	2.50	25%

3.23 While prices are now set at economic levels (except for kerosene and LPG), the regulatory regime has three major deficiencies: price competition is precluded, price/cost relationships are seriously distorted in some cases, and regulation is excessively rigid. Absent price competition, there is little incentive for the private oil companies to improve their distribution and retailing practices, or otherwise reduce costs in ways that would benefit consumers. The most serious market distortions result from the under-pricing of kerosene and LPG which, while intended to encourage the substitution of petroleum for biomass fuels, is probably unnecessary. As Chapter V points out, given the high cost of biomass fuels, substitution incentives would remain ample even if the prices of kerosene and LPG were raised to import parity.

3.24 The lack of a mechanism for regularly reviewing and adjusting prices in line with changes in international prices and the exchange rate may be the most serious deficiency in the existing system. Prices are adjusted infrequently and on an ad hoc basis. Indeed, prior to the 1992 devaluation, product prices had not been changed for 10 years and, when prices are adjusted, the procedures and criteria used are far from transparent and appear not to take full account of market realities. This was reflected in the private oil companies' objections to the May, 1994 wholesale price increase which they have refused to accept on the grounds that it unduly squeezed their allowed profit margins.

3.25 The present system of price regulation and the best means of improving petroleum pricing are to be investigated carefully in the Petroleum Pricing and Market Structure Study to be conducted under the Calub project. Pending the completion of the study, it appears that the basic choice lies between two broad approaches: deregulation and rationalization of the regulatory system. At this time, it appears that the most economically realistic, efficiency-promoting and flexible approach to petroleum pricing would be to eliminate official regulation. Deregulation would enable prices to reflect actual procurement and distribution costs and adjust automatically to changes in import parity, thereby providing correct signals to consumers. If the refinery is closed and procurement opened to all, it would be possible to free prices all along the supply chain. However, even if the refinery remains open, prices still could be deregulated at the retail level to obtain some of the benefits of competition.

3.26 With four international companies presently active in the country, competition should be sufficient so that prices move freely and fairly in response to market forces. This can be ensured through the establishment of a monitoring system that will enable the government to detect any signs of collusion or other failures in the market that may distort prices. In addition, the government may wish to consider permitting EPC to enter the retail market, where its presence could provide a check on the private companies' pricing practices, and where it might also serve a social function by making products available in areas not now reached by the distribution system. However, such a move would entail considerable start-up expenses, which EPC might not be able to recover, especially in view of the likely low sales volumes in remote areas. Accordingly, the costs and benefits of EPC's entry into retailing would have to be carefully studied before any decision is considered.

Port, Transportation and Storage Improvements

3.27 At the present time, all of Ethiopia's petroleum products are delivered by tankers to the petroleum port of Assab, which is administratively and physically separate from the city's commercial port. Petroleum unloading facilities include two sea berths and one sea jetty, with maximum ship drafts restricted to 11 and 7 meters for the sea berths, and 8.5 meters for the sea jetty (see Annex 8). These draft restrictions require the use of tankers of 40,000 tons or less whose costs are excessive in comparison to more normal sea-going tankers with capacities in excess of 60,000 tons.

3.28 Tank storage facilities at the Assab petroleum port include a nominal 100,000 tons of crude capacity, and 93,400 tons of product. The latter are split between the refinery product tanks, and those which are owned by the private oil companies. Together their capacity represents 15% or 53 days of current consumption for Ethiopia, and with the exception of LPG capacity, is adequate (see Annex 9).

3.29 Ethiopia's current product requirements are trucked 950 km inland on the winding, two lane Assab-Addis Ababa road in an expensive, time-consuming process. The approximately 100 tank trucks that use the road every day in each direction contribute significantly to road congestion, air pollution and road surface deterioration on the only road from Ethiopia's port of entry, which is shared by all goods imported into the country. Traffic is susceptible to interruption through major road accidents, acts of nature or civil unrest, contingencies against which the existing inland storage capacity appears to offer inadequate security. Petroleum products are stored in eight inland depots for consumption, and onward distribution. This inland storage capacity represents only 6%, or about 21 days, of the country's 1993 consumption.

3.30 Dependence on a single road, coupled with limited storage capacity, makes Ethiopia's petroleum supply vulnerable to disruptions of either a natural or man-made nature. Moreover, forecast annual consumption increases will further exacerbate inland supply, storage and distribution problems. In view of this, Ethiopia should critically review the supply and distribution situation. The focus of this review should be on expanding the Assab port unloading and storage facilities, in agreement with Eritrea; strengthening transportation links; and augmenting inland storage facilities.

- Expansion of Assab port capacity and product storage: In order to obtain lower unit costs for petroleum products through the use of larger tankers, the larger of the two sea berths should be converted from crude to white products discharge. The costs of this are relatively small compared to the likely savings, and much of the work can likely be undertaken by the refinery-based construction crews. Required additional specific product storage facilities; e.g. LPG spheres, and additional gasoil and kerosene tanks, should be constructed as required to optimize the available product storage facilities, and to take commercial advantage of large tanker-load bulk product purchases. Should the refinery be decommissioned, the refinery-associated crude tank capacity should be converted to product storage, rationalized with the existing product tank farms, and the existing piping system improved.

- Strengthening transportation links: Transportation in the all-important Assab-Addis Ababa corridor can be improved in the short run through market and regulatory changes, but major infrastructural investments to upgrade the road and/ or construct a products pipeline may be needed in the longer run. In addition, the role of other transport routes that serve interior population centers should be investigated.

- Road haulage: Competition should be increased and the regulatory framework strengthened. There are strong indications that the existing system of petroleum product haulage contract bidding is a process dominated by a cartel of three contractors, the result of which is that haulage rates are set by agreement rather than open bidding. The basis on which haulage contracts are bid should be restudied. It is likely that if contracts were broken down into smaller components, more competitive bidding would take place. On the regulatory side, consideration should be given to issues of highway usage taxation, en route safety, loading regulations compliance, and general operating conditions of rolling stock. The latter would result in significantly reduced air pollution due to poorly maintained equipment, and a reduction of road degradation through enforcement of axle weight regulations.

- Products pipeline: Projections of inland product deliveries suggest that requirements may be approaching the practical upper limit to the amount of truck traffic which can be economically engaged in this transport. Thus, preliminary calculations indicate that a product pipeline would be economically and financially competitive with truck transport. It is estimated that a 10" underground line, 900 km long with four pumping stations, would cost $200 million to install, and would be capable of delivering 1.3 million tons of product per year at the rate of 200 cubic meters/hour. Assuming that product requirements and pipeline throughput increase as presently forecast (see above), product could be transported at an estimated $39.90/ton, which compares favorably with the $41.30/ton current cost of truck transport.

3.31 While the apparent cost advantage of the pipeline seems modest, it should be noted that truck transport charges are currently among the lowest in Africa and are likely to increase significantly. In addition, the pipeline itself and the proposed pipeline storage terminals would help meet the need for increased inland storage and, particularly in the case of the proposed tap-offs at Mile and Awash, facilitate distribution outside of Addis Ababa. The pipeline would also substantially reduce heavy truck traffic on the road with significant benefits in the form of reduced congestion and road maintenance requirements and increased safety. Furthermore, an underground pipeline would provide important protection against natural catastrophes, and a degree of security against acts of banditry, simple stealing of product, and politically-inspired disruption.

3.32 In view of the potential benefits of a pipeline, a pre-feasibility study should be conducted to firm up the cost and throughput estimates, quantify insofar as possible the aforementioned ancillary benefits of the pipeline, and examine the competitiveness of the pipeline vis-à-vis upgrading the highway to international standard and other options for increasing transport capacity and reducing costs.

- Massawa and Djibouti: The product needs of the northern and eastern parts of the country may be most efficiently supplied through fuller use of Massawa and Djibouti, respectively. It is likely that the existing port, product storage and transshipment facilities at Massawa can be expanded, and transportation developed to accommodate product storage at Asmara, with onward transportation to the north of Ethiopia as part of an integrated delivery system serving the two countries. Mutually beneficial port, transit and duty charges at Massawa need to be negotiated for such activity to take place. Establishment of a Djibouti-Dire Dawa product haulage transportation corridor would require either a partial rehabilitation of the existing railroad, or the upgrading of the road parallel to the railroad. It is likely that such a corridor would also require an adaptation of the existing Djibouti port storage facilities to southeastern Ethiopia's product requirements, the establishment of a regional storage depot at Dire Dawa, as well as negotiations regarding appropriate port, transit and duty charges. Preliminary studies are needed to determine the magnitude of the investments required and whether they might be justified by the benefits of expanding either or both of these transportation routes

- Storage: To increase Ethiopia's security of supply, inland storage capacity should be approximately doubled to the equivalent of two months' requirements. As already indicated, construction of a products pipeline and associated storage facilities could be expected to largely meet this need. If a pipeline is not to be built, or seems likely to be long delayed, it may be advisable to independently construct a major inland storage depot. In view of the existing transportation network, this should probably be constructed in the Awash/Addis Ababa area, and a lesser depot constructed at Mile. A study should be made of Ethiopia's storage needs and how they can be most economically met. The study should include an examination of the role of the seven "strategic" storage facilities that EPC maintains in rural areas and, in particular, whether and how these sites should be converted to commercial rural distribution points.

Increasing Rural Supplies

3.33 As already indicated, petroleum products are often in short supply and available only at high prices in rural areas. The private companies have shown little interest in moving significant amounts of product into the rural areas. To compensate for this, an informal distribution system has developed in which local entrepreneurs buy drums of product from Addis

Ababa, and truck them into the rural areas in pickup trucks, to sell them on the local economy for whatever price the market will bear.

3.34 Meaningful incentives for the efficient distribution of products in rural areas can be provided either through deregulation, or by revising the price control system to permit higher margins in rural areas. If prices are deregulated, freeing the oil companies to charge prices they consider adequate to cover the costs of distribution in rural areas, it is likely that the private sector petroleum companies would consider expanding their distribution system to include a rural network of product outlets. Product availability would be greatly improved and, while prices would be higher than the present regulated ones, they might well be less than what many farmers now actually have to pay. Incorporating greater cost differentials in the regulated price structure could produce similar results, but with greater difficulty and less certainty than if this were left to the market.

IV. RURAL AND RENEWABLE ENERGY

Rural Electrification

4.1 Definitions of rural electrification vary widely. At the most general level, it means the provision of electricity supplies to the rural population by whatever means are appropriate. Within this overall concept, two broad approaches can be distinguished: *conventional rural electrification* and *complementary rural electrification.*

4.2 Conventional rural electrification means the extension of utility supplies to rural areas, using grid extensions or isolated generating plant. This is the approach being implemented by EELPA and involves the provision of supplies to rural communities by extending the ICS or the provision of SCSs.

4.3 Complementary rural electrification[15] covers the wide variety of possible means by which rural communities and families can be provided with, or obtain for themselves, some form of limited alternative electricity supply pending the arrival of a conventional service. Complementary rural electrification is taking place, if at all, on an extremely limited scale in Ethiopia.

4.4 In effect, "rural" when applied to electrification in Ethiopia at the present time, means the provision of supplies outside the four largest cities - Addis Ababa and its surrounds, Nazreth, Dire Dawa, and Harar. In practice, it involves the extension of the distribution system to smaller urbanized areas.

Conventional Rural Electrification

4.5 EELPA is the sole authority responsible for the provision of public electricity supplies in Ethiopia. There is, however, no department or division in EELPA dedicated to rural electrification as a specific activity. Electrification of the rural areas is carried out as part of the normal and continuing expansion of the supply system, which is probably the most efficient way of carrying it out at this stage of the development of the system.

4.6 The overall coverage of the electricity supply system in the country is limited. The number of consumers supplied by the ICS in 1993 was 392,277 and a further 58,750 were supplied by SCSs. The total number of domestic consumers was 380,000; this is around 2 million people or about 3.5%[16] of the total population of the country. Some 13 towns with populations over 10,000 and around 80 towns with populations over 5,000 have no public electricity supply.

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[15] This is sometimes described as pre-electrification, generally with reference to the use of photovoltaic systems.

[16] A figure of around 11% is often quoted as the proportion of people with access to an electricity supply. This is obtained by counting the total numbers of households in towns with an EELPA supply whether or not these households are actually connected to the supply.

4.7 A high proportion of EELPA's consumers are concentrated in the main urban areas. Addis Ababa city accounts for about 50% of the total number of consumers and electricity sales in the country. Addis Ababa, its surrounding area and the towns of Nazreth, Dire Dawa and Harar, accounted for 72% of the total number of consumers and 81% of the consumption on the ICS in 1990.[17]

4.8 As of 1993[18] there were 25 SCSs with a combined generating capacity of 29.4 MW. The largest, at Bahir Dar, is a hydro plant with a capacity of 11.5 MW and accounted for nearly 60% of the total SCS output in 1993. It serves a small interconnected grid which was connected to the ICS in 1994. Of the other SCSs, six stations are classed as medium size, with capacities in the range 1.0-2.4 MW. The remaining 17 stations have capacities in the range 150-870 kW.

4.9 The number of SCSs in operation at any given time varies. This is because existing centres are regularly brought into the ICS as it expands while, at the same time, new SCSs are established in other areas. About 70 SCSs were brought into the ICS in the period 1984-94 while around 50 new ones were set up. When an SCS is brought into the ICS, the existing diesel plant is normally transferred to another location. As of 1993, the SCSs accounted for about 13% of the total number of consumers and about 5.5% of total electricity sales in the country.

4.10 As discussed in Chapter II, the performance of EELPA in extending and maintaining the distribution system in recent years has been generally weak. The backlog of applications for connections has been growing and reportedly presently stands at around 70,000. Little preventive maintenance is carried out and the distribution system is in a poor condition with sagging conductors, badly designed networks and inappropriate clearances. There are frequent outages as a result of short circuits and overloading.

4.11 The practice of making *ad hoc* additions to the distribution system has led in some gross over-extensions of 15 kV lines. In extreme cases, voltage drops to as low as 140 V have been recorded at line extremities. Any further expansion of the distribution system in such areas is clearly counterproductive unless it is preceded by a proper redesign and rehabilitation of the existing system.

4.12 The total number of customers served by the ICS grew at an average rate of 7.6% per year over the period 1984-93. This is a nationwide connection rate of just over 20,000 consumers per year. Of these, perhaps 6,000 per year are connections outside the base ICS. Discounting those which are accounted for by SCSs being connected to the grid, the number of new customers being connected outside the base ICS, is about 5000 per year.

4.13 The rural population, at some 85% of the national total, is around 45 million people or 9.3 million households. The present annual rate of new connections being provided by

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17 This supply area is sometimes referred to as "the base ICS."

18 Acres Aleltu study (1994).

EELPA thus amounts to about 0.5% of the number of families without a connection. This is almost certainly well below the rate of rural population growth.

4.14 The lack of progress in conventional rural electrification has a variety of causes. The civil war, for example, put an obvious brake upon rural electrification activities in many areas during the recent past. The principal present reason is the precarious financial position of EELPA which means there are few resources available for expansion in the rural areas. The fact that rural and urban tariffs are uniform also means that supplying the rural areas is a major money-loser for EELPA. This is because connection costs per consumer are much higher for rural than for urban consumers whereas the return tends to be considerably less.[19] The financial position is particularly unfavourable in the case of SCSs where diesel generation costs are considerably greater than the supply costs on the ICS. Under these circumstances, prudent management requires EELPA to proceed slowly with the expansion of rural services where every consumer connected and kWh sold leads to a worsening of the utility's financial position.

Municipal, Self-Help and Private Generating Systems

4.15 A small number of towns have their own municipal generating company which provides a limited service during the evenings. These municipal companies were set up under the previous government as a form of community self-help. Technical advice was provided by EELPA but the companies were supposed to cover all their own costs. This meant that tariffs were considerably higher than those charged by EELPA.

4.16 The initiative was not particularly successful. Apart from a lack of the necessary technical and managerial abilities at the municipal level, EELPA's much lower tariffs created considerable resentment against the system. The expectation that EELPA, with its subsidized tariffs, would take over the municipal system if it failed also undermined the approach. No details of the remaining municipal systems were available to the mission but there are apparently only three or four still operating.

4.17 The previous government also endeavoured to mobilise some communities to pay a proportion of the costs incurred by EELPA in connecting them into the ICS. These are referred to as self-help schemes. This initiative also failed because communities were unwilling to pay EELPA for what it provided without any community contribution in other areas. While communities were prepared to make an initial small contribution, once EELPA began work no further payments were generally forthcoming.

4.18 Reference is also made in some documents and statistics to the existence of "private generators" in some centres. Although no details of these were available to the mission, they are said to consist mainly of hospitals, missions or other institutions with generators for their own electricity supply. They do not provide public supplies.

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19 Average household sales in the base ICS in 1990 were, 1,130 kWh/year in comparison with 430 kWh/year for households outside the base ICS.

The Ethiopia National Rural Electrification Project (ENREP)

4.19 A long-range planning study of rural electrification entitled the Ethiopia National Rural Electrification Project (ENREP) was carried out by the Canadian consulting firm Acres with funding by CIDA. Work began on the study in 1990 and the final report was published in August 1994. The study covered the potential expansion of EELPA supplies over the whole country apart from the base ICS area of Addis Ababa and its surrounds, Nazreth, Dire Dawa and Harar. The planning period covered was 1991-2011.

ENREP Methodology

4.20 The study identified a total of 852 "urban" centres - many of these are small towns or villages serving the local agricultural community.[20] Of this total, 231 were already supplied by the ICS and 21 were served by SCSs.[21] The country was then divided into 84 project areas to which the urban centres were allocated. All these project areas contained a mix of already supplied and unsupplied centres.

4.21 Population forecasts for the project areas were prepared by projecting the 1984 census results forward to 2011 at 4.07% annual growth. It was assumed that 10% of the households in each unsupplied centre would take a supply immediately it became available and that this would rise to a saturation figure of 35% over ten years. An initial consumption of 280 kWh/household/year was assumed to rise to 434 kWh/household/year after 10 years, with a growth rate of 5%/year thereafter. Non-residential connections were assumed to have an initial consumption of 685 kWh/year rising to 1398 after 10 years, and growing at 8.25%/year thereafter.

4.22 In areas with an existing electricity supply, residential consumption was forecast to grow at 7.5% per year. This figure, which was based on historic growth rates, included both population growth and increased consumption within households. Commercial and small industrial consumption was forecast to grow at 5.6% per year.

4.23 An economic analysis was carried out for each project area comparing three supply options: the use of traditional energy forms (essentially kerosene for lighting); supply by an SCS; and connection to the ICS. In the analysis, a discounted benefit-cost ratio was calculated for shifting from traditional energy sources to diesel or grid supplies and for shifting from diesel to grid for each project area for each year from 1991 onwards.

4.24 Conversion from the existing energy supply source was initially taken to be economically justified in the year in which the benefit-cost ratio reached 1.0. As application of

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20 The Rural/Urban Household Energy Survey carried out by CESEN, for example, defined "urban" as any settlement with a population of over 2,000 people.

21 The Working Paper "Ethiopian Energy Assessment: The Power Sector" prepared for the mission gives the figure of supplied towns as 180. Significant differences in the data provided from different sources, often with EELPA itself, were frequently found by the mission.

this criterion excluded the great majority of projects, it was relaxed to a benefit-cost ratio of 0.9 to take account of some of the less tangible benefits of rural electrification.

ENREP Findings

4.25 Of the 84 projects considered, a total of 17 were found to be justifiable under the 1.0 benefit-cost criterion. A further 50 projects were found to be acceptable when the benefit-cost criterion was lowered to 0.9. These 50 projects were ranked in order of priority according to the date at which they met the 0.9 criterion. A further 17 projects which failed to satisfy the 0.9 benefit-cost criterion were rejected.

4.26 The ENREP recommended the immediate implementation, over the period 1994-96, of the 17 projects which met the 1.0 benefit-cost criterion. The 50 projects which met the 0.9 benefit-cost criterion were recommended for gradual implementation, in order of their benefit-cost ranking, over the remainder of the project period.

4.27 These projects all incorporate already-electrified communities as well as those to be electrified. Some of the already-electrified communities are presently served by SCSs and under the programme 20 of these would be brought into the ICS. Only four new SCSs are proposed under the programme. At the completion of the ENREP in 2011, there would be a total of 9 SCSs.

4.28 Under the ENREP, a total of about 460 communities would be newly electrified and the total number of additional EELPA consumers is projected to be 310,000. This represents a connection rate of around 15,000 new consumers per year, about three times greater than that presently being achieved outside the base ICS. At the end of the project, the total number of rural consumers is projected to be 462,000. This is about 2.3 million people - some 3-4% of the projected rural population at that time.

4.29 The ENREP analysis showed that the proposed programme would have no significant impact on either transmission or generation requirements. The total increment of rural consumption over the project period was calculated to be less than one year's projected growth for the whole EELPA system. No electricity supply constraints, other than those applying to EELPA as a whole, would therefore arise if the programme were implemented.

4.30 At the institutional level, it was estimated that a further 8 regional offices, 32 new branch offices and 136 new satellite offices would be required. These requirements would evolve at a steady pace over the implementation period. Given the relatively slow pace at which these additional institutional requirements would emerge, they are not predicted to cause any major institutional problems.

4.31 The study found that the use of 33 kV as the primary distribution voltage was generally preferable, both technically and economically, to the present use of 15 kV. It therefore recommended that future new extensions should generally use a 33 kV primary distribution voltage.

4.32 The total economic cost of the project was calculated to be $306.9 million (1991 $) and the financial cost was calculated at $363 million. Under the proposed implementation programme, the expenditure would be more or less evenly spread over the 20 year project period. This represents an investment rate of around $15 million (75 million Birr) per year, which would be a massive increase in the rate of investment in the distribution system outside the base ICS.

4.33 Although the ENREP does not deal in any detail with the financial implications of the programme, it is clear that at present and planned future tariff levels it will not cover its financial costs and will therefore represent a substantial drain on EELPA's finances.

Mission Comments and Recommendations[22]

4.34 Although a formal decision has not yet been made, the mission understands that the ENREP recommendations are broadly acceptable to EELPA and will form the basis for its rural electrification activities up to 2011. The mission agrees that the ENREP provides a useful overall framework for these activities but it is clear that, as matters stand at present, the actual implementation of the proposed programme is well beyond EELPA's capabilities.

4.35 There are a variety of institutional, financial and other reasons for this. On the basis of its past performance in rural electrification, EELPA does not appear to have the technical or administrative capacity required for a major expansion of its activities in this area. The necessary funds are not available within EELPA at present and, given the tariff policy, are not going to be internally generated in the foreseeable future. Mobilisation of these funds from external agencies is likely to be difficult. The ENREP, rather than representing a practical programme of action should thus be seen as the maximum plausible and economically justifiable expansion of the EELPA system outside the base ICS. Only a gradual build-up in investment toward the recommended level is likely, with the rate of increase dependent on how rapidly EELPA can improve its project implementation and financing capabilities.

4.36 In adopting the ENREP as a framework for its rural electrification activities up to the year 2011, EELPA should also recognise that many of the ENREP assumptions, for example those on population and load development, are highly uncertain. In many cases, they will tend to diverge increasingly from reality with time. It is essential that the detailed ENREP programme is viewed with considerable caution and no project is implemented without being independently analyzed and justified by EELPA on the basis of up-to-date information. The selection of areas for electrification should be based on the economic and technical criteria recommended in the ENREP.

4.37 The problem of the piecemeal and technically unsatisfactory development of the system in many areas also needs to be addressed as a matter of some urgency. One of the reasons for this failure to follow accepted electrical engineering practice, appears to be because of the division of responsibilities for distribution system expansion between the Corporate Planning Department and the Regional Operations Department. As discussed in Chapter VI, a

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.[22] The comments and recommendations on rural electrification given here must be seen as complementary to the broader discussion on the structure and functioning of EELPA elsewhere in this report.

possible solution would be to devolve some of the existing design responsibilities held by the Corporate Planning Department to the Regional Operations Department, with Corporate Planning focusing on setting system standards that meet technical and economic efficiency criteria. In this context, the ENREP provides a useful model for ensuring that the distribution system in each area is properly assessed, strengthened as required, and extended in a technically and economically logical manner.

4.38 The limited impact of the ENREP on the rural areas must also be recognised. Even if the full programme were implemented, some 96% of the rural population would remain without a conventional electricity supply in the year 2011. The benefits of whatever subsidies are provided for the programme will flow primarily to an extremely small, and generally better off, proportion of the rural population and the impact on broader issues such as reducing fuelwood consumption or increasing agricultural productivity will be slight.

4.39 Given such limited, and socially restricted, benefits, there is no case for advocating any increase in the level of rural electrification by EELPA beyond that recommended in the ENREP. Implementation of the programme should, moreover, be carried out in balance with the overall rehabilitation and development of EELPA.

4.40 The mission recommends the following:

- EELPA should ensure that no further *ad hoc* extensions of the distribution system are carried out and that proper system design standards are applied in future extensions;

- EELPA should draw up, cost and plan a programme of urgent rehabilitation work for its existing rural electrification network. This rehabilitation work should take priority over any major commitment of resources to expand the distribution system;

- Using ENREP as a starting point, EELPA should draw up a 5-year plan of distribution system expansion projects. These should be in areas where the distribution system is already in a technically satisfactory condition or can be brought to this condition before the extension work is carried out;

- To ensure that planning of the rehabilitation and expansion work remains realistic and up-to-date in the light of resource availability and progress achieved, the above rehabilitation and expansion programmes should be reviewed and revised on an annual basis. To facilitate this process, an effective monitoring and evaluation system should be made part of the rural electrification program.

Complementary Rural Electrification

4.41 Even the maximum plausible conventional rural electrification programme would leave more than 95% of the rural population without a supply by the year 2011. The practical reality is likely to be even worse. The great majority of rural Ethiopian families have no prospect of obtaining a conventional electricity supply within their lifetime.

4.42 Many other developing countries are in a similar position. In a large number of these countries, however, a variety of entrepreneurial or self-help methods of providing small scale electricity supplies to rural families have emerged. These include small diesel or gasoline generators for private or public supplies; car batteries to provide small amounts of electricity for lighting, radio, and even TV; and the use of PV systems for domestic and other small scale uses.[23]

4.43 The coming into use of these small scale electricity supply systems represents a significant mobilisation of private resources in the rural areas. It also enables rural families to obtain some of the key benefits of rural electrification in areas which cannot presently be reached by conventional rural electrification. As such, these approaches deserve to be encouraged by the GOE as part of its efforts to improve rural living standards.

Small Gasoline or Diesel Generators

4.44 Small privately owned generators running on diesel, gasoline or LPG are used throughout the developing world to provide electricity supplies to commercial enterprises, small industries, workshops, farms, and households for a host of end-uses. In many villages and small towns, local entrepreneurs use them to provide an alternating current supply to neighbouring households and, sometimes, workshops or businesses.

4.45 A World Bank study of the Yemen, for example, found that 38% of the rural population obtained an electricity supply in this manner. In Indonesia, a 1986 World Bank study found some 17,000 small private electricity supply systems. The practice is also found in a variety of other developing countries and appears to emerge spontaneously where there are no legal obstacles to the provision of such supplies.

Car-Battery Recharging Systems

4.46 Car batteries are widely used by rural and peri-urban families throughout the developing world as a means of providing power for radios, radio-cassette players, lighting and even small black and white TVs. They are recharged for a fee at recharging centres where the electricity is obtained from the grid or a diesel generator. Their widespread use is reported from Kenya, The Gambia, Senegal, Sri Lanka, the Yemen, Peru and a variety of other countries. Although the electricity supply provided is minimal, it clearly meets a strongly felt need among rural and peri-urban families unable to obtain a conventional supply.

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23 This is discussed in the section on renewable energy resources.

4.47 The batteries are usually standard 12 volt car batteries with capacities in the range 60-120 Ah, but in some countries purpose-designed batteries are used. In Sri Lanka, for example, a system known as the Prasakthi unit was designed by the National Engineering and Research Centre in the middle 1980s and sold at $27. In Zimbabwe, a commercial firm produces a 14 Ah battery with a specially-designed warning system to help prevent excessive discharge which shortens the battery life.

Present Position on Complementary Rural Electrification in Ethiopia

4.48 According to the information provided to the mission by EELPA and the MME, the use of small privately-run generators in Ethiopia is rare and car batteries are not used at all by households. There is, however, anecdotal evidence that some businesses and entrepreneurs use small generators and they are certainly on sale in Addis Ababa. It is also likely that with economic growth, stability in the country and the emergence of a market economy, demands for small scale electricity will, if they do not already exist, begin to manifest themselves as they have done in other countries.

4.49 There has been, however, little investigation carried out in this area and virtually nothing is known about potential markets for complementary electricity supplies in the rural areas or how such markets might best be encouraged to develop. Additional information on household expenditures on energy sources other than those used for cooking is thus required.

4.50 The legal position in relation to the provision of small scale public supplies of electricity by private suppliers seems to be somewhat unclear. It appears that although EELPA has had a *de facto* monopoly on the provision of public electricity supplies, the production and sale of electricity by private suppliers is not strictly speaking illegal. This, however, still leaves potential private suppliers facing a variety of ill-defined and variable bureaucratic hurdles if they wish to set up a local distribution system.

4.51 The creation of a positively encouraging legislative framework is therefore an essential, and urgent, first step if private resources are to be mobilised for the provision of electricity in areas which EELPA cannot supply within the reasonably near future. Such a legislative framework would set out both the rights and obligations of private suppliers in relation to the government, EELPA and their customers.

Mission Recommendations

4.52 The mission makes the following recommendations:

- The GOE should establish a positive and encouraging legislative framework for the provision of small scale public electricity supplies by private suppliers. This should encourage the provision of such supplies, allow suppliers to set their own tariffs and remove bureaucratic obstacles. It should, at the same time, provide for minimum safety standards and a reasonable degree of consumer protection.

- The Ethiopian Energy Studies and Research Center (EESRC) of the MME should set up a small task force on the potential use of car batteries and small generators in areas outside the immediate reach of EELPA services[24]. Its purpose would be to stimulate interest in deploying such systems, identify areas of high potential and assess the means by which the EESRC could most usefully support private sector activities (e.g., by facilitating the transfer of hardware and know-how). The task force should be chaired and serviced by the EEESC and should consist of representatives of private sector suppliers of generators and car batteries.

4.53 The Task Force should carry out a tightly focused and limited amount of field investigation concentrating on a small number of the more prosperous urban centres and peri-urban areas where the emergence of small scale electricity markets is likely to be most rapid. The aim should be to identify measures which can facilitate the development and servicing of any such emerging markets.

Small Scale Renewable Energy Resources

4.54 Ethiopia is well endowed with renewable energy sources. These include solar, wind, mini-hydro and geothermal. There are also large quantities of cattle dung which might be used for biogas production. In looking at the possible future uses of these sources, three potential types of applications can be considered: in conventional rural electrification; in complementary rural electrification; and in the provision of non-electrical energy.

4.55 Institutionally, the EESRC has overall responsibility for renewable energy development and promotion in the country. Some renewable energy activities are also carried out at EELPA (small hydro) and the Ministry of Agriculture (biogas and PV pumping). Although a considerable amount of technical research and development work has been carried out, the practical harnessing of renewable energy sources is at an early stage in the country and their present contribution, apart from a number of small hydro stations, is negligible.

4.56 One of the most important weaknesses in the work carried out to date is an almost complete lack of analysis of the economic viability of renewable energy applications and their competitiveness relative to their conventional alternatives. Nor has there been any significant amount of investigation into whether potential markets exist for the technologies or how such markets might be developed.

4.57 The general assumption has been that the state, or donor agencies, will act as providers of the technologies and will bear the difference between their costs and the amount potential users are willing to pay. While this may be necessary at a promotional stage, it cannot form the basis for large scale or sustainable dissemination strategy unless it leads reasonably

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24 See also the discussions on mini-hydro and PVs in the renewable energy section.

quickly to users paying close to the full cost.[25] Otherwise, programmes remain unsustainable, constrained by the availability of funds for subsidies, and generally negligible in their impact.

Photovoltaics (PVs) and Solar Thermal Energy

4.58 The average daily insolation over the whole country is about 5.0 kWh/m^2. There are, however, substantial regional and seasonal variations. Insolation data from 21 meteorological stations were assembled, analyzed and presented by the CESEN study and provide an adequate basis for the cautious design of solar energy systems. Improved coverage is clearly desirable and should be seen as a medium term objective.

4.59 The largest PV project in the country to date was a 31.5 kWp centralised plant installed at Mitto in 1985. It was designed to provide power for water pumping, and house and street lighting. The installation had an array of 900 modules each of 35 Wp. The plant experienced a variety of technical problems and has been abandoned.

4.60 It is reported that some 600 of the modules have been stolen. Many have apparently been combined with car batteries and sold as makeshift home lighting kits. No detailed information is, however, available - the fact that the modules are stolen property makes it difficult to carry out an official survey. The episode is, nevertheless, a indication that some level of commercial demand for alternative forms of energy supply exists in the rural areas in question.

4.61 The Ethiopian Telecommunications authority has installed about 230 PV systems with a total output of around 100 kWp. They are mainly for VHF radio communications. The systems have functioned satisfactorily apart from some initial problems with load controllers which have now been solved. The PV systems replace small diesel generators with which there were many problems because of the remoteness and inaccessibility of the sites. The intention is that PVs will be used in all new remote installations.

4.62 Maintenance is carried out by Telecommunications Authority technicians as part of the normal six-monthly routine servicing of installations. The installed price of systems, based on international tenders, is around $6/Wp. There is a local dealership in Addis Ababa for handling orders but the nearest available technical expertise is in Nairobi.

4.63 UNICEF has a programme for the installation of PV refrigerators at health clinics. This is part of the WHO/UNICEF worldwide Expanded Programme of Immunisation (EPI) in which three types of approved refrigerators are used: LPG; PV and kerosene.

4.64 The installed costs of approved PV vaccine refrigerators tend to be in the range $5,000-6,000 compared with $1,100-1,500 for kerosene and LPG models. Even on an annualized basis, the PV models tend to cost around twice as much as those running on kerosene

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[25] The successful dissemination of the Lakech stove without any subsidies to users or fabricators is an extremely relevant example.

or LPG. Refrigeration costs are, however, a small proportion of the total costs of the EPI, whereas the integrity of vaccine stocks is crucial.

4.65 EPI policy is to use LPG refrigerators wherever LPG supplies are reliable. Where LPG supplies are not reliable but there is adequate insolation, PV is now normally the technology of choice despite its higher costs. Kerosene refrigerators, which are less reliable and have a generally lower performance than the other types, are used where there is no practical alternative.

4.66 The current EPI programme in Ethiopia envisages the extension of vaccination services to a further 825 clinics by the end of 1995[26] provided the funding is available. A total of about 100 PV refrigerator systems have already been installed at health clinics and are apparently performing satisfactorily. Around another 50 installations are planned.

4.67 A PV pump project funded by the EC has been under implementation by the Ministry of Agriculture (MOA) since 1985. A total of 30 systems, each of 1.14 kWp, have been imported under the project. The training component in the project has been inadequate and much of the supplied equipment has apparently been defective. Only 18 pumps have so far been installed of which just three are functioning. No analysis of the costs of the PV systems compared with the possible alternatives appeared to be available.

4.68 Only one solar thermal system is known to have been installed. This is a flat plate hot water system installed at an EELPA training centre with assistance from the Italian government. No details of costs or performance appeared to be available.

Next Steps

4.69 Outside the Telecommunications Authority, the information required for long range planning, or even taking the next steps in the deployment of solar energy systems, is almost totally lacking. The EESRC should therefore begin to assemble a data base on the performance of systems which have been installed and the reasons why installations have succeeded or failed. The costs of new systems such as solar lanterns, solar home systems and other equipment available for import to the country should also be established.[27]

4.70 An analysis of where, if at all, PV pumping provides a technically satisfactory and least-cost solution should be carried out in collaboration with the MOA. The results should be used as a basis for planning the completion of the present programme and deciding on whether funding for any extension should be sought.

4.71 Centralised village level PV systems, which employ large PV plants as village "mini-utilities", have no present applications in Ethiopia because of their extremely high costs and the institutional and financial problems they pose. Solar energy is therefore of no immediate

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[26] "Ethiopia: towards UCI by 1995." UNICEF, AAO Health Section, 1993.

[27] Contact could, for example, be made with suppliers in Nairobi to establish the delivered costs of such equipment.

relevance to conventional rural electrification and the only EELPA involvement required is to maintain a watch on international developments in this area.

4.72 The most promising way forward for self-sustaining dissemination of PV systems in Ethiopia is through private sector promotion of solar lanterns and Solar Home Systems (SHSs) as has happened in Kenya (see Box).

Solar Home Systems: The Kenya Experience

It is estimated that at least 20,000 PV units have been sold in Kenya since 1987. This is more than the number of rural consumers connected under the national power utility's Rural Electrification Programme during the same time.

The deployment of PVs on a significant scale in the country began in the early 1980s and was almost entirely within government and donor projects. Among these were PV power supplies for remote telecommunications purposes, an OXFAM project to supply 52 pumps to Somali refugee camps, the provision of PV refrigerators under the EPI, and PV-powered electric fences in game parks. It is estimated that by 1993 around 1 MW of PVs had been installed under such programmes.

These substantial donor programmes meant that PV modules and system components began to become known and available in Kenya. The programmes also provided a basis for the development of local capacities in component assembly, and the installation, repair and maintenance of PV systems. In addition, they created a widespread public awareness of PV technology and its potential for meeting small-scale electricity demands in the rural areas. As a result, substantial numbers of PV kits began to be sold commercially to private householders in the late 1980s.

The fact that Kenya has a dynamic and competitive private sector capable of seizing the market opportunity presented by PVs is a major factor in the diffusion of PVs which has taken place. As a World Bank report comments "*Over twelve firms supply photovoltaic equipment to households. Hundreds of agents, service personnel and technicians form the infrastructure of Kenya's photovoltaic economy. At least three firms assemble inverters and wind transformers for baton-type fluorescent lamps. Kenya's private sector, from large multinational firms to local cottage industries, is a driving force in the expansion of photovoltaics in the country*[28]."

The purchasers are usually better-off farmers, teachers and other government employees, rural business people, and city-based workers with homes in the rural areas. Marketing is carried out through press and radio advertising and demonstrations at agricultural shows. A typical system consists of a 40-50 Wp module and four lamps with a locally made battery. The charge regulator is frequently omitted in order to reduce the cost of the system, although this is likely to result in premature battery failure.

The selling prices for units are high in comparison with Asian countries such as the Philippines. The mid-1993 purchase price of a 53 Wp system, including local 100 Ah battery, four fluorescent lamps, charge regulator and ancillary equipment and wiring was $922. The installed price was $1,378. These prices include a total import duty and value added tax of $263, approximately 40% of the tax-free purchase price of the components.

It is noteworthy that the Kenya government has adopted an almost totally hands-off attitude to private sector PV activities. The rapid growth in sales has occurred because there is a relatively prosperous and sophisticated rural middle class in the densely populated and fertile highlands of the country. The great majority of the people living in these areas have no realistic possibility of obtaining an electricity supply within the next five or ten years under the country's rural electrification programme. PVs provide an expensive, but effective and convenient means of meeting their needs for high quality lighting and power for radio-cassette players and TVs.

The future of PV in Kenya is unlikely to be problem free. There are inevitable concerns about the quality and durability of the systems being sold in such a highly competitive and unregulated market. Kenya is thus both a showcase and testbed for the commercial dissemination of PVs in the developing world.

[28] Hankins and Best (1993) "Photovoltaic power to the people - the Kenya case." Industry and Energy Department, World Bank.

4.73 SHS kits consist of a PV module, load controller, battery, one or more lamps and a power outlet. The most basic kit has a 10 Wp module and an 8 Wp lamp and will provide about four hours light per evening under reasonably sunny conditions in the developing world. A 20 Wp kit will also include a power outlet for a radio or other piece of equipment and will provide double the electricity, 70-80 Wh under reasonable conditions. This is sufficient for two lamps, or one lamp and a radio cassette player for around four hours.

4.74 A typical medium-range SHS kit has a 50 Wp module which provides an average of around 180 Wh per day. This considerably increases the range of options for the household. It is sufficient, for example, to provide power for three or four lamps and a radio-cassette player for four or five hours. By reducing the amount of power used for lighting, a small black and white TV can be used for several hours. Towards the upper end of the SHS range, a kit with two 50 Wp modules will provide up to 360 Wh per day, giving considerable further flexibility to the household in its choice of services. In this case, even a small colour TV can be considered.

4.75 Another option for a household is to use a rechargeable PV lantern. Rechargeable PV lanterns usually have a nickel-cadmium battery, though some have a lead-acid, an integral 2.5-10 Wp PV module and a 5-10 W fluorescent lamp. They recharge in normal daylight, the brighter the better, and provide 2-5 hours light. Some versions do not have their own PV module but are designed for recharging from a 10-25 Wp stationary module.

4.76 There has been a substantial general fall in SHS prices over the past few years but they still vary widely according to country and manufacturer. The actual installed price in any given country depends upon a variety of factors including the initial cost of the equipment, the level of import duties and taxes, the installation costs and dealer mark-ups. Installed prices in Kenya, for example, where there are extremely heavy import duties and taxes, tend to be two to three times higher than in Asian countries such as Indonesia or Sri Lanka.

4.77 The initial costs of PV systems are generally high in comparison with alternatives such as kerosene lamps or car batteries. PV systems score over the alternatives because of their higher level of performance and their lower running costs - the only expense with a well designed and maintained PV system is the replacement of the battery every four years or so. The table below gives the monthly amortisation costs for a variety of PV systems based upon representative international costs. The discount rate used is 10%; a five-year life has been assumed for the lantern; and an overall life of 12 years for other kits. Battery replacements are assumed to take place every four years.

System size/type	Initial cost $	Lifetime	Battery cost $	Monthly amortisation $
Lantern	70	5		1.49
20 Wp	300	12	60	4.42
50 Wp	750	12	120	11.64
100 Wp	1,300	12	240	20.65

4.78 Figures such as these provide a means of comparing the economics of SHSs with the alternatives. For the family spending $4-5 per month on lighting, for example, a 20 Wp SHS is an economically competitive alternative and likely to be able to provide a superior level of service.

4.79 Households may nevertheless have difficulty in raising the initial capital required for the purchase of the SHS. Lack of investment capital, in other words, blocks them off from making an economically viable investment. Under these conditions, governments can help by providing seed finance for revolving funds which advance a proportion of the initial payment to purchasers and recover the advance over a period of perhaps three to five years. Such revolving funds would not provide subsidized financing but, rather, help overcome the barrier to private purchases posed by the high initial costs of SHS. The use of revolving funds requires the existence of a commercial market for PV systems and an effective system for the recovery of the advances made to system purchasers.

4.80 The EESRC, once it has established a relevant data base on the available products and their costs, should in conjunction with potential private sector suppliers, carry out a limited study of whether and where markets exist for presently available products[29]. If such markets are found to exist, the study should recommend measures which can be taken by the GOE to ensure that this market potential is realised.

Wind

4.81 Wind speeds vary widely over the country and, given the rugged nature of much of the topography, are heavily influenced by local conditions. An analysis of data from 39 measuring stations for the period 1971-78 was carried out under the CESEN energy study in collaboration with the MME.

4.82 The highest daily averages were found close to the Red Sea in Eritrea[30]. In Ethiopia, however, speeds are generally well below the 5 m/s which represents the minimum at which electric power generation might be economic. There are, therefore, no immediate prospects for the production of electricity from wind in the country.

4.83 Wind speeds are, however, adequate for wind pumping in many areas. A programme to install wind pumps for the supply of village and small scale agricultural water supplies run by the Italian NGO, Lay Volunteers in Technical Assistance, has been in operation since 1985. A total of 36 of these pumps have been installed.

4.84 The windmills are of the multiblade type mounted on towers around 20 metres high. The rotor is locally manufactured but the tower is imported. A small proportion of the cost is contributed by the village served by the system and the village also assumes responsibility for operation and maintenance. The total cost of the whole installation is around 200,000 Birr. This

29 This work should be carried out as part of the market study of potential applications for small privately-owned generators and car battery systems

30 Assab, for example, had an average of 8.51 m/sec, which is highly promising for electricity generation.

is far in excess of what the local community is able, or prepared, to pay. Expansion of the programme depends entirely on the continued availability of funds to cover the costs of the programme.

4.85 As in the case of other renewable, and conventional technologies, the limitations on the deployment of wind pumps are financial and economic. The primary task is therefore to identify applications in which water pumping is economically justifiable and affordable to the local community. This analysis needs to be carried out in collaboration with the MOA and any other relevant agencies. Where water pumping is found to be justifiable, an analysis of the various options, including hand pumps, diesel power, PVs and wind should be carried out to establish which provides the least cost solution and hence the greatest economic benefit.

Mini-hydro

4.86 Four mini-hydro power stations with capacities in the range 100-190 kW are operated as SCSs by EELPA. A number of other larger sites, with capacities up 1.4 MW have also been identified by EELPA as possibilities for development.

4.87 An MME project in the late 1980s, which was carried out with Italian assistance, identified some 50 possible sites from aerial photographs and maps. These were reduced to 25 after preliminary site investigations and further reduced to 12 on further study. From these, four were selected for detailed design studies and possible implementation but the project was abandoned when funding ended.

4.88 Preliminary studies were carried out at 57 sites under the auspices of the MOA with Chinese assistance. This was part of the "villagisation" programme of the previous government. Of these, 11 were selected for implementation but lack of funding prevented any action. No further activities are being carried out on this project. There is also a small UNDP-funded project which aims to provide training on mini-hydro feasibility studies to EELPA but the level of activity is apparently low.

4.89 Mini-hydro may have a role in conventional rural electrification within the ENREP framework. As part of its assessment of the least cost options for the expansion of its rural supplies in each particular area, EELPA should consider whether a mini-hydro station could be used as a potential supply source. Information which has already been assembled under the various mini-hydro initiatives mentioned above should be assessed by EELPA for its relevance to the implementation of the ENREP.

4.90 Mini-hydro can also, in principle, provide a local source of supply for communities without access to the grid. In principle, the development and operation of mini-hydro systems could be done by the private sector. They could also be community operated. In either case, successful implementation of such projects requires a willingness to pay for electricity on the part of a sufficient number of local people to cover the costs, as well as the existence of the skills and commitment to build and operate the plant. The available evidence suggests that such conditions are unlikely to exist in Ethiopia at present.

4.91 The mission recommends that the EESRC should nevertheless remain aware of the possible relevance of mini-hydro as a potential source of power for private suppliers. Once there is a clearer picture of potential electricity markets in the rural areas, an assessment, based on the already available information, should be made as to where mini-hydro might be a serious candidate for supplying the necessary electricity. If the results of this assessment indicate a realistic potential for mini-hydro, the EESRC should seek to stimulate interest in the private sector and mobilize the necessary technical and financial support from the international donor community.

Geothermal

4.92 The high temperature geothermal resources of the country are found in the Rift Valley which stretches from the Kenyan to the Eritrean borders. In this area, the magnetic intrusions resulting from the geological faulting which has taken place are relatively close to the surface and water reservoirs with temperatures of 200-335°C have been found at depths of 2000-2500 metres. The most promising resources are grouped in four areas: the Lakes District; Southern Afar; Central Afar; and the Danakil Depression in the north.

4.93 Detailed feasibility studies have been carried out in the Alùto-Langano area in the Lakes District. A total of eight wells have been drilled to depths of 1300-2500 meters; of these, five are productive. The estimated electric power potential is 30 MW for around 30 years. Preliminary assessments of the country's total firm geothermal electricity generating capacity are about 700 MW.

4.94 Elsewhere in the country, although there are numerous hot springs, with temperatures in the range 45-70°C, the geology is much more stable and high-temperature water reservoirs are not known to exist. A number of these hot springs are exploited commercially for hot baths and swimming pools. The Addis Ababa Hilton Hotel, for example, uses water at 47°C obtained from a 400 metre deep borehole for its swimming pool.

4.95 There has been some discussion of the possibility of using small-scale low-temperature geothermal plants in the 0.1-1 MW range as a means of providing electric power to isolated communities. The technology for such applications has been developed and applied in the western USA. The typical plant uses geothermal water in the temperature range 100-120°C and a hydrocarbon liquid with a low boiling point as the heat exchange medium. The geothermal water is obtained from a production well and a reinjection well is also required if an environmentally acceptable surface water-disposal area is not available. The total system cost depends largely on the borehole cost which, in turn, depends on the depth at which a suitable water reservoir is found.

4.96 Because of the poor prospects of finding exploitable resources elsewhere, any potential applications of this technology in Ethiopia would appear to be confined to the Rift Valley. Although data exist on the depth at which high temperature resources are found, there does not appear to be any information on the depth at which resources in the intermediate temperature range of 100-120°C are likely to be found.[31]

4.97 Assuming, for discussion purposes, the existence of suitable reservoirs at 1000 metres - half the depth at which 200-300°C resources are known to exist in the Langano area - a production well, assuming there are no infrastructural or preliminary exploration costs to be borne, could be drilled for perhaps $1.0 million. The capital cost of a 500 kW plant operating with a 100°C water supply is estimated at $2,000/kW under California conditions[32], perhaps $2,500/kW installed in Ethiopia. On this basis, a 500 kW unit could be set up for around $2.25 million which could well be competitive with diesel on a life-cycle basis - though whether this is actually the case would depend on a detailed analysis of actual costs, load profiles, life cycles and other factors.

4.98 Small low-temperature geothermal is thus, at least in principle, a potential contributor to Ethiopia's future electricity supply. For a viable stand-alone installation, the basic requirements include the existence of a suitable water reservoir at an economically viable depth in an area not served by the ICS but with a substantial electricity demand. Assuming large-scale geothermal development goes ahead, low-temperature geothermal technology could also prove viable as a means of exploiting low temperature resources which are encountered and cannot otherwise be harnessed.

4.99 These possibilities should be borne in mind during future geothermal exploration. The aim should be to establish whether there are resources which are suitable for low temperature small scale applications as well as the more conventional larger and higher-temperature developments presently being considered.

Biogas

4.100 Ethiopia has around 27 million cattle. The amount of dung produced is, in principle, sufficient to provide feedstock for over two million family-size biogas digesters. But technical, institutional, and cost constraints mean that, at best, only a very small proportion of this potential can practicably be realised in the near to medium term future.

4.101 Among the requirements for sustainable biogas digester operation are an adequate year-round supply of water, a system of stall-feeding or corralling cattle which enables dung to be easily collected, a suitable temperature regime[33], and, above all, families who feel the availability of biogas for cooking or lighting is worth the substantial efforts required for feeding,

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31 A suitable temperature is not the only requirement; a reservoir which provides a sustainable water flow is equally essential.

32 "Small geothermal electric systems for remote powering." Entingh et al. Paper at US Dept of Energy Conference "Geothermal Program Review XII" San Francisco, 1994.

33 Biogas production can fall substantially, or fail completely, if the temperature in the digester drops below about 20¥C.

cleaning and general management of the digester, and are willing to make the cash investment required.[34]

4.102 The earliest biogas digesters in Ethiopia were installed in the early 1970s but soon fell into disuse. Beginning in 1979, a series of digesters were installed for research and demonstration purposes by the Ethiopian Energy Authority (EEA). A number of other government and private organisations have also installed digesters since that time. It is estimated that the total number installed is about 200.

4.103 The Indian model, which uses a floating steel dome, accounts for about 80% of those installed, about 15% are of the Chinese fixed dome type and the remainder are of various types. A survey carried out by the EEA found that 55% of the digesters were out of action. Among the reasons were technical problems, lack of proper management, unavailability of dung and lack of interest among users. The Indian models are particularly liable to rusting of the dome while the Chinese models are susceptible to cracking and leaks.

4.104 The performance of community digesters, as well as those at schools and such institutions, was particularly bad. The problems of feedstock supply, general operation and maintenance, and equitable sharing of benefits appeared to be virtually insoluble and almost all these digesters failed. It is generally agreed that any near-term biogas deployment will have to be based on family digesters providing fuel for cooking and lighting, with sludge being used as fertiliser.

4.105 At the MOA's request, $4.0 million for the construction of biogas digestors has been included in the recent IDA-financed National Fertilizer Sector Project. A satisfactory action programme will have to be prepared before the biogas component is implemented. The mission recommends that any such programme be approached with great caution. The lack of detailed and properly documented data on why over half the previously installed digesters have failed means that, at a purely technical level, the information required for site selection, digester design and management routines is still lacking. Equally importantly, there are no properly recorded data on the designs, local conditions, performance levels and management routines where digesters have worked satisfactorily. In short, there does not appear to be any basis for the preparation of locally relevant manuals and training materials required to support an implementation programme.

4.106 The mission recommends that a selection of 20-30 of the existing properly functioning digesters should be made with a view to assessing their yield and general performance on a year-round basis, establishing the optimum management routines and identifying common problems and their solutions. If this review indicates that biogas is economically, technically and socially feasible, a limited program for the construction of, perhaps, 20 prototype digesters in typical target rural households should be considered.

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34 Investing in a biogas digester may not be a particularly attractive option to families with access to non-commercial wood supplies for their cooking needs.

4.107 The technical performance of these digesters as well as the user reactions, perception of benefits and willingness to pay for them should then be carefully monitored over at least one full year's operation. This will provide the data, which are presently lacking, for an assessment of the type and scale of biogas programme which might be feasible and appropriate for the country.

Summary Of Mission Recommendations On Renewable Energy Sources

4.108 Detailed suggestions and recommendations have been provided under the individual renewable energy source headings above. These are summarised below:

- The EESRC should assemble the available data on the performance of the renewable energy technologies which have already been installed in Ethiopia and assess the reasons for successes and failures;
- Data on the costs of the various renewable energy technologies should be assembled using experience in Ethiopia and quotations from potential suppliers. This information should be used to compare the various technologies with competing energy options and identify which renewable technologies provide the least cost solutions in which applications in Ethiopia;
- Market studies of the potential niches for the different technologies should be carried out in collaboration with potential private sector suppliers and recommendations should be made on how the development of such markets could be encouraged by the GOE;
- The results of all these investigations should be used as a basis for a revised overview of new and renewable energy sources in Ethiopia, the drawing up of a promotion programme and the preparation of relevant project proposals for consideration by the donor community and the private sector.

V. HOUSEHOLD ENERGY AND DEMAND MANAGEMENT

Introduction

5.1 The first Energy Assessment, fielded in 1983, estimated that over 90% of final energy consumed in Ethiopia was in the form of biomass fuels used in households. Though this was not unlike the patterns in neighboring countries, what was different about Ethiopia at the time was that certain areas of the country, especially the north and central, appeared to be in a severe woodfuel crisis. Existing fuel use and grazing practices were depleting the woody biomass resource base and degrading land productivity so severely in certain regions that the abilities of local populations to maintain a subsistence existence were put at risk. The mission's energy recommendations were driven by this finding. Short term measures were recommended to reduce demand for woodfuels in urban areas and make previously unutilized biomass fuels available. For the longer term, an ambitious program to establish and expand tree plantations was recommended to put the country back on the path toward a sustainable renewable resource base.

5.2 Though no comprehensive data exists on recent household fuel consumption in rural and urban areas, it is clear that woody biomass fuels consumed in rural households continue to dominate Ethiopia's energy balance. Nearly 90% of Ethiopia's population live in rural areas. Rural dwellers collect and consume the vast majority of the biomass fuels used nationwide (dung, crop residues, and woody biomass - wood and branches, leaves, and twigs) as they have little access to or disposable income for conventional fuels. With population growth, demand for biomass fuels can be expected to increase, thus worsening biofuels scarcities in the absence of effective initiatives to manage the woody biomass resource base. Much needs to be done to protect and replenish Ethiopia's forests and a comprehensive Forestry Action Plan that focuses, inter alia, on the fuelwood problem has been prepared and is now being implemented.[35] For this reason, and because the pressure on traditional energy supplies can only be alleviated in the near/medium term by measures to increase the efficiency with which they are used and to replace them with modern fuels, Ethiopia's experience in these areas, and how to build on it, is the focus of this chapter.

5.3 Briefly, rapid penetration of electric injera mtads and kerosene stoves along with a liberalized policy on kerosene imports have reduced woody biomass consumption in Addis Ababa considerably, but have not substantially altered the consumption of woody biomass and charcoal in other urban areas. Improved charcoal stoves disseminated by the private sector have achieved impressive market shares in Addis Ababa. Conversely, efforts to improve the efficiency of charcoal conversion and to make new biomass fuels available did not yield positive results.

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[35] The *Ethiopia Forestry Action Program* has been prepared by the TGE with the assitance of the World Bank. The report was completed in December 1994. The second phase of the program is underway, and is designed to provide support for the development of regional and local forestry action plans. The EFAP contributes to the National Environmental Action Plan.

5.4 Substitution of conventional fuels has made a major difference in the household energy economy of Addis Ababa since the mid 1980s. Since 1990, efforts in Addis Ababa to improve the efficiency of charcoal use in households has made major progress. Efforts to improve the efficiency of woodfuels use in urban households and to substitute conventional fuels will not have much of an impact on the overall biomass supply/demand situation in areas of acute woody biomass shortages. However, they can easily be justified on the grounds that they raise the welfare of urban dwellers by reducing the financial burden of cooking and reduce indoor air pollution. As such, the Lakech charcoal stove dissemination efforts should be extended to other urban areas and initiatives to develop and disseminate an improved biomass mtad and a low cost electric mtad should be continued and expanded.[36]

5.5 The efficiency of charcoal conversion in traditional earthen kilns could be improved substantially in Ethiopia. Previous efforts were aimed at improving kiln technology, but a reoriented effort to train charcoalers in better management practices for traditional kilns stands a much better chance of succeeding in the Ethiopian context.

5.6 Finally, the role of the private sector in supplying urban household fuel needs should recognized and included in policy reform. The charcoal and woodfuel trade should be legalized. The experience of individual entrepreneurs in briquetting operations has been far more encouraging than efforts sponsored by the State. As such, the private sector should play a lead role in moving forward with the stalled agricultural residues briquetting project.

Interfuel Substitution in the Household Sector

5.7 In 1980, kerosene was essentially not a cooking fuel in Ethiopia, but electricity was used by as many as 10% of households in Addis Ababa to prepare injera on electric mtads. In 1983, the first World Bank Energy Assessment mission identified severe degradation of the woody biomass resource base in several regions. The mission recommended that government adopt policies to encourage the substitution of conventional fuels for woodfuels in urban areas as one element of a short-term bridging strategy designed to buy time for peri-urban and other plantations to be established. In response to this recommendation, government began aggressively importing kerosene stoves. Over 600,000 stoves were imported between 1983 and 1987. In addition, EELPA stepped up its production of electric injera mtads.

5.8 The use of kerosene and electricity for cooking in Addis Ababa grew dramatically in response to these policies. As of September 1994, fully 91% of households in Addis Ababa owned a kerosene stove (Table 1), thereby completing the transition from no use of kerosene as a household cooking fuel in 1980 to complete penetration of the Addis Ababa residential market in 1994. The share of households cooking with LPG remained relatively constant at 17%. Moreover, electricity had become as important as biomass fuels for preparing injera as 62% of homes owned an electric mtad (Table 1).

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[36] The mtad is a special stove used to prepare injera, the round, flat bread that is a staple of the Ethiopian diet.

Table 5.1: Stove Ownership in Addis Ababa, 1985 and 1994

Share of households owning each device	1985	1994
open fireplace	92%	86%
charcoal stove	93%	91%
Lakech charcoal stove	0%	22%
Lakech as % of all charcoal stoves in households	0%	18%
kerosene stove	38%	91%
LPG stove	15%	17%
electric stove/hot plate	3%	3%
electric mtad	23%	62%
regularly cook injera on an open fireplace	76%	45%

Sources: CEPPE 1986 and Fuel & Stove Survey conducted by CEINFM enumerators for the main Energy Assessment mission, September, 1994.

5.9 Using estimates of specific fuel consumption in electric and biomass mtads from tests conducted by the Cooking Efficiency Improvement and New Fuels Marketing Project (CEINFMP) team, these trends in stove ownership can be cautiously interpreted to yield indicative estimates of actual fuel use in households of Addis Ababa since 1980.[37] Figure 1 displays resulting historic and projected estimates of fuel use in Addis Ababa for preparing injera.[38] In 1994, 160,000 MWh of electricity used in electric injera mtads displaced over 175,000 tons of dung, crop residues, and woody biomass, thereby cutting biomass fuels consumption for preparing injera in half. Injera mtads added roughly 35 MW to the morning system peak in Addis Ababa in 1994 and this peak load is forecast to rise to 80 MW in the year 2005.[39] Currently, the cost of electric mtads is beyond the reach of the poorest households. Moreover, a weak distribution system in Addis Ababa results in a substantial share of households that do own an electric mtad having to occasionally use biomass instead. The projections in Figure 1 assume no intervention to reduce the cost of electric mtads or to strengthen the distribution system. As such, the use of electric injera mtads will not completely displace the use of biomass fuels for preparing injera in Addis Ababa.

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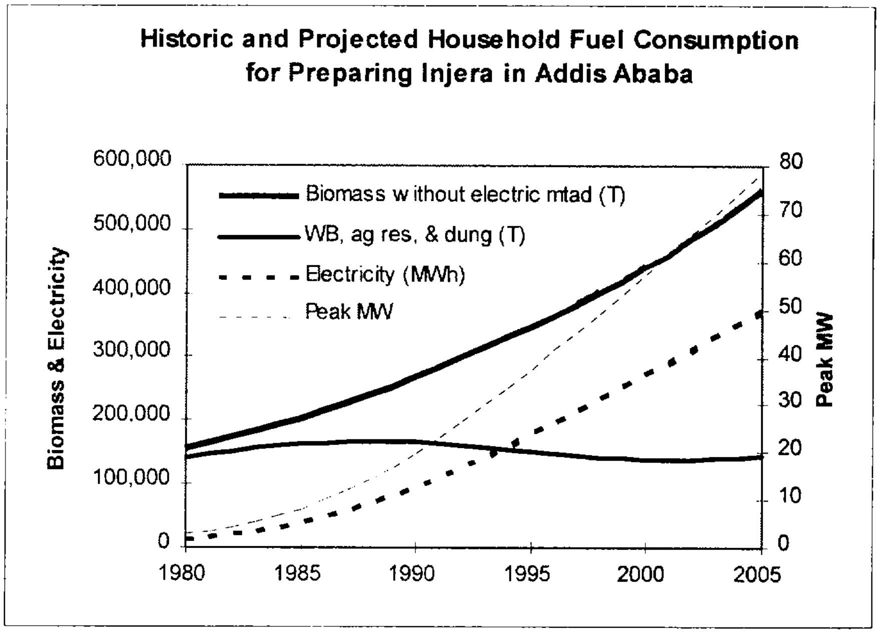
[37] Relevant details from past household sector studies and surveys that are used to infer actual substitution are presented in Annex 12.

[38] Quantities of biomass fuels and electricity used by households for preparing injera with each fuel are from CEINFMP 1994a, 1993a, and 1991a. Since a substantial share of households that own electric mtads also occasionally prepare injera on a ceramic mtad over an open fire, the share of households that use electricity exclusively for preparing injera is less than the overall penetration of electric mtads. Estimates of total electricity and biomass fuels use for preparing injera are derived from population estimates, specific fuel consumption estimates in each type of mtad, and the estimated share of injera prepared on electric mtads (lower than the overall penetration rate). Projections are based on the assumption that the share of injera cooked with electricity in Addis Ababa will rise from 48% in 1994 to 67% in 2005 following a logistic diffusion curve. Detailed assumptions for historic estimates and projections are presented in Annex 12.

[39] Assumes 2.5 kW/mtad and a 6% system peak coincidence factor.

Figure 1



5.10 For non-injera cooking, official figures of kerosene and LPG distribution in Addis Ababa were combined with efficiencies of cooking with kerosene, LPG, charcoal, and woody biomass from tests conducted by the CEINFM Project team to yield estimates of cooking services provided by each fuel.[40] Figure 2 displays resulting historic and projected estimates of non-injera cooking fuel use in Addis Ababa. Under the assumption that modern fuels displace wood and charcoal in shares equal to their use, 53,000 tons of kerosene and 3,800 tons of LPG displaced over 48,000 tons of charcoal and 195,000 tons of woody biomass in Addis Ababa in 1994, thereby reducing use of biomass fuels for cooking by roughly 50%. As kerosene is clearly a low cost cooking fuel in Addis Ababa (see Table 2 below) and nearly every household has a kerosene stove (Table 1), continued displacement of wood and charcoal is contingent on kerosene availability in the future. Between 1995 and 2005, kerosene and LPG consumption in Addis Ababa have been projected to grow at 10% and 19% annually.[41] Under these assumptions, the substitution trend that emerged in the 1980s will continue and kerosene and LPG will displace more than 85% of the charcoal and woody biomass that would have been consumed in Addis Ababa by 2005.

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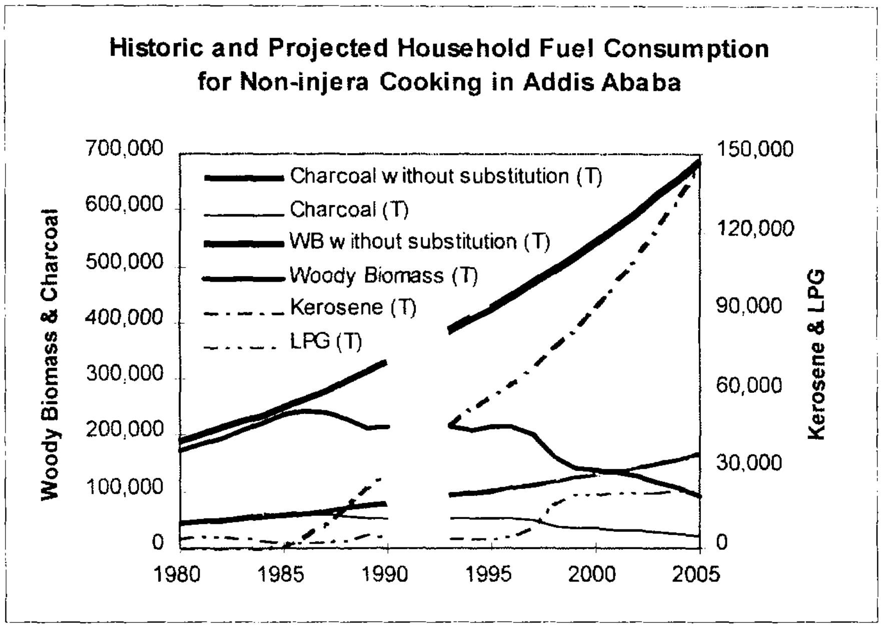
[40] Non-injera cooking energy services (939 utilized MJ/capita/year) met by all fuels is assumed to remain constant throughout the historic and projection periods and to be the same as that determined by analysis of CSO 1980 data shown in Annex 4. Residential kerosene consumption is projected at 10% annual growth and LPG consumption is projected at 6% annual growth. In addition, the projections assume that 80% of LPG produced by the Calub Gas Project will be absorbed in the Addis Ababa market. Total estimates of biomass fuels use for non-injera cooking are derived from population estimates, the estimate of cooking energy services from all fuels, and the estimated amount of cooking energy services provided by kerosene and LPG. The amounts of charcoal, woody biomass, crop residues, and dung displaced by kerosene and LPG are assumed to be in proportion to their use in 1984 from CESEN 1986. Detailed assumptions for historic estimates and projections are presented in Annex 4.

[41] LPG consumption in Addia Ababa is presently constrained by supply. Consumption is expected to grow rapidly when the Calub project comes on line, since it will increase supplies by a factor of four. 80% Of the LPG from Calub is assumed to be absorbed in the Addis Ababa market.

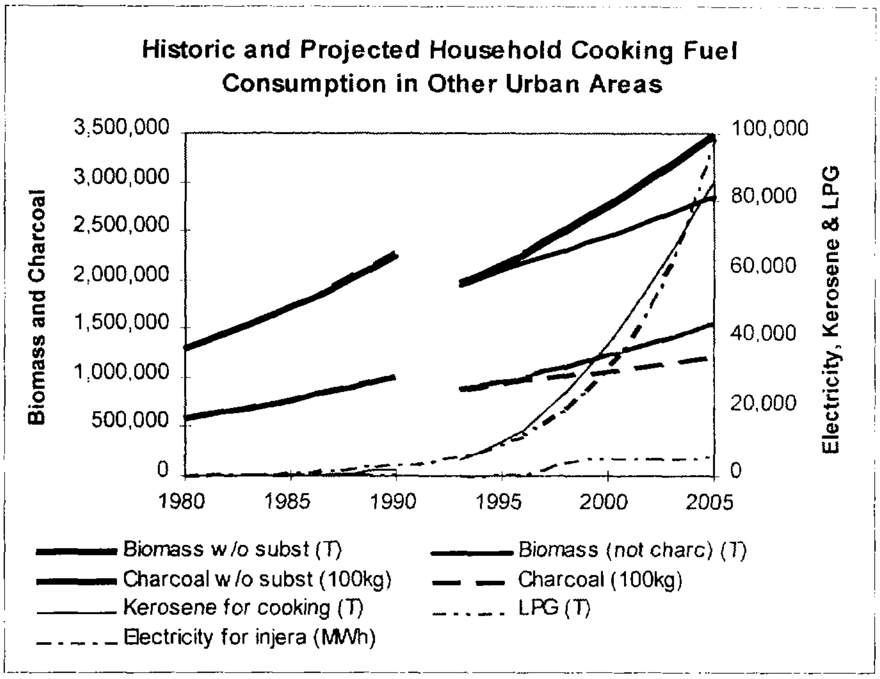
Figure 2



5.11 Household fuel consumption in rural areas and other urban areas have also been inferred using similar assumptions, regional kerosene and LPG distribution, EELPA residential sales, and estimates of biomass fuel consumption from CESEN 1986. Historic and projected cooking fuel use estimates for households in other urban areas are displayed in Figure 3.[42] The effects of substitution by conventional fuels through 1994 are far less noticeable than in Addis Ababa. In 1994, 7,100 tons of kerosene used for cooking and 290 tons of LPG displaced 2,900 tons of charcoal and 43,000 tons of woody biomass in urban areas outside of Addis Ababa in 1994, thereby reducing use of biomass fuels for cooking by roughly 2%. Growth in kerosene, LPG, and electricity is projected to displace roughly 20% of the charcoal and woody biomass that would have been consumed in other urban areas by 2005.

[42] Historic and projected rural fuel use estimates assume no rural electrification and all kerosene consumed in rural households is for lighting. An increasing share of kerosene used in other urban households is assumed to be used for cooking as a result of increasing electrification rates in urban areas outside of Addis Ababa. All residential LPG and electricity sales outside of Addis Ababa are assumed to be to urban households. See Annex 12 for detailed assumptions.

Figure 3



5.12 Little is known of how the fuel use patterns of rural households in Ethiopia's different regions have changed since the CESEN study in 1984. The historic and projected estimates of fuel consumption in rural households, presented in Annex 4, assume that the per capita consumption of fuels in rural households has not changed since 1984 and will remain constant, with little fuel substitution for cooking expected over the projection period. Under these assumptions, rural households consumed 30 million tons wood equivalent (TWE) of woodfuels in 1994, more than 10 times the amount consumed by urban households (charcoal accounted for 1/3 of the TWE of woodfuels consumed in urban areas).[43] Hence, roughly 90% of the biomass energy consumed by households in Ethiopia is consumed by rural dwellers.

5.13 In sum, the interfuel substitution measures adopted by government since 1983 to alleviate some of the pressures on the woody biomass resource base have had substantial impact in Addis Ababa and some impact in other urban areas. However, the available evidence indicates that the overall energy balance of the household sub-sector has not changed much. In 1994, conventional fuels reduced national household consumption of woodfuels by 1.4% (in TWE terms). Unless the resource productivity of areas that were in woodfuel deficit in 1983 has improved markedly, they are probably still in deficit. Moreover, given the evidence from Tigray and other northern towns surveyed in 1992 (CEINFMP 1993b) it appears that the resource base in some woodfuel scarce areas may have deteriorated significantly.

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[43] Assumes a 15% charcoal conversion efficiency on a weight basis, i.e., 6.7 kg of wood yield 1 kg of charcoal.

Comparative Cooking Costs

5.14 Residents of Addis Ababa have switched to kerosene for cooking and electricity for preparing injera partly in response to liberalized policies on imports of kerosene and stoves and increased production of electric mtads by EELPA. But these supply policies would have had little effect if households could not reduce their financial burden and/or increase their welfare by cooking with these fuels. The annual costs of cooking and preparing injera for an average Addis Ababa household in 1994 are presented in Table 5.2. These estimates use the average market price of each fuel in its most commonly purchased quantity and represent the annual cost that would be realized by an average household if it were to meet its entire cooking or injera baking needs with any given fuel.

Table 5.2 Comparative Cooking Costs in Addis Ababa, 1994

Cooking	Heating Value (MJ/unit)	unit	Stove Effic. (%)	Fuel Cost (EBirr) Financial (/unit)	Fuel Cost (EBirr) Economic (/unit)	Stove price (EB)	Life (yrs)	Annual Cooking Cost (EB) a/ Financial r=40%	Annual Cooking Cost (EB) a/ Financial r=12%	Annual Cooking Cost (EB) a/ Economic r=12%
3 stone open fire	16	kg	0.17	0.55	0.65	0	1	930	930	1,099
metal woodstove	16	kg	0.22	0.55	0.65	10	3	723	722	853
metal char stove	30	kg	0.34	1.75	2.42	12	4	794	793	1,093
Lakech stove	30	kg	0.42	1.75	2.42	18	4	646	644	888
kerosene wick	35.3	liter	0.42	1.00	1.97	45	5	326	321	622
LPG	45.2	kg	0.55	2.50	2.92	525	5	647	593	670
electric hot plate	3.6	kWh	0.60	0.17	0.53	35	3	378	375	1,142

Preparing Injera	Fuel per session d/	unit	Fuel Cost (EBirr) Financial (/session)	Fuel Cost (EBirr) Economic (/session)	Mtad price (EB)	Life (yrs)	Annual Cooking Cost (EB) b/ Financial r=40%	Annual Cooking Cost (EB) b/ Financial r=12%	Annual Cooking Cost (EB) b/ Economic r=12%
traditional mtad	9.5	kg	5.23	6.18	6	0.7	552	552	651
Mirte mtad	7.25	kg	3.99	4.71	35	3	430	428	503
standard elec. mtad	7.4	kWh	1.26	3.92	400	8	253	203	480
low cost elec. mtad	7.4	kWh	1.26	3.92	250	8	207	176	453

Notes:

a/ Annual costs based on average annual utilized energy for non-injera cooking of 4,600 MJ/household (CSO 1984).

b/ Injera is commonly prepared twice weekly.

Sources: Annex 10.

Kerosene is clearly the lowest cost cooking fuel for households in Addis Ababa in terms of both market prices and import parity. Even at a 40% financial discount rate, which models tight cash constraints on the average household, kerosene can cut the financial burden of cooking roughly in half relative to charcoal or fuelwood.

5.15 To wealthier households (12% discount rate), LPG is more expensive than kerosene, but marginally cheaper than using charcoal in an improved stove. At its import parity price, LPG is also a much lower cost fuel in economic terms than fuelwood or charcoal.

5.16 Under existing tariffs, electricity is only marginally more expensive than kerosene as a cooking fuel. Given this, it is surprising that only 3% of the households in Addis Ababa own an electric stove or hot plate for cooking (Table 1). If the full costs of future expansion in generation and transmission capacity and strengthening of the Addis Ababa distribution system were included in the residential tariff, electricity would be the most expensive fuel for non-imjera cooking. Consequently, cooking with electricity should not be encouraged in Addis Ababa, nor in other urban areas where woodfuels are cheaper.

5.17 The annual financial costs of preparing injera on an electric mtad are less than half of the costs of using a traditional biomass mtad. The rapid rise of households preparing injera with electric mtads is in no small part due to this. Electricity is also less expensive in economic terms than woodfuels for preparing injera.

5.18 Kerosene for cooking and electricity for baking injera are the lowest cost cooking fuels for consumers in Addis Ababa in economic as well as financial terms. As such, revising tariffs to cover LRMC and pricing kerosene at import parity would probably not result in significant switching back to woodfuels, though it would raise the financial burden to households. In 1980, about 20% of expenditures by the poorest households in Addis Ababa were for fuel and light while the average household spent roughly 12% on fuels (CSO 1984). Though it is not possible to determine how the financial burden on households for fuel expenditures has changed since then, the Central Statistics Authority plans to conduct a thorough urban/rural income and expenditure survey in 1995. When the results of this survey are in, it will be possible to determine whether or not such price revisions would place an undue burden on households in Addis Ababa.

Demand Management: Improved Stoves

5.19 The most successful improved stove dissemination effort to date in Ethiopia is the Cooking Efficiency Improvement and New Fuels Marketing Project (CEINFMP), sponsored by MME, and financed under the World Bank Energy I Project. Managed entirely by dedicated MME staff, this effort is one of the best designed and monitored stove dissemination programs in the developing world.

5.20 The CEINFM Project was initiated in 1989 to implement plans of the Cooking Efficiency Program Planning in Ethiopia (CEPPE) to disseminate improved wood stoves in Addis Ababa. According to surveys conducted by the CEINFMP team, most households preferred an improved stove designed for charcoal rather than a wood stove. With data collected by the Biomass Fuels Supply Systems Marketing Review (BFSMR 1990), also funded under the

World Bank Energy I Project, the team estimated that charcoal was meeting as much as 50% of household non-injera cooking services. In the face of this evidence, the CEINFMP team shifted its focus to improving the efficiency of charcoal use.

5.21 A recent review of the experience of over 50 stove programs around the world[44] indicates that in addition to a rapid payback period, which appears to be necessary for successful dissemination of improved stoves, successful efforts are those that maintain consistent, long term, and high level commitment to stove manufacture and dissemination, pay attention to targeting markets, and design stoves that consumers actually want. The CEINFM Project approach contains all of the elements identified by this review as leading to successful outcomes. CEINFM Project staff have maintained an admirable level of professional integrity and have enjoyed a high degree of autonomy to determine project objectives and methods.

5.22 Current and future CEINFMP efforts are reviewed and evaluated below (details of proposed program evaluations are presented in Annex 11). Recommended efforts for continued financing under the CEINFM Project include: dissemination of the Lakech charcoal stoves in other urban areas; development and dissemination of the Mirte biomass injera mtad in Addis Ababa and other urban areas; and development and dissemination of a low cost electric mtad in Addis Ababa. These programs would cost a total of 7.0 million EBirr (US$ 1.4 million) annually between 1995 and the year 2000 and would likely yield a 35% economic rate of return (see Tables A2.13 and A2.14 in Annex 11). As such, continuation of the CEINFM Project would be a sound investment for the country. As they are in the best position to select markets and devise marketing strategies that have the highest chances of success, the CEINFM Project Team should continue to enjoy wide autonomy in setting their own objectives and in applying their financial and staff resources to activities that are most cost effective in meeting these objectives.

"Lakech" Improved Charcoal Stove

5.23 Working closely with private sector stove makers and potters, the program began disseminating the Lakech charcoal stove (a metal stove with a ceramic liner not unlike the Kenyan Ceramic Jiko) in Addis Ababa in 1991. The project team paid a great deal of attention to private sector producer capabilities, quality control, and consumer preferences. Through controlled cooking tests, the Lakech stove has been proven to reduce charcoal consumption in actual practice by roughly 25% relative to traditional metal charcoal stoves. Nonetheless, as shown in Table 5.2, cooking with charcoal in a Lakech still more expensive than kerosene or LPG to better off households (the target market for the Lakech). When compared to a traditional charcoal stove at existing charcoal prices in Addis Ababa, the additional cost of a Lakech would pay for itself in fuel savings in less than one month if it met all non-injera cooking needs of an average household. In actual practice (most households use multiple fuels and stoves to meet non-injera cooking needs), the average payback period is still under two months. This very rapid payback plus the fact that the stove is attractive and fits well in the traditional coffee ceremony are two reasons behind its rapid dissemination.

[44] Barnes, Douglas, Keith Openshaw, Kirk Smith, and Robert van der Plas, What Makes People Cook with Improved Stoves", FPD Energy Series Working Paper #60, the World Bank, 1993.

5.24 Over 65,000 Lakech stoves have been purchased in Addis Ababa since the first stoves were marketed in late 1991. After 3 years of well designed CEINFMP dissemination efforts, there is currently at least one Lakech in 22% of Addis Ababa households and 18% of all charcoal stoves used in Addis Ababa are of the Lakech variety (Table 1). Moreover, 7% of households surveyed that cook with charcoal but do not own a Lakech say they intend to buy a Lakech as their next charcoal stove. This rapid dissemination which is driven entirely by consumer demand met by private sector producers can be characterized as no less than a stunning success relative to most stove programs that never attain double digit penetration rates even after many years of effort.

5.25 The CEINFMP team initiated Lakech dissemination efforts in 5 other urban centers in the Southern region in 1993. Results from surveys of four Northern town and three Southern towns showed that charcoal prices are generally higher than in Addis Ababa in the north and generally lower in the south, reflecting relative biofuel scarcity in the north (CEINFMP 1993b). As such, urban centers in the north and central regions should be considered high priority for Lakech dissemination efforts.

5.26 Indicative costs and expected effects of Lakech dissemination efforts extended to 10 urban areas are detailed in Annex 11. The extended effort would be implemented by ten field offices. Each field office would be staffed by three full time professionals and two support staff, appropriately equipped, and provided an operating budget to support Lakech promotion and demonstration activities for four years, after which the quality of Lakech stoves on the market would be monitored through Year 10, as appropriate. Program costs for 10 field offices for the first 6 years (5 offices open in the first year and five more open in the third year) average about EBirr 2.7 million (US$ 450,000) per year. This level of continued funding of the Lakech dissemination effort would represent a long-term commitment to stove dissemination, one of the key factors associated with successful stove programs around the world.[45] If CEINFMP field offices are able to achieve market penetration in other urban areas similar (albeit delayed) to that being experienced in Addis Ababa, the proposed extended dissemination effort is expected to result in a healthy 70% economic rate of return (see detailed evaluations in Annex 11).

"Mirte" Improved Biomass Mtad

5.27 The Mirte, an enclosed biomass mtad made from pumice and cinder block, has been under development by the CEINFM Project team since 1991. The stove development team has produced a light stove that can be shipped in pieces, is more hygienic than the traditional mtad used over an open fire, is becoming more reliable with each materials improvement, and addresses the concerns of women in targeted low income urban areas. The Mirte has been shown to reduce biomass fuel consumption in actual practice by roughly 23%. As such, it pays for its higher cost in fuel savings at existing woodfuel prices in Addis Ababa within 2 months.

5.28 Several past efforts that attempted to improve the efficiency of injera preparation and reduce indoor air pollution met with only partial success. The successful dissemination of an

[45] Barnes, et. al., 1993.

enclosed biomass mtad will be very challenging and will require innovative development, communication, and marketing methods. Target markets for the Mirte, middle and lower income urban households that cannot afford an electric mtad, have proven difficult to reach in the past. The experience built up by the CEINFMP team in developing and disseminating the Lakech in direct coordination with stove makers and potters with a continuous focus on satisfying consumer preferences, will be invaluable in moving the Mirte into urban markets.

5.29 Urban areas outside of Addis Ababa in which to concentrate Mirte dissemination efforts should be selected with primary consideration to areas with high existing biomass fuel market prices and/or high implicit prices for collected fuels. Evidence from surveys conducted in 1992 and 1993 (CEINFMP 1993b, 1993c) indicates that fuelwood prices are generally lower in other urban areas than in Addis Ababa, even in areas with severe woody biomass scarcity. This lower economic value of woody biomass has been accounted for in the program evaluations summarized below.

5.30 Indicative costs and expected benefits[46] of a program to develop and disseminate the Mirte mtad in Addis Ababa, other urban areas, and selected rural areas are presented in Annex 11. The program in Addis Ababa would be staffed by 10 professionals and 5 support staff and field offices in ten other urban areas with two full time professionals and one support staff each (phased as in the Lakech effort described above). Program costs for the head office and 10 field offices for the first 6 years average about EBirr 2.9 million (US$ 480,000) per year. If these efforts result in diffusion of the Mirte to 35% and 13% of households preparing injera with biomass in Addis Ababa and other urban areas, respectively, by the year 2005, the proposed Mirte program would yield economic returns of 25% in Addis and 17% in other urban areas (see detailed evaluations in Annex 2). A similar effort for Mirte dissemination in rural areas is also evaluated in Annex 2. A rural effort was found to be only marginally economic (12% IRR), and is therefore not recommended.

Low Cost Electric Mtad

5.31 By late 1994, 62% of all households in Addis Ababa owned an electric mtad. Under existing market prices and tariffs, preparing injera with electricity is much cheaper than using a traditional mtad over an open fire in Addis Ababa (Table 5.1). In economic terms, electricity is also marginally lower in cost than woody biomass for preparing injera in Addis. However, the initial price of an electric injera mtad (400 EBirr) is well out of reach of low income households that continue to use a traditional mtad over an open fire. The CEINFM Project team has developed an electric mtad with a ceramic body that uses no less electricity than a standard electric mtad, but is designed to appeal to poorer households as it costs substantially less to produce (EBirr 250). Since the target market for the low cost electric mtad is the low income urban market, dissemination efforts will face the same challenges as the Mirte program described above. When compared to preparing injera with woody biomass, a low cost electric mtad pays for its entire cost in woody biomass savings in 8 - 9 months, given existing market

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46 Only the economic value of fuel savings are quantified, reductions in indoor air pollution are not included as benefits in the program evaluations.

prices and tariffs in Addis Ababa. In other urban areas, where the market prices of woody biomass are lower than in Addis, the financial payback period increases to 1.5 - 2 years (using EBirr 350/ton for woody biomass vs. EBirr 550/ton in Addis).

5.32 Indicative costs and projected benefits of a program to develop and disseminate a low cost electric injera mtad in Addis Ababa and other urban areas are presented in Annex 11. The proposed program in Addis Ababa would be staffed by 10 professionals and 5 support staff and includes low cost electric mtad development costs. Program costs for the head office for the first 6 years average about EBirr 915,000 (US$150,000) per year. Under reasonable assumptions of additional households that would switch to electricity for preparing injera due to lowered initial costs, the proposed low cost electric mtad development and dissemination program yields an economic return of 20% in Addis Ababa. Under reasonable assumptions about program effectiveness, the proposed program is not economic in other urban areas since the economic value of biomass displaced is lower than the additional economic costs of the mtads and the electricity that they would consume. Dissemination in other urban areas is, therefore, not recommended (see detailed evaluations in Annex 11).

Improved Charcoal Production Methods

5.33 The objective of the Improved Charcoal Production Pilot Project, financed by Energy I, was to demonstrate that charcoal could be produced using advanced kiln designs far more efficiently than with traditional methods. The project was implemented by the forestry department of what was to become the Ministry of Natural Resources Development and Environmental Protection (MoNRDEP). During the life of the project, nearly 60 staff were assigned to it. The project was designed to utilize wood from state plantations (coffee, tea, etc.) and from clearing of state lands for agriculture. Woodfuels from these sources are distributed to consumers in urban centers by the Construction and Fuelwood Production and Marketing Enterprise (CFPME) of MoNRDEP, the only entity in Ethiopia legally allowed to market charcoal and fuelwood from public lands and state enterprises. The project was beset early on with a host of problems due to unworkable institutional arrangements and poor performance by the original consultant. Since MoNRDEP views the CFPME as a profit making enterprise, it argued that CFPME should finance the local contribution to the project out of its earnings. However, CFPME was not committed to the project as it was not the implementing agency. In addition, the original consultant proved unacceptable. Two and one half years passed before another consultant was selected. Shortly thereafter, in May 1990, the government changed and the priority of the project was re-evaluated. After a meeting with Bank officials, it was jointly decided to divert funds earmarked for the project into the Emergency Fund for Rehabilitation and Reconstruction of Infrastructure. The government failed to reallocate its contribution to the project and other multilateral and bilateral donor agencies were approached as possible sources of funds to keep the project afloat. This was unsuccessful and the project team was disbanded.

5.34 Estimates of the Biomass Fuels Supply and Marketing Review, CEINFMP market surveys, and CFPME records all indicate that over 80% of the charcoal produced in Ethiopia is produced informally (and hence, illegally) by thousands of small informal rural producers.

Charcoal production without a permit from CFPME is illegal because the government does not wish to encourage further depletion of the biomass resource base which is seriously degraded in certain regions. The illegality of the bulk of the charcoal trade has led to its transport in small lots on private lorries, other vehicles, and on donkey back. Charcoal is often transported into urban centers at night to avoid official inspection that may result in confiscation or fines. Evidence gathered by the Biomass Fuels Supply and Marketing Review and by the CEINFMP studies of other urban areas indicates that enforcement of the official ban on the informal charcoal trade is rare and limited to certain urban areas. Nonetheless, the fact that much of the trade in charcoal is illegal has restricted the private sector from obtaining economies of scale in charcoal production, transport, and marketing.

5.35 Since methods used by small informal private charcoal producers are very inefficient, there is a large potential to raise the efficiency of charcoal transformation in traditional earthen kilns by improving kiln construction, firing, and tending practices. A serious effort should be made to improve the efficiency of charcoal conversion in Ethiopia. This effort should be aimed at delivering technical assistance to the thousands of small producers who now produce the bulk of the charcoal illegally. A project designed to improve the efficiency of charcoal production in traditional earthen kilns through improved kiln management practices should interest charcoalers as this would serve to increase yields from each charge and effectively raise their incomes.

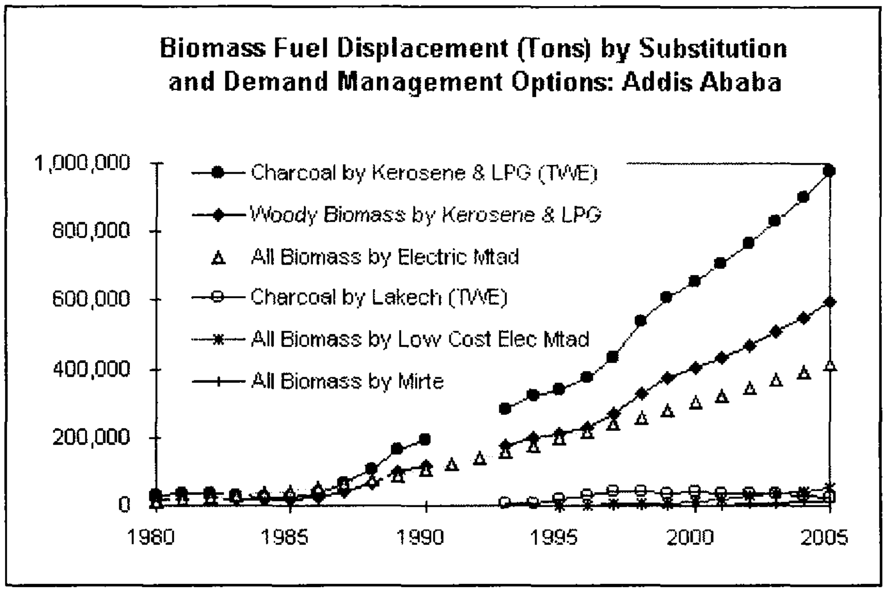
5.36 Such a project would require lifting the ban on charcoaling. Due to the illegal status of the private sector charcoal trade, the relationship between farmers and rural dwellers who produce charcoal and MoNRDEP is not characterized by amity nor trust. The implementing agency should be carefully selected and must be on good terms with farmers.

5.37 Indicative costs and benefits of a national project to assist kiln operators to improve yields through better kiln construction and management are presented in Annex 11. The project would be staffed by 10 professionals and 5 support staff, with assistance from international consultants. Training and demonstration activities should be conducted over a ten year period in association with an existing effective extension service. Without such a long-term and sustained commitment to improving traditional charcoal production practices, it will be difficult to make a significant impact on the methods employed by the thousands of small informal charcoal producers throughout the country. The proposed program costs about EBirr 1.2 million (US$ 200,000) per year over ten years. If initiated in 1995 and sustained for 10 years, the proposed improved charcoal production methods project can be reasonably expected to result in improved methods being used for 25% of all urban charcoal by the year 2005. Given the state of current traditional practice, it can be safely assumed that the adoption of improved kiln construction and management methods can easily decrease the amount of wood feedstock required to yield a given quantity of charcoal by 25%. Under these assumptions, the proposed charcoal production project would yield an economic return of 25%, with the benefits obtained largely by charcoalers (detailed evaluations in Annex 11).

Comparison of Biomass Fuel Displacement by Substitution and Demand Management

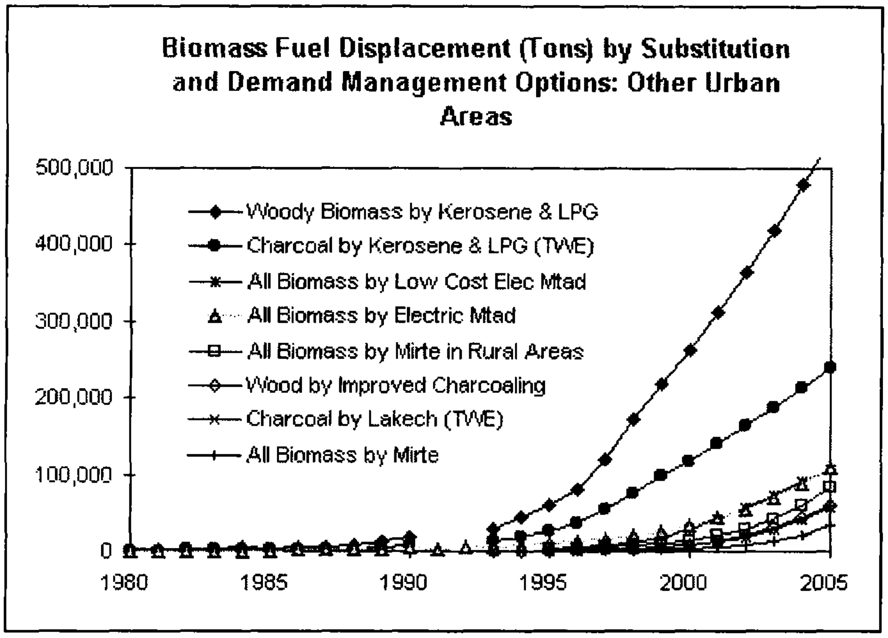
5.38 Projections of biomass fuels displaced by ongoing penetration of kerosene, LPG, and electricity in urban markets are compared to the displacement potential of ongoing and proposed demand management efforts in Figures 4 and 5 below. In Addis Ababa, the wood equivalent of biomass displaced by conventional fuels is at least one order of magnitude above any of the demand management options, including continued penetration of the Lakech charcoal stove. Demand management options in other urban areas fare somewhat better when compared to biomass displacement expected by conventional fuels, but increased usage of kerosene and LPG will be responsible for the lion's share of biomass fuel reductions over the next ten years in urban households outside of Addis.

Figure 4



5.39 The transition to conventional fuels that urban households in Ethiopia are now experiencing is a universal phenomenon, often led by a major urban area and spreading to regional urban centers, that occurs in all economies whether centrally planned or market oriented. In the case of Ethiopia, urban dwellers find conventional fuels cheap, fast, clean, and convenient when compared to traditional fuels. Moreover, kerosene and LPG are lower cost to the economy as a whole than woodfuel (at least in Addis Ababa and some other major urban centers). Since the domestic electricity tariff does not reflect LRMC, a weak distribution system rations demand for heavy electrical appliances that do not perform satisfactorily during voltage fluctuations, but this is an inefficient way to regulate demand for a valuable form of energy. Increased kerosene imports and increased production of electric mtads since the mid 1980s were seen as a bridging strategy to buy time for peri-urban plantations to take root. It must be recognized that urban dwellers will not shift back to woodfuels unless market prices fall substantially or more draconian measures are taken to restrict supplies of conventional fuels. Restrictions on imports of kerosene or LPG would hinder economic growth since they now represent the lowest economic cost fuels for meeting urban domestic cooking needs.

Figure 5



5.40 The demand management options evaluated in Annex 11 and recommended above may not significantly reduce demand for biomass fuels when compared to projected effects of the urban transition to conventional fuels, but each of the recommended programs is economically attractive and would benefit consumers as well as producers of stoves and charcoal by lowering costs or increasing output. In addition to lowering household financial burdens, the Mirte and low cost electric mtads increase welfare by reducing indoor air pollution, similar to conventional fuels.

New Fuels: Agricultural Residues Briquetting

5.41 The Agricultural Residues Briquetting Pilot Project, funded under Energy I, was designed to make new biomass fuels available to households and commercial establishments. Under grant financing, five briquetting plants were essentially given to state enterprises that generate enough wheat, cotton, sugar, and coffee residues for economically and financially viable briquetting operations. The briquetting plant at Dixis (wheat straw) actually produced briquettes for one year in 1991, but could not sell the briquettes at a price that would cover operating costs. As of 1994, the briquettes from this original run have yet to be sold and the briquetting plant has ceased operations. The second plant to be installed at Amibarra (cotton stalks) is expected to produce briquettes in December 1994, but is also expected to encounter similar marketing difficulties. The plant at Shoa (bagasse) has encountered a technical difficulty with drying the bagasse that is still unresolved. The two plants intended for coffee mills at Kaffa and Dilla are still in their containers as the recipient enterprises are no longer interested in installing and operating the plants.

5.42 In contrast to this unhappy experience, Ethiofuels in Addis Ababa and another plant in Nazareth, both entirely private sector operations, have successfully produced and sold agricultural residue briquettes for many years (though not without some difficulties). It appears that the private sector is fully capable of exploiting opportunities for converting agricultural residues into forms of fuel usable in industry, commercial establishments and households. In fact, only the private sector appears to be capable of doing this in Ethiopia.

5.43 The government should reconsider its strategy for promoting the briquetting of agricultural residues. The first step should be to commission an independent, expert review of the technical, economic and financial outlook for briquetting. Secondly, the private sector's interest in owning and/or operating the existing plants should be determined through a request for proposals from all qualified parties, including the current staff of the briquetting pilot project who may be in the best position to identify economically viable and financially profitable alternative applications or operating arrangements for these plants.

Fuelwood and Charcoal Marketing

5.44 As stated above, the Construction and Fuelwood Production and Marketing Enterprise (CFPME) of MoNRDEP is the only entity in Ethiopia legally allowed to market woodfuels from plantations, State lands, and State enterprises. Its mandate is to distribute fuelwood and charcoal to urban centers at well below market prices to provide low cost cooking fuels for urban dwellers. According to CFPME management, the Enterprise can harvest, transport, and market fuelwood and charcoal in urban markets at substantially below market prices and still make a profit without subsidy. Discussions are currently underway to make CFPME an autonomous commercial enterprise that may set its own prices and compete fully in the marketplace. With its fleet of lorries and staff, the Enterprise has considerable economies of scale in harvesting and transporting wood and charcoal. Since it has no comparative advantage in marketing, the Enterprise could become a low cost supplier to urban wholesalers. If allowed to freely set prices, management is confident that the Enterprise can compete and be financially sound. But the ability to freely set prices is in doubt as the autonomous Enterprise would be overseen by a board of directors drawn from all Ministries that have a stake in its operations.

5.45 The private sector is the dominant supplier of biomass fuels to urban markets in Ethiopia. Since its inception, CFPME has commonly supplied less than 20% of woodfuels consumed in urban areas. Urban consumers do not fully benefit from CFPME's continued status as a State Enterprise operating under price regulation. CFPME should be converted into an autonomous commercial enterprise as soon as possible. In concert, CFPME's monopsony status as the only buyer of woodfuels from clearing State lands and plantations should be discontinued. The commercial enterprise should be able to compete for all legitimate sources of woodfuels and all other hauliers should be able to compete with it for concessions and source contracts. If CFPME is indeed a low cost supplier of woodfuels to urban markets, owing to its economies of scale in transport and operations, it will retain its relationship with its current sources and expand its sources of supply and market share, benefiting urban consumers with lower prices. Expanded operations of an efficient transporter/wholesaler may also serve to increase netback prices at the farm gate which would serve to increase incentives to produce and manage woody biomass resources.

Industrial Energy Efficiency

5.46 In 1989, energy audits were completed at 15 of 30 energy intensive industrial enterprises by Merz & Mclellan under the Industrial Energy Efficiency Study financed by Energy I. Each audit identified housekeeping "Target 1" (T1) measures and more substantial "Target 2" (T2) investments that were financially and economically attractive in breweries, textile mills, an iron and steel foundry, a tannery, a pulp and paper mill, and sugar, tobacco, and edible oils plants. A follow-up review of T1 recommendations conducted by the Bureau of Energy Utilization and Conservation Studies (BEUCS) in 1993 shows a wide variation in actual implementation. Many cost effective measures have not been implemented due to poor plant management and lack of financing. As a result, only 1/3 of the potential savings were realized (BEUCS 1993). The annual value of total savings of all T1 measures are estimated at over 1.5 million EBirr (1 million EB economic) for a one time cost of 1.4 million EBirr (1.3 million EB economic). Given this potential, the Industrial Energy Efficiency Study should be revisited, audits be performed on the remaining 15 plants if warranted, and financing be arranged for recommended measures and for training interested plant mangers in energy management.

Recommendations

5.47 Addis Ababa is well underway in the household energy transition to conventional fuels. Kerosene, LPG, and electricity have made major inroads into the household energy economy since the mid-1980s and by 1994 displaced roughly one half of the woody biomass fuels that would have been consumed in households in the absence of conventional fuels. As of 1994, these fuels represent lowest economic cost cooking fuels in Addis Ababa. This transition is projected to continue over the next ten years resulting in reductions in total quantities of both woody biomass and charcoal consumed in Addis Ababa households. This transition is just getting underway in other urban areas. Kerosene and LPG are expected to displace substantial amounts of biomass fuels over the next ten years. Nonetheless, with population growth, the bulk of Ethiopia's annual energy demand is consumed in the form of biomass in rural stoves where few conventional alternatives are available or viable. As such, proper attention must be paid to the complex and interdisciplinary problems posed by various competing land uses if Ethiopia is to move closer to sustainable biomass resource management.

5.48 Funding for the CEINFM Project should be replenished at an average annual cost of EBirr 7.0 million (US$1.2 million) between 1995 and the year 2000. This would include Birr 2.9 million for Lakech dissemination in other urban areas; Birr 3.1 million for Mirte mtad development and dissemination in Addis Ababa and other urban areas; and Birr 1.0 million for development and dissemination of a low cost electric mtad in Addis Ababa (see Tables A2.13 and A2.14 in Annex 11). Project staff should continue to have a high degree of autonomy to determine project objectives and methods for monitoring the quality of Lakech stoves and disseminating the Mirte biomass and low cost electric mtads.

5.49 A sustained program to train small producers of charcoal in improved construction and management practices for earthen kilns should be undertaken. Such a program would require lifting the ban on informal charcoaling and should be implemented by an extension service on good terms with farmers and rural dwellers. Indicative program costs have been estimated to be about EBirr 1.2 million (US$ 200,000) per year over a ten year period.

5.50 Government should invite the private sector to submit proposals for purchasing, operating, or otherwise contracting for the five briquetting plants now in various stages of installation throughout Ethiopia. Working through entrepreneurs in the private sector, the sunk costs in these plants can be optimally allocated to the highest value productive activities. Government should offer technical assistance for interested entrepreneurs by assessing the potential for making a profit from briquetting at certain facilities and then assisting the private sector to secure financing from local sources, the donor community, and multi-lateral lending agencies.

5.51 The Construction and Fuelwood Production and Marketing Enterprise should be commercialized as soon as possible. CFPME's monopsony status as the only buyer of woody biomass from government land clearing operations and plantations should be removed and it should bid for wood and charcoal concessions along with private sector competitors. Through direct competition with private sector hauliers and dealers, CFPME's economies of scale will fully benefit consumers and the economy as a whole.

5.52 Industrial audits have been completed on priority plants. Some plant managers have expressed interest in pursuing costly recommendations, but financing is not readily available. Audited plants should be re-visited and cost effective measures that are of interest to plant management should be supported.

VI. INSTITUTIONAL ISSUES

6.1 From the foregoing discussion it is clear that the energy sector faces severe challenges in almost every area: as regards petroleum, to reduce import, refining and distribution costs by freeing up the market; with respect to rural and renewable energy, to expand access to electricity through both conventional and non-conventional means; and, in the household energy area, to extend efforts to increase efficiency in the use of biomass fuels and encourage fuel substitution. However, it is power that poses the greatest challenges owing to the need to simultaneously and quickly improve operations, restore financial health and undertake an investment program of unprecedented magnitude. As already noted, these challenges cannot be met on a business-as-usual basis. Rather, they call, inter alia, for basic institutional changes that will provide incentives for improved performance, establish accountability, increase domestic resource mobilization, and make it possible to draw on the technical and financial resources of the private sector.

6.2 As discussed below, these changes can best be accomplished by:

- Changing the MME's relationship to EELPA from one of command and control to one of arm's length regulation,
- Commercializing or corporatizing EELPA so as to enable it to function as an autonomous public utility, and
- Opening the way for private participation in the sector as a provider of technical and management services and as owner/operator of capital facilities.

6.3 What needs to be done in each of these areas, the major issues involved and the principal options for action are explored below. However, these are matters that should be examined much more fully than is possible in the context of this assessment. It is therefore recommended that a comprehensive study be made of the legal, organizational and policy changes necessary to establish an institutional framework consistent with the above objectives.

New Role for the MME

6.4 The MME has recently undergone an extensive reorganization (see organization chart), in line with the responsibilities and authority indicated in the governmental organization proclamation issued by the TGE (41/1993). The broad duties of the MME enumerated in the proclamation include:

- Formulate policy
- Collect and maintain data
- Regulate exploration & development of mineral resources by state-owned enterprises or private companies

- Study energy demand and promote expansion of the country's electricity supply
- Cooperate with appropriate agencies or companies to ensure the availability of oil, gas and refined products
- Issue licenses and regulate the exploration, development and production of energy.
- Supervise the generation of electricity from small scale sources.
- Establish energy training activities and centers.

6.5 The MME is, thus, responsible for an appropriate mix of policy, regulatory and support functions. In practice, however, the Ministry's role in electric power is quite different. Vis-‡-vis EELPA it actually plays the multiple roles of owner's representative, regulator and chief executive officer. These roles frequently conflict. Because EELPA functions, de facto, as an operating arm of the MME, the Ministry as regulator is in the unenviable and impracticable position of trying to regulate itself. The result is something of the worst of both worlds in which the MME lacks the "distance" from EELPA necessary for it to function effectively as a regulator while EELPA lacks the autonomy it needs to function efficiently as a utility.

6.6 A clear separation of the MME's role as regulator from EELPA's role as operator would benefit both institutions. It would not only put the Ministry in a position to effectively regulate the power sector, but also enable it to devote a greater share of its attention and resources to its primary policy-making responsibilities, and to its related planning and research functions.

Regulation

6.7 The MME's principal objectives in regulating power should be to ensure that:

- the supply of electricity is adequate to meet the needs of a growing economy,
- electricity is generated, transmitted and distributed as efficiently as possible,
- high levels of reliability are maintained,
- access to electricity is expanded to the extent economically feasible,
- revenue is sufficient to cover economic cost, and
- entry to the sector is open to all who can contribute to the achievement of the above objectives.

6.8 Developing a regulatory framework consistent with these objectives should be the principal focus of the newly created Energy Operations Departments (EOD).

6.9 Regulating Operations. Operations can be regulated by influencing either the conduct or the performance of the operating enterprises. Conduct regulation relies on direct control of enterprise behavior through, e.g., the detailed vetting of operating budgets and investment plans; performance regulation aims to secure desired outcomes by setting targets and providing incentives. Conduct regulation has been the approach traditionally employed in most developing countries where, as in Ethiopia, power operations have been reserved to the public sector. It has rarely been successful because it blurs the distinction between regulation and management, deprives enterprise managers of real responsibility and opens the door to political interference.

6.10 For these reasons, developing countries have been turning to performance regulation. The twin keys to successful performance regulation are the establishment of credible targets and the maintenance of accountability for the achievement of these targets. To be credible, the targets must be set in terms of performance indicators that are objective and measurable and, like all good targets, must reflect a judicious balance between what is desirable and what is achievable in a given time frame. Targets should be selected and framed to cover the areas of performance most in need of improvement; they may include some or all of the following:

Supply:	kWh generated; peak demand met
Efficiency:	fuel consumption; reduction of line losses; staff per kWh sold
Reliability:	reduction in number/duration of outages; voltage maintenance
Access:	number of new connections
Investment:	physical implementation of projects; adherence to project budgets
Finances:	rate of return; self-financing of investment; reduction of receivables

6.11 Performance regulation is most likely to be effective where targets are established by mutual agreement between the regulator and the operating enterprise; where the enterprise is given both the resources and the incentives to meet the agreed targets; and where there is a suitable mechanism for ensuring accountability. These requirements can be met through the use of performance contracts (see box). Such contracts may be negotiated annually and contain not only performance targets but explicit reciprocal obligations on the part of the regulator (government) to, for example, allow tariff increases, provide budgetary support and/or obtain foreign loans if the enterprise performs as agreed. Because the targets are mutually agreed, they are both more likely to be realistic and more likely to reflect a real commitment on the part of the enterprise than targets handed down unilaterally by the regulator. And because they contain verifiable, numerical targets performance contracts provide a means of ensuring that enterprise managers know exactly what they will be held accountable for and how it will be measured.

Examples of Performance Contracts

France
The first *contract-plan* was signed with Electricité de France (EdF) in 1970 and is considered the contract plan model. It reduced government control by allowing greater regulation by market forces. This was in response to EdF's entering the competitive industrial-heating market, adopting a profit-center approach and decentralizing financial management. After 1987, EdF expanded its scope for competition by exporting its surplus capacity to other European utilities. Its contract plan therefore focused more on increasing efficiency and reducing costs. Five-year contract plans regulate the company by comparing actual performance against key objectives such as productivity targets, rate commitments, sales and investment strategies, self financing and debt strategies, wage and salary scales. Objectives are set by each departments corporate plan, and efficiency is encouraged by comparing performance of similar units. Rates are based on the marginal cost of system development. Price increases are limited to a ceiling negotiated with the General Directorate of Consumption and Competition and are determined by the inflation rate minus a percentage for productivity gain.

India
In India performance contract - or memoranda of understanding - are used at both national and state level to give incentives for improved performance by generation and transmission & distribution utilities. For India's National Thermal Power Corporation, the performance contract specifies such desiderata as generation efficiency, forced outage reductions, plant construction schedules. The incentive is increased funding and access to improved generation technology. In the case of the State Electricity Boards, performance contracts set out conditions for customer service, distribution loss targets and reductions in load shedding in exchange for increased funding from the central government (and the World Bank). Participation by each SEB is voluntary.

Morocco
Since 1987 a new form of regulation has been introduced for the national power utility Office National de l'Electricitè (ONE) which signs a 3-year renewable *contract-programme* with the government. The contract owes much to the 1984-88 contract plan of EdF and ONE's objectives and government obligations are portrayed in general terms. In the first 3-year contract, ONE undertook to satisfy its supply obligations at least cost within specified financial and economic parameters, and the Government undertook, *inter alia,* to raise tariffs to permit a minimum level of self-financing (30% after 1990), to grant greater financial autonomy and to contribute to the financing of ONE investment. The physical and financial performance indicators included level of productivity of personnel, level of productivity of equipment, number of workers per installed kW in production, profit level of the grid, consumption of inputs, average level of value-added, rate or return of fixed assets, ratio of financial equilibrium, debt/equity ratio, debt service ratio, ratio of self-financing to investments, level of investment financing by external loans.

6.12 Tariff Regulation. As discussed in Chapter II, tariffs presently do not fully reflect economic costs or generate sufficient financial resources, and are not reviewed and adjusted in any systematic way. These deficiencies can only be corrected through the establishment of a mechanism that will ensure that tariffs are (i) regularly reviewed and (ii) adjusted in accordance with sound economic and financial criteria.

6.13 Ideally, tariffs should:

- provide power producers with correct signals about the true economic costs of supply, thus encouraging them to make least cost operating and investment choices,

- guide consumers to use electricity only to the extent economically justifiable, thus encouraging conservation,
- generate the internal resources necessary to maintain the sector's financial health and contribute to meeting its investment needs, and
- be affordable by all classes of consumers, including the poor to whom electricity is being supplied more on social than on economic grounds.

6.14 In practice, tariff regulators seek to approach these ideals by using adjustment criteria that focus either on financial results or on the cost of service. The more traditional approach is to adjust tariffs on the basis of such familiar financial criteria as rate of return on assets or contribution to investment. This has the advantages of using well known and usually readily available financial data for tariff calculation, and of linking tariffs directly to desired financial outcomes. Its principal disadvantage is that the effect can often be to grant power producers tariff increases on a "cost-plus" basis, giving them no incentive to improve efficiency and reduce financial costs to economically justifiable levels.

6.15 The other, more recent, approach is to link tariffs directly to the economic cost of supply, using marginal cost or avoided cost models. The avoided cost model, for example, establishes the cost of energy and capacity at different times of day and in different seasons (important for a hydro-dominated system, such as Ethiopia's). To provide incentives for maintaining operating costs at efficiency levels, energy charges for hydro plants are adjusted with reference to O&M costs at the most efficient plants in the system while, for thermal plants, adjustment is made on the basis of cost indices determined by the most efficient fossil-fueled units. To promote least cost development, capacity charges are adjusted to reflect changes in the cost of generating and other equipment required for system expansion using the best technology. The principal advantage of this approach is that it provides the correct economic signals to producers and consumers and strong incentives for cost containment. The principal disadvantage is that the cost calculations can be difficult to make, and difficult to understand.

6.16 The choice of criteria for tariff adjustment may be less important than the establishment of a process for their application that is as transparent and as automatic as possible. To begin with, the criteria should be carefully defined, fully disclosed and clearly explained to the general public as well as to the effected entities. Secondly, a regular process for tariff review and adjustment, on at least an annual basis, should be established. Fixed periods of time should be specified for the various stages in the process including the preparation and submission by EELPA of tariff increase proposals justified in terms of the established criteria; review of the proposals by the regulatory authority; public comment and/or public hearings; and announcement of the regulator's findings. Allowance will presumably also have to be made for political level review in the MME before tariffs are actually adjusted. However, it is hoped that adjusting tariffs regularly according to accepted technical criteria, and thus avoiding the need for very large increments occasioned by years of delay, will take much of the political sting out of tariff adjustment and help take the process out of politics insofar as possible.

Policy, Planning and Research

6.17 As already indicated, by divorcing itself from power sector operations, the MME should be able not only to develop an effective regulatory function but also to strengthen its performance in its primary policy-making role. The recent reorganization has put in place an appropriate support structure for policy making in the form of the Planning and Programming (PPD) and Energy Studies and Research (ESRC) departments.

6.18 The PPD is responsible for seeing to it that MME policy is reflected in the programs and annual budgets of the sector operating agencies. It reviews and revises the agencies' budgets, compiles and coordinates these budgets for submission to the Ministry of Planning, and monitors budgetary implementation, including the execution of investment projects. The PPD intends to bolster its monitoring role by undertaking technical and on-site supervision of agency activities.

6.19 The PPD's programming and budgeting responsibilities give it a key role in short term planning. As the volume of investment grows, it may also expect to play an expanded role in identifying and implementing long term priorities. The PPD should focus its efforts on improving its effectiveness in carrying out these responsibilities. On the other hand, the PPD's proposed technical and on site monitoring activities may be unnecessary and distracting. Such activities will overlap with the responsibilities of enterprise management and will consume substantial PPD resources. In addition, with a shift toward performance regulation, there will be measurable performance indicators that can be used in the place of detailed technical monitoring and regulation.

6.20 The ESRC will take over the functions of the current Ethiopian Energy Authority (EEA) with regard to statistics, research and renewable energy. It will be responsible for the maintenance, gathering and dissemination of energy statistics, a task in which it need to work closely with the line and regulatory departments and enterprises to gather and analyze information on power generation, oil refining and imports, pricing levels, household energy use, imports of energy products and the like[47]. ESRC is also the logical locus of modeling and database activities aimed at providing the government with information on trends in energy demand and supply in various sectors of the economy. In addition, the department should have the capability to perform surveys of various consumer groups - household, commercial, industrial - in both urban and rural areas. These responsibilities should also make ESRC the MME's principal resource for the analytical and impact studies required to support long term sector planning.

6.21 As regards renewable energy, while carrying on EEA's research and ongoing project management activities, ESRC should begin to focus its efforts on identifying markets and catalyzing private sector efforts to commercialize renewable products.

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[47] The ESRC staff could also provide some analytical and modeling support to the EOD for electricity tariff setting and avoided cost calculations.

EELPA: A More Autonomous and Stronger Enterprise

6.22 Some of the power sector problems described in Chapter II -- low reliability of service, high line losses, inadequate resources for expansion, excessive uncollected bills- - can be traced to EELPA's present organizational status which deprives management of real control over and responsibility for vital operational and organizational decisions. Conflicting objectives and interference from the political sphere have undermined EELPA's ability to earn its way, influenced investment decisions, imposed low salaries, induced overstaffing and, at the same time, weakened the accountability of management. If EELPA is to operate efficiently and be an asset to rather than a burden on the economy, its organizational status and institutional culture will have to be changed. EELPA will need to be commercialized or corporatized in order to transform it from a government department providing a service to a commercially oriented utility producing and selling a product. And for this to happen, EELPA will have to be granted a high degree of managerial and financial autonomy.

Autonomy

6.23 Managerial Autonomy. True autonomy for EELPA is essential to ensure that management is able to make investment and operating decisions on efficiency grounds. In particular, EELPA must be free to adopt the most efficient operating procedures and management practices; hire and fire staff and set remuneration in the best interests of the institution; contract out for services wherever this is most economic; make investment decisions strictly in accordance with least cost principles; and cooperate with the private sector by entering into joint ventures or other suitable arrangements. Autonomy of this sort would give management the flexibility necessary to achieve the enterprises' performance goals in the most cost-efficient manner, something for which management would be held accountable in the manner discussed above.

6.24 Commercialization along these lines can probably best be achieved in the Ethiopian context by converting EELPA from a public "authority" to a public "enterprise". This is what was recently done with EPC and would be consistent with the government's overall policy of commercializing state owned economic undertakings as set out in its Proclamation on Public Enterprises (25/1992), which sets forth the terms of establishment, operation, and governance of such enterprises. The goal of the proclamation is to further the autonomy and efficiency of such public enterprises and to enable them to operate independently of the government and to become self-supporting.

6.25 The shift to enterprise status would mean that EELPA would be governed by an independent board of directors that, unlike its present board, would be open to non-governmental members. The independent directors could be representatives of industry, commerce and other consumer groups and/or knowledgeable individuals serving in their own right. Their presence on the board would both enhance EELPA's autonomy and help to endow the board with the standing and the resources necessary for the effective governance of the enterprise. Having a board that effectively has the last word will also greatly increase the efficiency of the decision making process in EELPA in contrast to the present situation in which decisions often have to be referred to the MME and even passed to higher government authorities.

6.26 Giving EELPA real autonomy would also help to create the level playing field that is necessary to attract possible private power producers. An EELPA that is not part of the government would be able to deal with the private sector on a more equal footing, and an EELPA that is able to act decisively and in a business-like manner would be a more attractive partner in possible joint ventures or other commercial arrangements.

6.27 Financial Autonomy. Given the power of the purse, the benefits of managerial autonomy are only likely to be realized if EELPA is also given greater financial autonomy. At present, EELPA is heavily dependent on the government budget. Its net earnings, when it has any, are taxed away and EELPA must obtain the funds it needs through the usual budgetary process like any other department of government. As the table below shows, in the past this has sometimes meant that EELPA received less in budgetary allocations than it paid in taxes and was, thus, a net contributor to the government's coffers. More recently, as earnings have disappeared, the government has been a net contributor to EELPA. In either case, the process not only makes EELPA dependent, but has left it seriously short of resources.

Table 6.1: EELPA/Government Payments (Birr Million)
(Ethiopia Fiscal Year)

	1987/88	1988/90	1990/91	1991/92	1992/93	Budget 1993/94
By EELPA						
Capital Charge	34	84	47	48	25	25
Profit Tax	15					
Residual Surplus	13					
Total	62	84	47	48	25	25
By Government		35	15	26	35	120
Net Payments						
By EELPA	62	49	32	22		
By Government					10	95

6.28 The first, and most important, step toward enhancing EELPA's financial autonomy would be the establishment of a regulatory regime, such as that outlined above, that would ensure adequate tariffs. In addition, EELPA should be permitted to retain the bulk of its earnings, paying only such taxes as are due from other public (and private) enterprises. This would place greater control of that indispensable management tool, the budget, in EELPA, thus enabling management, rather than the government process, to allocate resources. While EELPA is likely for some time to require government support of its investment program, this should, as already indicated, be negotiated as part of the process of performance regulation.

Enhancing Capability

6.29 Increasing autonomy is a necessary but not a sufficient step if EELPA is to become an efficient public utility. Much also needs to be done to build up its technical and managerial capabilities by improving staff skills, by supplementing EELPA's resources with outside skills, and by improving organization, practices and procedures in key areas. While human resources need to be upgraded throughout the organization, the need is particularly great at the middle and upper management levels where many positions are occupied by recent appointees who are relatively young and inexperienced. An intensive and well-targeted training effort is clearly required if EELPA is to have the capability to implement the expansion program that lies ahead of it. It is, therefore, recommended that a study be undertaken to identify EELPA's principal training needs and formulate an action plan for meeting these needs by enhancing in-house training capabilities and through carefully structured programs for training abroad.

6.30 Training, together with the improvements in recruitment, pay and promotion practices that will be possible with greater autonomy, should enable EELPA to build up the capabilities it needs over the medium/longer run. To face its immediate problems of improving efficiency and mounting a major expansion program, however, EELPA will need to seek outside support. In addition to making greater use of consultants for studies and other ad hoc assignments, consideration should be given to obtaining technical assistance to fill important skills gaps by employing consultants in line as well as advisory positions. Twinning arrangements, under which a suitable foreign utility would provide a team of experts to support EELPA in specified areas over a number of years, are one way of organizing such technical assistance that has proven successful in African and other countries[48]. Another approach would be to make greater use of contractors for operations that are now carried out by force account and to contract out the management of specific functions where performance is most in need of improvement (e.g., collections). The latter practice, with which there has also been successful experience in Africa and elsewhere, would involve engaging foreign utilities and/or business firms with demonstrated capabilities under performance contracts in which their remuneration is linked to the achievement of specific targets.

6.31 Special attention needs to be directed to two critical areas --corporate planning and distribution-- in which enhancing capability would do much to improve power sector performance.

6.32 Corporate Planning. Corporate planning appears to be one of the most critical areas in which a different approach is needed. At present, the corporate planning department, which reports to the Deputy General Manager for Finance and Administration, is responsible for all planning in EELPA, including the planning of distribution works as well as major investments in generation and transmission. The recently appointed management of the department is relatively inexperienced and the department is short of qualified staff. Since it

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[48] For example, the experience in Ghana during 1986-87 when the Electrity Supply Board of Ireland helped to bring about major changes in the operations and management of theElectricity Corporation of Ghana, the country's distribution utility.

must try to combine corporate and operational planning and is organizationally remote from both top management and the operating departments, it is not surprising that corporate planning seems to be struggling. Its mission and organizational location need to be reexamined.

6.33 Corporate planning is best looked at as the operational and financial planning of the overall enterprise. A corporate planning department should be most interested in questions of the following types: what is an optimal expansion plan; how do we react to changes in the external environment; what are our funding requirements for the next 1, 2, or 10 years? Operational planning is better done where technical skills are located and where decisions are implemented. Thus, the mission of the corporate planning department should be re-defined to make it responsible primarily for planning at the "macro" or enterprise level, and for setting system standards that meet technical and economic efficiency criteria. It would work to ensure that resources are allocated according to senior management's investment priorities and that the operational plans of the generation, transmission and distribution departments are coordinated to this end and are consistent with established system standards.

6.34 If its mission is redefined as suggested, corporate planning would largely be performing a staff function in support of top management. This would make it all the more important that its work be seen as a continuous and interactive process in which management itself is closely engaged . Since this type of interface is inhibited by corporate planning's present organizational location, it is recommended that it report directly to the General Manager.

6.35 Distribution. EELPA's critical distribution problems --high losses, low reliability and inability to keep up with the demand for service-- stem in part from the lack of resources and in part from a failure to use available resources efficiently. While all of EELPA's operations have been hampered in recent years by a shortage of money and materials, distribution seems to have suffered most. It has generally been at the end of the queue when it comes to allocating resources as reflected in the fact, discussed in Chapter II, that distribution has received only a derisory share of EELPA's investment budget. The impact of the shortage of resources has been exacerbated by the lack of effective planning for the rehabilitation and expansion of the distribution system and by management practices and procedure that have diluted the responsibility of the distribution department. For example, all supplies and stores come from a separate directorate at EELPA and are not under the direct control of the distribution department.

6.36 Given the severity of the distribution problem, consideration should be given to the basic institutional strategy to be adopted in rebuilding the function. While the range of possibilities is wide, three options can be suggested here to illustrate the principal alternatives:

- strengthening the management of the distribution function within EELPA.
- decentralizing distribution, or
- separating distribution from generation and transmission, creating a new public enterprise.

6.37 *Strengthening distribution in EELPA* would require an intensive technical assistance effort beginning with a rehabilitation study of the sort suggested in Chapter II. Technical assistance would be focused not only on improving distribution planning, rationalizing management practices and operating procedures and training staff, but also on providing EELPA with the hands-on advisory and operational support it will need to efficiently undertake the major system rehabilitation and expansion programs required. As already indicated, such technical assistance could be provided through twinning arrangements, and/or by employing contractors to provide specific services (e.g., restringing lines, replacing transformers). A further option would be to contract out the management of all or a part of the distribution function to a qualified utility. This has, for example, been done in Ghana, where the distribution company has employed a European utility to manage its billing, collection and other customer service functions.

6.38 The principal advantage of this approach is that it would do no violence to the existing institutional framework and could be implemented with a minimum of organizational trauma. However, this might also be its greatest weakness since, without a basic change in institutional status, it is difficult to see how distribution could be assured the higher priority and larger share of resources it so badly needs.

6.39 *Decentralizing distribution* could involve either a variation on the above theme of working within EELPA or much more radical surgery. In the former case, it would mean transferring a maximum of authority and responsibility to EELPA's regional offices, thus allowing them great flexibility to manage agreed programs without reference to headquarters. In the latter case, responsibility for distribution might be devolved to the regional authorities in keeping with the government's emphasis on regionalization. Distribution would be handled by regional utilities that might be publicly or privately managed.

6.40 Decentralization would have the advantage of promoting more nimble and responsive management by putting responsibility in the hands of those closest to local conditions and to the customers the system should be serving. It should be feasible within EELPA and is a goal well worth considering. However, in the form of regionalization, decentralization raise real questions about economies of scale and particularly about whether there would be sufficient technical and managerial resources to staff a large number of small(ish) local companies.

6.41 *Transferring responsibility* for distribution to a new specialized enterprise, whose only business it would be, would create a dedicated institutional base for planning, financing and implementing the critically needed improvement and expansion of the distribution system. In such an enterprise, distribution would cease to be the least glamorous and rewarding component of a multi-purpose organization, and a staff trained in distribution and looking toward that function for career advancement could be created. A specialized institution could also more directly and easily be held accountable for expanding service and for its quality and cost to consumers. The distribution enterprise would buy power in bulk from EELPA (or any other power producers). To succeed, it would have to be assured under the regulatory system of being able to charge retail tariffs that provide a sufficient margin over the bulk tariff to enable it to cover its operating and investment costs.

6.42 Establishing a separate distribution enterprise could, thus, provide a direct approach to dealing with the twin problems of institutional priority and resource allocation that are at the root of the present difficulties. Separating distribution from generation and transmission is a common arrangement throughout the world which has generally worked well where the distribution enterprise has had sufficient autonomy to operate commercially, and adequate tariffs. It is also an arrangement that can facilitate the entry of private power producers by providing them with a customer who is not also a competing producer. The major drawbacks to this approach are that breaking up existing institutions and creating new ones is never easy; that the transition would involve difficult issues (e.g., the valuation and transfer of assets) that would have to be carefully worked out over time; and that the separation of distribution from generation and transmission in a system as small as Ethiopia's could involve the loss of significant economies of scale and could make coordination even more of a problem than it now is.

6.43 These options are by no means mutually exclusive. Indeed, measures to enhance distribution capabilities through intensive technical assistance and/or by contracting out for services will be required whether the function remains within EELPA or is transferred to a new institution. Similarly, decentralization is a strategy that should be considered in either case. Moreover, there are many possible variations on the above options such as the possibility of establishing a new distribution enterprise but, in order to facilitate coordination, keeping it under the same corporate umbrella as generation and transmission through a holding company type of arrangement. The options for institutional change should be carefully evaluated as part of the distribution study suggested in Chapter II.

Easing Entry for the Private Sector

6.44 Independent power projects (IPPs) --in which private investors, either alone or in conjunction with existing public utilities, finance, build, own and operate generating plants-- are an increasingly important phenomenon in many developed and developing countries. In the developing world, the main reason behind the growth of IPPs has been the inability of the traditional sources of capital --governments-- to meet the growing development requirements of the power sector. IPPs have been moving in to help fill the gap mainly in Latin America and in Asia, where they have been attracted not only to countries with large power markets that are considered good credit risks (e.g., China, Chile, Malaysia) but also to some smaller countries whose creditworthiness is more doubtful (Guatemala, Jamaica, Belize). However, the value of IPPs relies not only on their ability to raise significant amounts of capital but also on the fact that private participation brings with it the latest technologies and management expertise, and the assurance that plants will be completed rapidly and operated efficiently. As noted in Chapter II, Ethiopia not only needs private capital to help finance its power sector investment program but also is about to embark on the construction of thermal and geothermal plants with which it is not familiar and where private expertise would be indispensable.

6.45 In most cases, private investors provide equity and debt financing for IPPs on a project or limited-recourse basis, relying principally on the prospective earnings of the project itself to repay their investments. While the investments are usually not directly guaranteed by governments, back-up or "counter" guarantees for the commitments of power purchasers, fuel suppliers and other public sector entities whose performance is critical to the success of the projects are often called for. Where country credit and/or other risks are seen as high, guarantees from bilateral and multilateral agencies may also be essential to the successful financing of at least the first IPP.

6.46 International experience with IPPs indicates the type of environment that would have to be created in Ethiopia to attract them. In considering investment in the power sector, private financiers are mainly concerned with security and profitability. Security is likely to be deemed adequate only where there is a clear government commitment to private participation and where this has been spelled out through the establishment of a legal framework which explicitly encourages private entry, protects private investment and provides for the equitable settlement of disputes. A regulatory regime that provides clear rules of the game is essential for both security and profitability. To meet their concerns about profitability, private investors need to know that they will be able to charge realistic tariffs, that power purchasers (e.g., distribution companies) will be able to honor their contracts; that fuel will be regularly available at reasonable cost; that they will be able to repatriate their earnings; and that they will be able to exit the country on reasonable terms.

6.47 When their requirements are stated baldly, in this way, the creation of an environment attractive to private investors may seem a daunting proposition. Two facts need to be borne in mind in this connection. The first is that many of the conditions sought by private investors are, in any case, required for the efficient functioning of the power sector (e.g., transparent regulation and adequate tariffs). The second is that it has been possible to meet these requirements in a large number of countries, from China to Chile, having very diverse political, economic and social conditions through a combination of commitment and financial ingenuity, Thus, the term IPP covers a broad range of legal, financial operating arrangements designed to fit particular circumstances. For example, where selling to the grid has posed too great a market risk, projects have been structured to supply power to particular creditworthy industrial consumers (who may in turn be important investors in the project). Or, where fuel supply has appeared to be a major risk, energy conversion agreements have been devised under which the IPPs, in effect, earn a fee for processing fuel that is supplied to them (see box on the Philippines experience) And, where an exit strategy has seemed essential to one or both parties, IPPs have been organized on a BOOT (Build/Own/Operate/Transfer) basis, which provides that investors shall recover their investment over a fixed period after which the project is transferred to the government.

6.48 With its transition to a market economy still incomplete, whether Ethiopia can in the near term attract private investment in the power sector is very much open to question. Moreover, the process of finding out is likely to be a lengthy one. While the necessary institutional arrangements need not be fully in place before trying to attract IPPs, certain minimum conditions must be established and, even when this is done, the process of stimulating investor interest, negotiating project arrangements and raising financing is likely to be time consuming.

An Example of Private Power Project in the Philippines: the Navotas Gas Turbine Project

The Philippines offers a very good example of opening power generation to the private sector both in terms of number and variety of projects implemented. A key element of the rapid growth of IPPs in the Philippines was the enactment of an executive order in 1987 allowing the private sector to invest in electric power generating facilities, which included cogeneration, grid-connected plants, and plants located outside the national grid system that may sell power directly to end users. Since 1991, when the first IPP was commissioned, the state-owned utility National Power Corporation (NPC) has signed 33 agreements with the private sector, 13 of which were completed by the end of 1993. A total of 24 projects for about 2,500 MW were scheduled to be in operation by end 1994.

Five different schemes have been adopted: BOT (build, operate, transfer); BTO (build, transfer and operate); BOO (build/own/operate); ROL/ROM (rehabilitate, operate and lease/maintain); and OL (operate, lease). In most projects NPC has taken the fuel supply and cost risk through Energy Conversion Agreements (see below), and the market risk (through "take or pay" contracts) leaving the developer with only the project/country risk.

The Project

The first IPP contract in the Philippines was for the Navotas Gas Turbine Project. The project, a 210 MW gas turbine power plant, was commissioned in January 1991. The project, costing US $41 million, was developed by Hopewell Project Management Company Ltd. of Hong Kong using a BOT scheme and with limited-recourse financing (no government guarantees). The project was financed with equity from Hopewell, Citicorp, Asian Development Bank, IFC and with debt provided by ADB, IFC and a syndicate of commercial banks. The plant was built in twelve months.

Under BOT arrangements, Hopewell Energy Philippines Corporation (HEPC), a private company, owns and operates for twelve years and then will transfer full ownership and control to NPC. Under the twelve-year contract, HEPC supplies electricity to NPC. NPC provides the site, the fuel to the plant at no cost and pays HEPC for all the energy it takes. NPC pays a tariff consisting of a capacity fee and a fee for energy delivered from the plant.

6.49 However, given the pressing need for private capital, technology and management, this is a process well worth initiating. To do so, Ethiopia will need, first, to clearly and explicitly commit itself to private participation in the sector. Present investment law is ambiguous, at best, on this subject; while it reserves large scale investment in power to the government and permits only the Ethiopian private sector to invest in small and medium-size projects, it also refers to the government investing in partnership with private investors in capital and technology intensive large scale projects.[49] Thus, new legislation that will clearly open the door to all private investors should be put in place. While such legislation may contain minimum conditions for IPPs (e.g., concerning project feasibility and the credentials of the sponsors), it probably should not go beyond this since the government will need a maximum of flexibility in negotiating financial and other terms on a project-by-project basis.

[49] Chapter Two, Investment Law, 25 May 1992.

Ethiopia National Energy Balance 1992/93 (000 TOE)

	Primary Energy							Secondary Energy														
	Woody Biomass	Crop Residue	Process Residue	Bagasse	Dung	Hydro	Crude Oil	Biogas	Briquette	Charcoal	Electricity	Refin. Gas	LPG	Avgas	Gaso-line	Jet Fuel	Kero-sene	Diesel Oil	Fuel Oil	SubTotal Petrol& Fuel	Asphalt & Lubes	TOTAL
<u>GROSS SUPPLY</u>																						
Production	14300	4815	68	165	7455	368																27171
Imports							611								29	120	0	251	0	399	18	1028
Export (primary egy)																						
Stock change							14								3	-4	-1		-5	-7	0	7
TOTAL SUPPLY	**14300**	**4815**	**68**	**165**	**7455**	**368**	**625**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**32**	**116**	**-1**	**251**	**-5**	**393**	**17**	**28206**
<u>CONVERSION</u>																						
Petroleum refining							-576					15	5		78	49	1	150	263	561	10	-5
Charcoal production	-85									177												92
Electricity production						-313					323							-3		-3		6
Biogas																						
Briquette																						
Refinery fuel												-15							-12	-27		-27
Conversion losses	-657					-55	-49											-9		-9		-770
Trans.&Distrib. losses											-61											-61
<u>OTHER & NON-EGY USES</u>																						
Fertilizers		-1267			-5252																	-6519
Cattle feed		-1787																				-1787
Construction	-1295	-583			-819																	-2696
Other			-68													-87	86					-68
NET SUPPLY	**12263**	**1179**	**0**	**165**	**1384**	**0**	**0**	**0**	**0**	**177**	**261**	**0**	**5**	**0**	**110**	**78**	**86**	**388**	**246**	**914**	**27**	**16370**
<u>EXPORTS (Secondary Egy)</u>																			-146	-146		-146
NET SUPPLY AVAILABLE	**12263**	**1179**	**0**	**165**	**1384**	**0**	**0**	**0**	**0**	**177**	**261**	**0**	**5**	**0**	**110**	**78**	**86**	**388**	**100**	**768**	**27**	**16224**
Oil company stock changes												0	1	0	-187	10	5	46	26	-100	27	-73
NET DOM. CONSUMPTION	**12263**	**1179**	**0**	**165**	**1384**	**0**	**0**	**0**	**0**	**177**	**261**	**0**	**4**	**0**	**298**	**68**	**82**	**342**	**75**	**868**	**0**	**16297**
<u>CONSUMPTION BY SECTOR</u>																						
Household	11444	1127			1326					172	107		4				76	6		86		14262
Agriculture																		20		20		20
Transport															298	61		200	4	562		562
Industry	355	30		165	34					2	120					1		49	68	118		823
Services and Other	464	22		0	25					2	34					6	6	67	3	81		628

Source: EEA

Annex 2

Energy Demand Forecast (% annual growth, 1994-2000)

	1994	1994-2000	2001-2005	1994-2005
Total Energy Demand	3.2	3.2	3.2	3.2
Electricity	6.6	7.7	8.4	8.0
Petroleum Products	7.4	6.4	7.4	6.4
Woodfuel	2.9	2.9	2.9	2.9
GDP	3.5	5.4	5.5	5.4
Agriculture	-5.3	3.3	5.0	4.0
Indusry	7.6	7.6	7.3	7.5
Services	8.8	8.4	9.0	8.6
Total Population	3.1	3.1	3.0	3.1

Ethiopia - Load, System Requirement and Capability
(ELPA Capability w/out Upper Beles)

Load vs. Capability: GWh						System Deficit: GWh					
	Slower Load	High Load	Enhanced Capab.	Limited Capab.	Delayed Capab.	HL/LC[1]	HL/EC	HL/DC	SL/LC[2]	SL/EC	SL/DC[3]
1993	1111.2	1109.3	1645.0	1314.0	1645.0	204.7	535.7	535.7	202.8	533.8	533.8
1994	1184.2	1186.1	1645.0	1314.0	1645.0	127.9	458.9	458.9	129.8	460.8	460.8
1995	1267.1	1348.9	1645.0	1369.0	1645.0	20.1	296.1	296.1	101.9	377.9	377.9
1996	1361.1	1521.1	1647.7	1369.0	1645.0	-152.1	126.6	123.9	7.9	286.6	283.9
1997	1467.8	1703.1	1700.0	1414.0	1645.0	-289.1	-3.1	-58.1	-53.8	232.2	177.2
1998	1589.2	1983.8	1700.0	1414.0	1647.7	-569.8	-283.8	-336.1	-175.2	110.8	58.5
1999	1721.1	2259.6	1810.0	1414.0	1700.0	-845.6	-449.6	-559.6	-307.1	88.9	-21.1
2000	1864.2	2486.6	2210.0	2272.0	1700.0	-214.6	-276.6	-786.6	407.8	345.8	-164.2
2001	2019.6	2684.0	2632.8	2272.0	1810.0	-412.0	-51.2	-874.0	252.4	613.2	-209.6
2002	2188.4	2861.4	2632.8	2272.0	2210.0	-589.4	-228.6	-651.4	83.6	444.4	21.6
2003	2371.8	3049.4	2632.8	2272.0	2632.8	-777.4	-416.6	-416.6	-99.8	261.0	261.0
2004	2571.0	3249.1	2632.8	2272.0	2632.8	-977.1	-616.3	-616.3	-299.0	61.8	61.8
2005	2787.5	3463.7	2632.8	2272.0	2632.8	-1191.7	-830.9	-830.9	-515.5	-154.7	-154.7

Load vs. Capability: MW						System Deficit: MW					
	Slower Load	High Load	Enhanced Capab.	Limited Capab.	Delayed Capab.	HL/LC	HL/EC	HL/DC	SL/LC	SL/EC	LL/DC
1993	222.5	229.0	296.0	257.5	296.0	28.5	67.0	67.0	35.0	73.5	73.5
1994	237.2	249.2	296.0	257.5	296.0	8.3	46.8	46.8	20.3	58.8	58.8
1995	253.8	288.7	296.0	340.5*	296.0	51.8	7.3	7.3	86.7	42.2	42.2
1996	272.6	324.9	305.0	340.5	296.0	15.6	-19.9	-28.9	67.9	32.4	23.4
1997	294.0	363.2	305.0	340.5	296.0	-22.7	-58.2	-67.2	46.5	11.0	2.0
1998	318.3	421.5	305.0	340.5	305.0	-81.0	-116.5	-116.5	22.2	-13.3	-13.3
1999	344.7	478.9	320.0	340.5	305.0	-138.4	-158.9	-173.9	-4.2	-24.7	-39.7
2000	373.4	526.8	409.0	533.0	305.0	6.2	-117.8	-221.8	159.6	35.6	-68.4
2001	404.5	569.1	491.0	533.0	320.0	-36.1	-78.1	-249.1	128.5	86.5	-84.5
2002	438.3	607.5	491.0	533.0	409.0	-74.5	-116.5	-198.5	94.7	52.7	-29.3
2003	475.0	648.4	491.0	533.0	491.0	-115.4	-157.4	-157.4	58.0	16.0	16.0
2004	514.9	691.9	491.0	533.0	491.0	-158.9	-200.9	-200.9	18.1	-23.9	-23.9
2005	558.3	738.8	491.0	533.0	491.0	-205.8	-247.8	-247.8	-25.3	-67.3	-67.3

HL = High Load (EELPA's)
SL = Slower Load (WB's)
LC = Limited Capability (EELPA's)
EC = Enhanced Capability (WB's)
DC = Delayed Capability (WB's)
* 83 MW addded for Tis Abay?

1) Worse Case
2) Best Case
3) Intermediate Case

Annex 4

Thermal Power Plant Options

NOTES ON TABLE 3

Capital Cost ($ million)

Gas-fueled Gas Turbine: Includes $72million for Calub-Dire Dawa gas pipeline in addition to turbine costs below

Diesel-Fueled Gas Turbine: Ex-Factory cost = $36million ($600/Kw) + 33.3% for shipping, insurance and site costs

Total Cost ($million)

All options include interest during construction

Gas turbine options also include 15% for training and commissioning

Fixed Annual Costs ($million)

Interest rate 12%/a Assumed life 20 years

O & M Cost

Fixed O&M	2% of capital cost
Variable O&M	0.25-.45 c/kWh

Fuel Cost ($/kWh)

Gas-fueled gas turbine: Zero cost for Calub gas delivered to pipeline since gas extracted under project would otherwise be reinjected

Diesel fueled options:

Diesel - $24/bbl CIF import parity price (1993)

Inland transport - $0.06/ton/km ($0.008/bbl/km) actual 1993
300km Djibouti-Dire-Dawa for single plant
600km for multiple plants option

Consumption - gas turbine efficiency =0.368; diesel consumption = 0.26 liters/kWh

Annex 5

Long Run Marginal Cost Calculations

Table C.1

Ethiopia Basic Parameters	
Exchange Rate	6.5
General Shadow Multiplier	0.85
Real Discount Rate	0.1

Table C.2[1]

High Voltage Bulk Supply		
	Birr/kWh	US$/kWh
Generation and Transmission	0.69	0.11
Energy	0.14	0.02
Total Peak	0.89	0.14
Total Off Peak	0.14	0.02
Practical Peak	0.78	0.12
Equivalent Flat	0.35	0.05

Low Voltage Bulk Supply		
	Birr/kWh	US$/kWh
Total Peak	1.09	0.17
Off Peak	0.15	0.02
Practical Peak	0.96	0.15
Equivalent Flat	0.44	0.07
Low Voltage Domestic Flat Rate	0.53	0.08
Low Voltage Commercial Flat	0.50	0.08
Low Voltage Street Flat	0.35	0.05

1 Generation Cost: Mission estimates based on Acres Aleltu Study. Unit costs of generation of hydro/geothermal projects and transmission in the recommended plan vary from 0.07 to 0.08 $kwh. Distribution Costs: Mission estimates based on EELPA Tariff Study. Energy Costs: Mission estimates based on EELPA tariff study. In the short to medium term, additional generation can only be provided with new thermal at 0.15-0.20 $/kwh, while hydro costs 0.08 $/kwh. The expected long-term average utilization factor for the first two thermal units is just under 15%. The mission estimates are based on the more conservative set of costs: 0.08 $kwh for hydro and 0.20 for thermal.

The Assab Refinery

PCE Operation The Petroleum Company of Eritrea (PCE) took the refinery over in May 1991 as part of the comprehensive peace settlement between the two countries, and shut it down until the end of the year during which time major remedial work was undertaken. The refinery was restarted in January 1992, and shut down again in 1993 for a refinery turnaround of 25 days. Another turnaround is scheduled for 1995, following which 30-35 day turnarounds are forecasted every two succeeding years.

Contractual Relationships The contract between EPC and PCE was undertaken at the end of the war as part of negotiations between the two governments. These negotiations included a number of issues besides the utilization of the refinery, such as use of the port, transit duties etc. The refinery agreement is subject to year-to-year renegotiation during which the entire document may be renegotiated, or more simply, the numbers may be changed, which is what has occurred to date.

The refinery is organizationally part of PCE, and is not a free-standing corporation. As such it works as a service unit, receiving no margin on its operations and, hence, making no profit.

There is no institutional or contractual vehicle in place to provide incentives to improve the refinery's operating or financial efficiency. What incentives there are, are based on professional pride, rather than financial remuneration. Both EPC and the refinery management view the continuation of the domestic production and employment, as the actual incentives for efficient operation.

Accounting History and Current Practices At the time of refinery commissioning in July 1967, The Soviets provided the refinery to Ethiopia at a fixed cost, without specific component cost breakdown. EPC immediately started component auditing, and by the time the 1969 annual report was issued, the refinery was fully converted to the western system of accounting, for purposes of insurance. Accounts are currently calculated under the accrual system, utilizing Price Waterhouse as the external auditor.

When the refinery was taken over by PCE, it was again re-evaluated for insurance purposes, at $54 million. There have been no accidents to the refinery to date, and the insurance coverage is good. For financial accounting purposes, the plant is being depreciated at the rate of 4.6 million birr/year ($0.9 million/year), which would result in annual financial losses if the refinery operated as a legal corporation.

EPC's management negotiates the refinery's operating costs on an annual basis with the PCE refinery management. Costs include both variable and fixed costs, but not depreciation or capital expenditures. The latter have not yet been incurred, but the two governments have already agreed upon the methodology of discussing future major capital expenditures required to improve, upgrade or convert the refinery, and thus extend its period of functional usefulness. Major maintenance costs resulting from periodic refinery turnarounds held every two years, are paid by EPC as they occur; there is no amortization of these costs over the intervening years.

As a result of these annual negotiations, a cost-reduction program is expected to be discussed in the 1995 budget presentation. The 1992 and 1993 budget presentations to EPC, and the ensuing negotiations, resulted in fixed contracts, which allowed for profit margins if the refinery operated more efficiently than had been forecast. Starting in 1994, the contractual agreement will be on an actual cost reimbursement basis; there will be no efficiency margin built into the contract.

Payments are made to the refinery on a quarterly basis by EPC, based on the agreed upon budget; to date there has been no year-end account balancing. Payment is in cash to the refinery, by both governments. The budget process starts in August, is completed in October, and is presented to senior management in December. The annual budget becomes effective in January. There are indications, particularly in terms of major capital expenditures, that the budget cycle is thought of in terms of two to three year cycles, although the present presentation is restricted to an annual basis.

Foreign Exchange: The government of Ethiopia provides EPC with the foreign exchange required to purchase cri ude for the refinery and for spare parts, materials, etc.

Procurement: EPC acts as the tender agent on behalf of both Ethiopia and Eritria. Purchase specifications for motor gasoline are 83 octane, which is blended with the 79 octane refinery product to deliver a finished, blended product with an octane of about 81, well above the minimum national standard of 79. Premium grade gasoline of 93 octane which is required for use mostly in diplomatic vehicles, is also purchased at the rate of approximately 10,000 tons/year. The desired gasoil specifications are 1% sulphur, but market purchases are typically 0.3%

Purchases are undertaken by agents, rather than directly by EPC. The individual agents determine the point of actual origin of the crude, although specifications are for Arabian Light. Volume estimates are made in conjunction with the marketing companies. The timing of purchases is based both on the rate of change in consumption, and by changes in marketing conditions. The latter vary depending on the presence or absence of advantageously low prices.

By purchasing forward, on contract, rather than on the spot market, EPC avoids short term market price spikes as a form of risk avoidance. By using an agent, it simplifies its procurement procedures, but adds an agency fee to the price in return for this simplification. The same procedure is used for EPC's purchase of the required white oil products.

Payment for crude and product purchases is made by telegraphic transfer (2.5% C&F) within 30 days, rather than the less advantageous mechanism of a Letter of Credit (4.5% C&F).

Product Pricing: As a means of pricing its product output, the refinery routinely compares the Platts cost of each product, CIF Assab, to the allocated refinery cost of its products on a pro rata basis. The pro rata cost of the refinery products are divided by the CIF Platts prices in order to obtain a refinery coefficient pricing for its products with reference to the internationally traded costs. Starting with 1995, when the budgeting process will be based on actual costs, the refinery will have a true comparison of the cost of its products versus world prices.

Personnel Issues: The present permanent staff of the refinery is 897, of which approximately 40% are Ethiopian. The staffing pattern is as follows:

Refinery Staff Composition (mid-1994)

PCE Head Office	9
Plant Manager Office	14
Administration	128
Finance	19
Material	27
Operations	213
Technical Service	306
Utilities	98
Fire, Gas and Safety	85
Total Personnel	**897**

The labor pool has changed significantly since PCE took over. 150 have permanently left with the change of control, and have not been replaced. Of the remainder, many Eritreans have replaced senior Ethiopians, and because of their relatively junior status, their salaries are significantly less than the Ethiopians which they have replaced. The Plant Manager feels that this has not affected plant efficiency, since the new additions are as technically competent as those they have replaced, but are simply less senior. In addition, a number of the senior staff, including the Plant Manager, are classified as former Fighters, who have agreed to work for four years following independence at no salary (the Government provides housing, food, clothing and 50 Birr pocket money).

The result has been, that despite the October 1992 devaluation of the birr, the birr cost of personnel has remained nearly constant. In spite of the significant post-PCE reduction in personnel, the refinery is still greatly over-staffed although in absolute birr terms, the added cost is relatively small.

Environmental Issues

Gasoline Grade and Related Potential Environmental Issues: The 79 to 80 octane level of the refinery-produced gasoline product is a function of the Soviet bimetallic reformer catalyst (aluminum and platinum). If a trimetallic catalyst were installed, the octane level would approach world standards of 92-93 RON. The environmental issues associated with low octane gasoline have not yet surfaced as an issue in refinery-produced product specifications. The increase in octane rating through the installation of a better reformer catalyst would significantly reduce the use of lead additives, and lower the emissions levels, through improved engine combustion.

Physical Plant Issues

1) Power Generation Power is generated with three fuel oil fired turbines capable of a maximum of 6.5 MW. Under normal conditions, two turbines are working and one is used as a spare; present power generation is 2.5 MW. Excess power is sold to the city; this is a disadvantage in that the refinery power source is more reliable than that of the city's diesel powered generators, and the refinery commonly must provide additional power to Assab.

2) Cooling Refinery cooling water is untreated sea water, which causes significant corrosion and scale formation. The latter serves to protect the line from additional corrosion, but at the same time, causes turbulent flow, increases pressure drops, and significantly reduces heat transfer efficiency. The intake line has recently been improved through replacement with a cement coated line, but the problem still exists.

3) Spare Parts Spares are difficult to obtain from the original Soviet sources and Western manufactures are not familiar with GOST specifications. Western parts are being utilized where possible, often with required adaptations; eg. many Foxboro controls were noted in the process control panels. The refinery's procurement policy is being changed to western standards because of Russian supply problems. In general, refinery instrumentation and the tank farm are not problem areas. Where parts are unavailable, or unsuitable, the required parts are machined on site; more than 30% of the refinery staff are engaged in technical services and machine shops.

4) Construction Capacity of the Refinery Personnel The refinery technical group has the capacity to undertake major construction, and was the agency used to extend the sea jetty. There was a lack of underwater construction expertise in the local contractors, coupled with the

availability of previous plans and construction experience with the original jetty construction. In the case of tank construction, the refinery staff can erect one or two tanks; if more are to be built, the job would have to be contracted out on a bid basis. When major construction projects are undertaken by the refinery staff, separate project accounts are kept, and accurate project costs are recorded.

5) Refinery Efficiency and Proposed Improvements The efficiency of the refinery is evaluated by EPC every six months. In principle, EPC has the capacity to either fine or pay bonuses based on the meeting of production objectives. Since the transfer to PCE there has, however, been no such action taken, and the refinery is considered by EPC to be well run.

Annex 7

Potential Supply Savings			Import Parity Prices (1993, $ per ton)				
Products	FOB	Freight***	Insurance/Loss****	CIF	LC Costs (2.5% on CIF)	Other Costs*****	IPP
LPG	157*	125	2.0	284.0	7.1	1.3	292.4
Regular Gasoline (78 RON)	175*	7	1.3	183.3	4.6	1.3	189.2
Kerosene/Jet Fuel	183**	7	1.4	190.8	4.8	1.3	196.9
Gasoil	169*	7	1.3	177.3	4.4	1.3	183.0
Inland Fuel Oil (LSFO)	89*	7	0.7	96.7	2.4	1.3	100.4
Export and Bunker Fuel Oil (HSFO)	59*	7	0.5	66.5	1.7	1.3	69.9
Asphalt	54*	110	1.2	165.6	4.1	1.3	171.0
Crude Arabian	112	7	0.9	119.9	3.0	1.2	124.1

* FOB Med (Regular = 0.9 Premium, FOB Asphalt = FOB HSFO = 5$)

** FOB Arab

*** Freight per finished products in 25 Kton vessels (excluding LPG and Asphalt for which vessel size is 1500-2000 tons), in 35 K-ton vessels for crude

**** Insurance = 0.225% (FOB + Freight); Loss = 0.5% (FOB + Freight)

***** Port Dues = 0.2$/ton, Demurrage = 0.5$/ton, Shell Management Service = 0.6$/ton (for finished products only), EPC Procurement Service = 0.5$/ton (for crude only)

Annex 8

Assab Petroleum Port Facilities

The Assab oil port is south of the commercial port, is physically separated from it, and is controlled by the refinery rather than the Port Authority, although there is movement to include it within the Port Authority's jurisdiction. Facilities consist of two sea berths, and one jetty as follows

- Sea berth 1 can accommodate up to 40,000 ton tankers, with a maximum draft of 11 meters. It is configured for crude delivery, and taking on fuel oil for export. Crude shipments are received every two weeks, on average, with timing of delivery agreed upon between EPC and the refinery.

- Jetty berth number 2, which has recently (1994) been refurbished, extended, and refinished to eliminate tanker damage due to the previously exposed rock core of the jetty. It can accommodate up to 6,000 ton coastal tankers with maximum drafts of 7.0 meters, and is used for export of fuel oil, and white products to Massawa and Djibouti.

- Sea berth 3 has a design capacity of 20,000 ton tankers with a maximum draft of 8.5 meters, and is configured for disch of imported white products only. In practice the berth accommodates between 18,000 and 40,000 ton tankers depending on their draft, since they are usually not fully loaded, and draw less than 8.5 meters.

The port at Massawa has one sea berth, in deep water, and can accommodate tankers of any size. It is designed for the delivery of finished products only, which are shipped north from the refinery at Assab.

The Assab port capacity for oil could be easily enlarged to take larger tankers by moving sea berth 1 into deeper water, and extending the crude delivery and product lines. This would reduce the unit cost of both crude imports and product delivery through using more cost-efficient large tankers. If white product lines were added, the other two berths would no longer be required.

Annex 9

Assab Crude and Petroleum Product Storage Facilities

Tank storage capacity The refinery crude tank storage capacity is geared to volumes which can be accommodated by tanker delivery capabilities. It currently is comprised of six 10,000 ton tanks and two 20,000 ton tanks, for a nominal capacity of 100,000 tons. In practice, the working capacity is about 70,000 tons due to sludge accumulation and tank piping configuration.

Product storage capacity of the refinery is augmented considerably by tanks owned by the oil companies. The latter are in two tank farms, one owned and operated by Shell, and the other owned jointly by Mobil, Total and AGIP. Individual product configurations are as follows:

Product	Refinery	Tanks	Oil Companies	Total
Gasoline	9,400 tons	6	4,700 tons	14,100 tons
Gasoil	10,700	3	16,500	27,200
Kerosene	17,000	10	3,000	20,000
Fuel oil	22,400	5	9,500	31,900
LPG	200	8	0	200
TOTALS	59,700 tons		33,700 tons	93,400 tons

There is no bitumen storage; it is manufactured on a batch basis, poured into drums and sold on a real-time basis as soon as it is manufactured.

The limited LPG storage poses operational problems for the refinery, and for the importation of product as well. The refinery manufactures up to 6,000 tons/yr resulting in a theoretical tank turnover of 30 times/year. As a practical matter, the tank shortage results in the refinery refluxing the manufactured LPG into the gasoline component; it is not flared.

If the storage capacity is to be enlarged, it would be better to reorganize the entire refinery tank farm, rather than simply add more tanks in the available space.

Comparative Cooking Costs in Addis Ababa, 1994

Cooking	Heating Value (MJ/unit)	unit	Stove Effic. (%)	Fuel Cost (EBirr) Financial a/ (/unit)	Financial a/ (annual)	Economic b/ (/unit)	Economic b/ (annual)	Stove price (EB) c/	Life (yrs)	Forex Prem	Import share %	Annualized Stove Cost (EB) Financial r=40%	Financial r=12%	Economic r=12%	Annual Cooking Cost (EB) Financial r=40%	Financial r=12%	Economic r=12%
wood: 3 stone	16.0	kg	17%	0.55	930	0.65	1,099	0	1.0	1	0	0	0	0	930	930	1,099
metal woodstove	16.0	kg	22%	0.55	719	0.65	849	10	3.0	1	0.5	4	4	4	723	722	853
metal char stove	30.0	kg	34%	1.75	789	2.42	1,090	12	4.0	1	0.5	5	4	4	794	793	1,093
Lakech stove	30.0	kg	42%	1.75	639	2.42	882	18	4.0	1	0.3	7	5	5	646	644	888
kero wheel (wick)	35.3	liter	42%	1.00	310	1.97	611	45	5.0	1	1	16	11	11	326	321	622
kero Lark (wick)	35.3	liter	42%	1.00	310	1.97	611	65	5.0	1	1	23	16	16	333	326	627
kero pressure	35.3	liter	45%	1.00	290	1.97	570	250	5.0	1	1	88	62	62	377	352	632
LPG	45.2	kg	55%	2.50	463	2.92	540	525	5.0	1	1	184	130	130	647	593	670
electricity																	
local hot plate	3.6	kWh	60%	0.17	362	0.53	1,129	35	3.0	1	0.75	16	13	13	378	375	1,142
imported stove	3.6	kWh	55%	0.17	395	0.53	1,231	67	5.0	1	1	24	17	17	418	412	1,248

Preparing Injera	Fuel use per session d/	unit	Fuel Cost (EBirr) Financial /sess'n	Financial (annual)	Economic b/ /sess'n	Economic b/ (annual)	Mtad price (EB) c/	Life (yrs)	Forex Prem	Import share %	Annualized Mtad Cost (EB) Financial r=40%	Financial r=12%	Economic r=12%	Annual Cooking Cost (EB) Financial r=40%	Financial r=12%	Economic r=12%
Traditional mtad	9.5	kg	5.2	543	6.2	642	6	0.7	1	0	8	8	8	552	552	651
Tigray mtad	9.5	kg	5.2	543	6.2	642	16	1.0	1	0	16	16	16	559	559	658
Mirte mtad	7.3	kg	4.0	415	4.7	490	35	3.0	1	0	16	13	13	430	428	503
electric mtad	7.4	kWh	1.3	131	3.9	408	400	8.0	1	0.3	123	72	72	253	203	480
low cost mtad	7.4	kWh	1.3	131	3.9	408	250	8.0	1	0.7	77	45	45	207	176	453

Notes:

a/ Average fuel prices for the units most commonly purchased in Addis Ababa markets from CEINFMP records. Annual costs based on average annual utilized energy for non-injera cooking of 4,600 MJ/household (CSO 1984).

b/ Ec 10/kg and Ec 67/kg added to market prices of fuelwood and charcoal to cover the costs of natural forest management from EFAP documents cited in Calub Gas para 5.11. Import parity prices of kerosene and LPG from Annex 7. LRMC of domestic electricity from Annex 5.

c/ Stove and mtad market prices and lifetimes from CEINFMP staff. Market prices annualized at 40% financial discount rate reflect tight cash constraints facing households.

d/ Injera is commonly prepared twice weekly. Specific fuel consumptions from the CEINFMP reports cited below.

Sources: CSO 1984; Calub Gas 1994; CEINFMP 1994a, 1993a, 1991a.

Extension of Lakech Dissemination Efforts to Other Urban Areas

An extended "Lakech" dissemination program is proposed and evaluated below. The proposed effort is phased as follows: five field offices are opened in Year 1 in high priority urban areas followed by an additional five offices commencing in Year 3. Each field office is to be staffed by three full time professionals and two support staff. Each field offices is to be equipped with one vehicle and appropriate computing and office equipment. Field staff conduct Lakech promotion and demonstration activities in Years 1-4 and one professional (part time) would be responsible for monitoring and evaluation in Years 5-10. This approach represents a long-term commitment to stove dissemination, one of the key factors associated with successful stove programs around the world.[2] Program costs are detailed in Table A2.1 below.

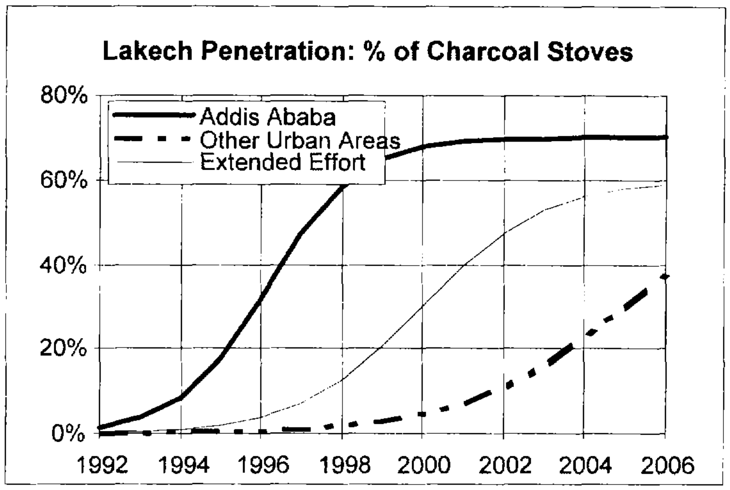
Table : Annual Lakech Dissemination Program Costs for Each Field Office (EBirr)

	Year 1	*Year 2-4*	*Year 5-10*
Staff: 3 Professional & 2 Support	200,000	200,000	25,000
Vehicles & Equipment	200,000		
Lakech Promotion & Demonstration	50,000	75,000	
Monitoring & Evaluation			25,000
Operations & Maintenance	25,000	25,000	
Contingencies (15%)	71,250	45,000	7,500
TOTAL	546,250	345,000	57,500

The proposed extended Lakech dissemination effort should increase and advance the penetration of Lakech stoves in other urban areas. The effect of the extended effort is displayed in Figure A2.1 below along with market penetration now underway in Addis Ababa and expected penetration in other urban areas without further dissemination efforts. The expected effect of an extended effort by CEINFM staff is reasonable since the team has a great deal of experience with Lakech dissemination in Addis where the program has had a pronounced effect on the market.

2 Barnes, et. al., 1993.

Figure A2.1



Program costs and estimates of additional market penetration are used to evaluate the economic implications of the proposed extended dissemination efforts in Table A2.2 below. Additional Lakech penetration refers to the share of charcoal stoves in use in other urban areas. The evaluation assumes that only 1/3 of urban households outside of Addis Ababa use charcoal. Consumers bear the additional cost of 6 Birr for each Lakech stove (a Lakech stove costs 18 Birr while a traditional metal charcoal stove costs 12 Birr). Charcoal savings resulting from the additional penetration of Lakech stoves are determined by multiplying the projected total quantity of charcoal to be consumed in households in the base case forecast by the increased share of households using a Lakech stove and by multiplying this product by the share of charcoal saved by each Lakech stove (25% according to CEINFMP Kitchen Performance Tests). Charcoal savings are valued at Birr 2,000/ton (below the economic value of displaced charcoal in the Addis Ababa market of 2,400 Birr/ton). Under these assumptions, the proposed extended dissemination effort is expected to result in a healthy 70% economic rate of return. Net benefits are obtained mostly by households, but also by producers of Lakech stoves.

Table A2.1 Lakech Dissemination Extended to Other Urban Areas

Year	Stove Program Costs (EBirr '000)	Additional Penetration %	Add'l Lakech sales + repl #	Lakech marginal cost EB6/stove (EBirr '000)	Charcoal savings Tons	Economic value EB2,000/Ton (EBirr '000)	Net Economic Benefits (EBirr '000)
1995	2,731						-2,731
1996	1,725	3.2%	7,025	42	748	1,496	-271
1997	4,456	6.1%	11,899	71	1,434	2,868	-1,659
1998	3,450	10.8%	21,587	130	2,584	5,169	1,589
1999	2,013	17.5%	34,174	205	4,298	8,597	6,379
2000	2,013	25.4%	48,750	292	6,409	12,817	10,512
2001	575	32.5%	53,896	323	8,388	16,775	15,877
2002	575	36.5%	57,586	346	9,667	19,335	18,414
2003	575	36.7%	56,090	337	9,960	19,919	19,008
2004	575	33.4%	55,273	332	9,310	18,619	17,713
2005	575	27.9%	37,457	225	7,980	15,960	15,160
						EIRR	70%

Share of households using charcoal in other urban areas: 33%.

Mirte Biomass Mtad Development & Dissemination

Experience in Ethiopia with developing and disseminating enclosed efficient stoves is reviewed in Annex 3. This experience shows that the successful dissemination of an enclosed biomass mtad will be very challenging and will require innovative development, communication, and marketing methods. The nature of the challenge becomes evident when considering that successful Lakech dissemination efforts were targeted at an upper income urban market segment. Conversely, target markets for the Mirte are middle and lower income urban households that cannot afford an electric mtad. Rural households that gather much of their fuel present an additional challenge. The approach taken by the CEINFMP team for developing the Lakech in direct coordination with stove makers and potters with a continuous focus on satisfying consumer preferences, will be invaluable in moving the Mirte into the marketplace.

A program to develop and disseminate the "Mirte" biomass injera mtad in Addis Ababa, other urban areas, and selected rural areas is proposed and evaluated below. The program in Addis Ababa is to be staffed by 10 professionals and 5 support staff and includes Mirte development costs. For other urban areas and selected rural areas, the proposed program is designed to be implemented by field offices in two phases like the extended Lakech dissemination effort proposed above: five field offices are opened in Year 1 followed by an additional five offices commencing in Year 3. Each field office for an urban area is to be staffed by two full time professionals and one support staff and is to be equipped with appropriate computing and office equipment. Each field office responsible for a rural area is to be staffed by three full time professionals and two support staff and is to be equipped with one vehicle and appropriate computing and office equipment. Field staff of urban and rural dissemination offices conduct Mirte promotion and demonstration activities in Years 1-4 and one professional (part time) would be responsible for monitoring and evaluation in Years 5-10. Program costs are detailed in Tables A2.3-5 below.

Table A2.2 Annual Mirte Development & Dissemination Program Costs for Addis Ababa (Ebirr)

	Year 1	*Year 2-4*	*Year 5-10*
Staff: 10 Professional & 5 Support	625,000	625,000	125,000
Vehicles & Equipment	200,000		
Mirte Development and Testing	150,000	150,000	
Mirte Promotion & Demonstration	125,000	175,000	
Monitoring & Evaluation		75,000	75,000
Operations & Maintenance	50,000	50,000	
Contingencies (15%)	172,500	161,250	30,000
TOTAL	1,322,500	1,236,250	230,000

Table A2.3 Annual Mirte Dissemination Program Costs for Each Field Office in Other Urban Areas (Ebirr)

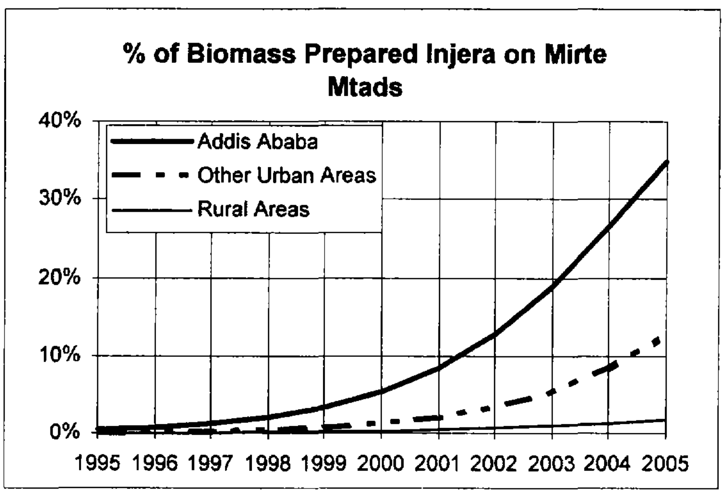
	Year 1	*Year 2-4*	*Year 5-10*
Staff: 2 Professional & 1 Support	125,000	125,000	25,000
Vehicles & Equipment	100,000		
Mirte Promotion & Demonstration	50,000	75,000	
Monitoring & Evaluation			25,000
Operations & Maintenance	20,000	20,000	
Contingencies (15%)	44,250	33,000	7,500
TOTAL	339,250	253,000	57,500

Table A2.4 Annual Mirte Dissemination Program Costs for Each Field Office Serving Rural Areas (Ebirr)

	Year 1	*Year 2-4*	*Year 5-10*
Staff: 3 Professional & 2 Support	200,000	200,000	25,000
Vehicles & Equipment	200,000		
Mirte Promotion & Demonstration	100,000	150,000	
Monitoring & Evaluation			25,000
Operations & Maintenance	75,000	75,000	
Contingencies (15%)	86,250	63,750	7,500
TOTAL	661,250	488,750	57,500

The proposed Mirte development and dissemination program can be reasonably expected to lead to the effects displayed in Figure A2.2 below. These effects are framed as the share of injera prepared on a Mirte mtad that would have otherwise been prepared on an open fire. The highest penetration rates are expected for Addis Ababa. This reflects the relative ease of reaching targeted consumers through existing Kebele organizations and the fact that the Mirte most cost effective for households in Addis Ababa as existing biofuel prices in Addis Ababa markets are substantially above prices in most other urban areas.

Figure A2.2



Program costs and estimates of market penetration are used to evaluate the economic implications of the proposed Mirte biomass mtad development and dissemination programs in Addis Ababa, other urban areas, and selected rural areas in Tables A2.6-8 below. Consumers bear the additional cost of 30 Birr for each Mirte mtad (a Mirte mtad costs 35 Birr while a traditional ceramic mtad for use over an open fire costs 6 Birr). Biomass savings resulting from the penetration of the Mirte mtad are determined by multiplying the projected total quantity of biomass to be used by households for preparing injera in the base case forecast by the share of households using a Mirte mtad and by multiplying this product by the share of biomass by each Mirte mtad (23% according to CEINFMP Kitchen Performance Tests). Biomass savings are valued at Birr 650/ton in Addis Ababa, Birr 450/ton in other urban areas, and Birr 200/ton in rural areas. Under these assumptions, the proposed Mirte program yields economic returns of 25%, 17%, and 12% in Addis Ababa, other urban areas, and rural areas, respectively. Considering the difficulties inherent in disseminating a stove that households must pay for to households in the largely non-monetized rural areas, the rural program appears to be marginal.

Table A2.5 Mirte Mtad Dissemination in Addis Ababa

Year	Mirte Program Costs (EBirr '000)	Total Penetration %	Mirte Sales + Repl #	Mirte Marginal Cost EB30/mtad (EBirr '000)	Biomass Savings Tons	Economic Value EB650/Ton (EBirr '000)	Net Economic Benefits (EBirr '000)
1995	1,323						-1,323
1996	1,236	0.8%	584	18	271	176	-1,078
1997	1,236	1.3%	1,149	34	435	283	-988
1998	1,236	2.1%	2,695	81	698	453	-864
1999	230	3.3%	2,605	78	1,116	725	417
2000	230	5.3%	5,169	155	1,773	1,152	767
2001	230	8.3%	9,546	286	2,782	1,808	1,292
2002	230	12.8%	10,357	311	4,274	2,778	2,237
2003	230	18.8%	18,690	561	6,358	4,133	3,342
2004	230	26.4%	28,079	842	9,051	5,883	4,811
2005	230	35.0%	27,782	833	12,211	7,937	6,874
						EIRR	25%

Table A2.6 Mirte Mtad Dissemination in Other Urban Areas

Year	Mirte Program Costs (EBirr '000)	Total Penetration %	Mirte Sales + Repl #	Mirte Marginal Cost EB30/mtad (EBirr '000)	Biomass Savings Tons	Economic Value EB450/Ton (EBirr '000)	Net Economic Benefits (EBirr '000)
1995	1,696						-1,696
1996	1,265	0.2%	819	25	331	149	-1,141
1997	2,961	0.3%	1,604	48	570	256	-2,753
1998	2,530	0.5%	3,538	106	978	440	-2,196
1999	1,553	0.8%	4,488	135	1,676	754	-933
2000	1,553	1.3%	8,613	258	2,860	1,287	-524
2001	575	2.1%	15,945	478	4,852	2,184	1,130
2002	575	3.3%	22,830	685	8,161	3,672	2,412
2003	575	5.3%	41,035	1,231	13,544	6,095	4,289
2004	575	8.3%	67,914	2,037	22,035	9,916	7,303
2005	575	12.8%	96,961	2,909	34,827	15,672	12,188
						EIRR	17%

Table A2.7 Mirte Mtad Dissemination in Rural Areas

Year	*Mirte Program Costs (EBirr '000)*	*Total Penetration %*	*Mirte Sales + Repl #*	*Mirte Marginal Cost EB30/mtad (EBirr '000)*	*Biomass Savings Tons*	*Economic Value EB200/Ton (EBirr '000)*	*Net Economic Benefits (EBirr '000)*
1995	3,306						-3,306
1996	2,444	0.1%	4,813	144	3,352	670	-1,918
1997	5,750	0.1%	7,032	211	4,813	963	-4,998
1998	4,888	0.2%	9,519	286	6,909	1,382	-3,791
1999	2,731	0.2%	14,316	429	9,912	1,982	-1,178
2000	2,731	0.3%	20,559	617	14,215	2,843	-505
2001	575	0.5%	28,184	846	20,369	4,074	2,653
2002	575	0.6%	42,213	1,266	29,158	5,832	3,990
2003	575	0.9%	59,714	1,791	41,679	8,336	5,969
2004	575	1.2%	82,543	2,476	59,459	11,892	8,841
2005	575	1.7%	122,308	3,669	84,594	16,919	12,675
						EIRR	12%

Low Cost Electric Mtad Development & Dissemination

By late 1994, 62% of all households in Addis Ababa owned an electric mtad. Given the market prices of woody biomass fuels and existing tariffs, preparing injera with electricity is much cheaper than using a traditional mtad over an open fire in Addis Ababa. In economic terms, electricity is also marginally lower in cost than woody biomass for preparing injera (see Annex 1). However, the initial price of an electric injera mtad is well out of reach of low income households that continue to use a traditional mtad over an open fire. The CEINFM Project team has developed a low cost electric mtad with a ceramic body that is designed to appeal to poorer households. The challenges facing an effort to disseminate the Mirte enclosed biomass mtad must also be addressed by efforts to disseminate a low cost electric mtad aimed at low income households.

A program to develop and disseminate a low cost electric injera mtad in Addis Ababa and other urban areas is proposed and evaluated below. The program in Addis Ababa is to be staffed by 10 professionals and 5 support staff and includes low cost electric mtad development costs. Other urban areas should be selected and evaluated in direct coordination with EELPA staff. A key component of selection and evaluation of other urban areas will be a determination of the economic costs of strengthening local distribution systems to account for additional demand placed by increased use of electricity in electric mtads. For other urban areas, an indicative program is proposed to be implemented by field offices in two phases like the extended Lakech and Mirte dissemination programs proposed above: five field offices are opened in Year 1 followed by an additional five offices commencing in Year 3. Each field office for an urban area is to be staffed by two full time professionals and one support staff and is to be equipped with appropriate computing and office equipment. Field staff conduct low cost electric mtad promotion and demonstration activities in Years 1-4 and one professional (part time) would be responsible for monitoring and evaluation in Years 5-10. Program costs are detailed in Tables A2.9-10 below.

Table A2.8 Annual Low Cost Electric Mtad Development & Dissemination Program Costs for Addis Ababa (Ebirr)

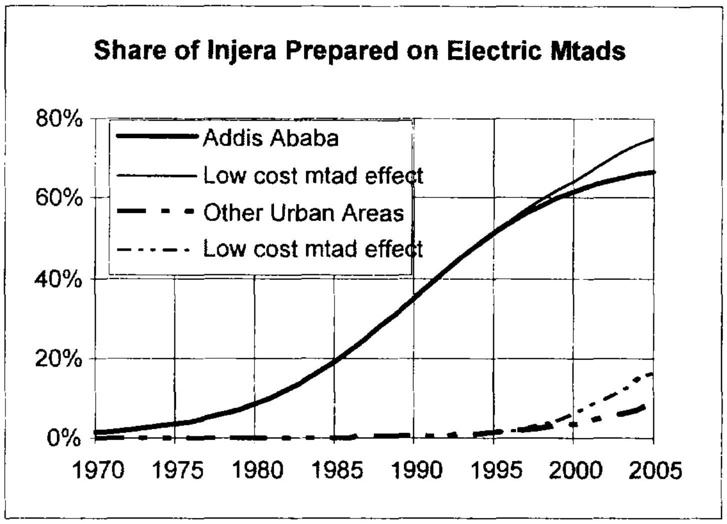
	Year 1	*Year 2-4*	*Year 5-10*
Staff: 10 Professional & 5 Support	625,000	625,000	125,000
Vehicles & Equipment	200,000		
LC Mtad Development and Testing	150,000	150,000	
LC Mtad Promotion & Demonstration	125,000	175,000	
Monitoring & Evaluation		75,000	75,000
Operations & Maintenance	50,000	50,000	
Contingencies (15%)	172,500	161,250	30,000
TOTAL	1,322,500	1,236,250	230,000

Table A2.9 Annual Low Cost Electric Mtad Dissemination Program Costs for Each Field Office in Other Urban Areas (Ebirr)

	Year 1	*Year 2-4*	*Year 5-10*
Staff: 2 Professional & 1 Support	125,000	125,000	25,000
Vehicles & Equipment	100,000		
LC Mtad Promotion & Demonstration	50,000	75,000	
Monitoring & Evaluation			25,000
Operations & Maintenance	20,000	20,000	
Contingencies (15%)	44,250	33,000	7,500
TOTAL	339,250	253,000	57,500

The proposed low cost electric mtad development and dissemination program can be reasonably expected to lead to the incremental effects displayed in Figure A2.2 below alongside the natural rate of electric mtad diffusion now underway in Addis Ababa and other urban areas.

Figure A2.3



Program costs and estimates of incremental penetration are used to evaluate the economic implications of the proposed low cost electric mtad development and dissemination programs in Addis Ababa and other urban areas in Tables A2.11-12 below. Since the program is designed to appeal to households that would otherwise have prepared injera over an open fire, consumers bear the additional cost of 250 Birr for each low cost electric mtad (a low cost electric mtad costs roughly 250 Birr while a traditional ceramic mtad for use over an open fire costs 6 Birr). Biomass savings resulting from the incremental penetration of low cost electric mtads are determined by multiplying the projected total quantity of biomass to be used by households for preparing injera in the base case forecast by the incremental share of households that choose to purchase a low cost electric mtad. Additional electricity used by these households is quantified using the same assumptions as in the household fuel use forecasts (715 kWh/hh/yr for an average household of 5 people) and valued at the domestic LRMC estimate of 53E¢/kWh. Biomass savings are valued at Birr 650/ton in Addis Ababa and Birr 450/ton in other urban areas. Under these assumptions, the proposed low cost electric mtad development and dissemination program yields economic returns of 20% in Addis Ababa. The proposed program is not economic in other urban areas since the economic value of biomass displaced is lower than the additional economic costs of the mtads and the electricity that they would consume.

Table A2.10 Low Cost Electric Mtad Development & Dissemination in Addis Ababa

Year	*Low Cost Electric Mtad Program Costs (EBirr '000)*	*Increased Penetration %*	*Mtad Sales + Repl #*	*LC Electric Mtad Cost EB250/mtad (EBirr '000)*	*Electricity MWh*	*Electricity LRMC Ec53/kWh (EBirr '000)*	*Biomass Savings Tons*	*Economic Value EB650/Ton (EBirr '000)*	*Net Economic Benefits (EBirr '000)*
1995	1,323								-1,323
1996	1,236	0.5%	996	249	1,730	917	1,922	1,249	-1,153
1997	1,236	0.8%	1,644	411	2,903	1,538	3,225	2,096	-1,089
1998	1,236	1.2%	2,638	660	4,785	2,536	5,316	3,456	-976
1999	230	1.8%	4,060	1,015	7,681	4,071	8,535	5,548	231
2000	230	2.7%	5,885	1,471	11,879	6,296	13,199	8,579	582
2001	230	3.8%	7,870	1,967	17,493	9,271	19,437	12,634	1,165
2002	230	5.0%	11,217	2,804	24,302	12,880	27,002	17,552	1,637
2003	230	6.2%	10,772	2,693	31,737	16,820	35,263	22,921	3,177
2004	230	7.3%	11,722	2,930	39,100	20,723	43,445	28,239	4,355
2005	230	8.2%	11,782	2,946	45,870	24,311	50,967	33,128	5,642
								EIRR	20%

Table A2.11 Low Cost Electric Mtad Dissemination in Other Urban Areas

Year	*Low Cost Electric Mtad Program Costs (EBirr '000)*	*Increased Penetration %*	*Mtad Sales + Repl #*	*LC Electric Mtad Cost EB250/mtad (EBirr '000)*	*Electricity MWh*	*Electricity LRMC Ec53/kWh (EBirr '000)*	*Biomass Savings Tons*	*Economic Value EB450/Ton (EBirr '000)*	*Net Economic Benefits (EBirr '000)*
1995	1,696								-1,696
1996	1,265	0.5%	2,096	524	3,639	1,929	4,043	1,820	-1,898
1997	2,961	0.8%	3,458	865	6,106	3,236	6,784	3,053	-4,009
1998	2,530	1.2%	5,550	1,388	10,065	5,335	11,183	5,033	-4,219
1999	1,553	1.8%	8,542	2,135	16,158	8,564	17,954	8,079	-4,173
2000	1,553	2.7%	12,379	3,095	24,989	13,244	27,765	12,494	-5,397
2001	575	3.8%	16,555	4,139	36,798	19,503	40,886	18,399	-5,818
2002	575	5.0%	23,596	5,899	51,121	27,094	56,802	25,561	-8,008
2003	575	6.2%	22,660	5,665	66,761	35,383	74,178	33,380	-8,243
2004	575	7.3%	24,658	6,164	82,250	43,593	91,389	41,125	-9,207
2005	575	8.2%	24,784	6,196	96,491	51,140	107,212	48,246	-9,666
								EIRR	

Overall CEINFM Demand Management Program

The economically viable programs evaluated above are presented here as a continued Cooking Efficiency and New Fuels Marketing Program. These elements include: extended efforts to support the dissemination of the Lakech charcoal stoves in other urban areas; development and dissemination of the Mirte biomass injera mtad in Addis Ababa and other urban areas; and development and dissemination of a low cost electric mtad in Addis Ababa. Overall program expenditures, including periodic visits by international consultant to assist with program design, monitoring, and evaluation, are displayed in Table A2.13 below.

Table A2.12 Annual Costs for Overall CEINFM Demand Management Program (EBirr)

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5-6*	*Year 7-11*
Field Office Staff: 80 Prof. & 30 Support	1,625,000	1,625,000	4,250,000	3,250,000	1,875,000	500,000
Addis Ababa Staff: 20 Prof. & 10 Support	1,250,000	1,250,000	1,250,000	1,250,000	250,000	250,000
International Consultants	1,250,000	625,000	625,000	250,000	0	0
Vehicles & Equipment	1,900,000	0	1,500,000	0	0	0
Development and Testing	300,000	300,000	300,000	300,000	0	0
Promotion & Demonstration	750,000	1,100,000	1,600,000	1,850,000	750,000	0
Monitoring & Evaluation	0	150,000	150,000	150,000	400,000	650,000
Operations & Maintenance	325,000	325,000	550,000	550,000	225,000	0
Contingencies (15%)	1,110,000	806,250	1,533,750	1,140,000	525,000	210,000
TOTAL	8,510,000	6,181,250	11,758,750	8,740,000	4,025,000	1,610,000

Overall CEINFM program costs, additional consumer costs, economic benefits, and net benefits are presented in Table A2.14 below. The overall demand management program yields a healthy 35% economic rate of return.

Table A2.13 CEINFM Demand Management Program

Year	*CEINFM Program Costs (EBirr '000)*	*Additional Consumer Costs (EBirr '000)*	*Economic Value of Net Fuel Savings (EBirr '000)*	*Net Economic Benefits (EBirr '000)*
1995	8,510	0	0	-8,510
1996	6,181	333	2,153	-4,361
1997	11,759	565	3,965	-8,359
1998	8,740	976	6,982	-2,734
1999	4,025	1,433	11,553	6,095
2000	4,025	2,177	17,540	11,338
2001	1,610	3,056	24,130	19,464
2002	1,610	4,145	30,457	24,701
2003	1,610	4,821	36,247	29,816
2004	1,610	6,142	41,934	34,182
2005	1,610	6,913	48,387	39,864
			EIRR	35%

Project to Improve Charcoal Production Practices

Previous efforts to improve the efficiency of charcoal production in Ethiopia have been largely unsuccessful. However, there is a large potential to raise the efficiency of charcoal transformation in traditional earthen kilns by improving kiln firing and tending practices. Indicative costs of a national project to assist kiln operators to improve yields through better kiln management are proposed and evaluated below. The project is to be staffed by 10 professionals and 5 support staff, with assistance from international consultants. The project office is to be equipped with at least two vehicles and appropriate computing and office equipment. Training and demonstration are to be conducted over a ten year period in association with an existing effective extension service. Without such a long-term and sustained commitment to improving traditional charcoal production practices, it will be difficult to make a significant impact on the methods employed by the thousands of small informal charcoal producers throughout the country. Project costs are detailed in Table A2.15 below.

Table A2.14 Annual Charcoal Production Improvement Project Costs (EBirr)

	Year 1	*Year 2-4*	*Year 5*	*Year 6-11*
Staff: 10 Professional & 5 Support	625,000	625,000	625,000	625,000
International Consultants	1,000,000	250,000	250,000	
Vehicles & Equipment	400,000		400,000	
Improved Methods Demonstration & Training	125,000	175,000	175,000	175,000
Monitoring & Evaluation		25,000	25,000	50,000
Operations & Maintenance	100,000	100,000	100,000	100,000
Contingencies (15%)	337,500	176,250	236,250	142,500
TOTAL	2,587,500	1,351,250	1,811,250	1,092,500

If initiated in 1995 and sustained for 10 years, the proposed improved charcoal production methods project can be reasonably expected to result in improved methods being used for 25% of all urban charcoal by the year 2005. Project costs above and diffusion of improved methods reaching 25% of all urban charcoal in the year 2005 are used to evaluate the economic implications of the proposed charcoal production project in Table A2.16 below. Wood savings are calculated by assuming that the adoption of improved methods alone can easily decrease the amount of wood feedstock required to yield a given quantity of charcoal by 25%. Wood savings are valued at Birr 200/ton (the average economic value of woody biomass in rural areas). Under these assumptions, the proposed charcoal production project yields an economic return of 25%, with the benefits obtained largely by charcoalers.

Table A2.15 Project to Improve Charcoal Production Practices

Year	*Charcoal Production Program Costs (EBirr '000)*	*Share of Urban Charcoal Improved %*	*Improved Charcoal Tons*	*Wood Savings Tons*	*Economic Value EB200/Ton (EBirr '000)*	*Net Economic Benefits (EBirr '000)*
1995	2,588					-2,588
1996	1,351	0.5%	842	1,403	281	-1,071
1997	1,351	0.9%	1,364	2,273	455	-897
1998	1,351	1.5%	2,097	3,494	699	-652
1999	1,811	2.4%	3,322	5,537	1,107	-704
2000	1,093	3.8%	5,378	8,963	1,793	700
2001	1,093	6.0%	8,525	14,208	2,842	1,749
2002	1,093	9.1%	13,121	21,869	4,374	3,281
2003	1,093	13.4%	19,397	32,329	6,466	5,373
2004	1,093	18.9%	27,215	45,358	9,072	7,979
2005	1,093	25.0%	35,885	59,808	11,962	10,869
Evaluated on the basis of charcoal for all urban markets.					EIRR	25%

Past And Projected Fuel Substitution In The Household Sector

A1. Fuel use in Ethiopian households has been studied extensively since 1979 (CSO 1984, CEPPE 1986, CESEN 1986, and CEINFMP 1991, 1992, 1993, 1994). Despite the amount of attention paid to household fuel use and woodfuel supply systems, no consistent and coherent basis exists to assess how patterns of fuel use in urban and rural households in Ethiopia have responded to changes in woody biomass resource conditions and to government policy on distribution of conventional fuels and stoves.

A2. It is possible, however, to infer changes in household fuel use in Addis Ababa by drawing evidence from several of these studies. According to a 1979/80 CSO household energy survey in Addis Ababa, wood and charcoal each provided roughly 40% of household cooking services (in terms of end use energy). Dung, agricultural residues, and other biomass provided about 10%. LPG met about 8% of cooking needs and electricity may have met as much as 2% of total cooking needs. Kerosene was essentially not a cooking fuel in Addis Ababa in 1980 (Table A4.8).

A3. In 1983, market prices for wood and charcoal were between 50% and 100% more expensive than the controlled prices of LPG, kerosene, and electricity (Tables 2.10, 2.11, and 2.12, IBRD/UNDP 1984). By mid-1985, 38% of households in Addis Ababa owned a kerosene stove and 15% had an LPG stove. At that time, electric mtads were in 23% of homes and 14% of households relied exclusively on electricity for preparing injera (Tables VII.9 and X.8, CEPPE 1986).

A4. Kerosene and electricity appear to have displaced wood and charcoal in Addis Ababa since 1985 and 1989. Forty (non-representative) households from the 1985 CEPPE survey were revisited in 1989. Of these households, the number reporting that they frequently use kerosene and electricity for cooking increased by 25% and 48%, respectively and frequent users of wood and charcoal declined by 37% and 35%, respectively (Table 23, CEINFMP 1992a).

A5. By 1991, private sector producers of electric mtads and importers of kerosene stoves had become dominant suppliers in meeting demand. A survey 865 (representative) households in Addis Ababa in August 1991 showed that the share of households owning an electric mtad had risen to 48% with 30% using only electricity for baking injera[3] (CEINFMP 1992a). As of September 1994, Fully 91% of households in Addis Ababa owned a kerosene stove (Table A4.1), thereby completing the transition from no use of kerosene as a household cooking fuel in 1980 to complete penetration of the Addis Ababa residential market in 1994.

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3 Fully 97% of households in Addis Ababa were electrified by 1991, either directly or through a shared meter.

The share of households cooking with LPG remained relatively constant at 17%. Moreover, electricity had become as important as biomass fuels for preparing injera as 62% of homes owned an electric mtad.

A6. Estimates of household fuel use in 1991 and 1992 are omitted in the tables below for two reasons. Civil disturbances severely disrupted the distribution of kerosene and LPG during this period. Moreover, the population of Eritrea, part of Ethiopia throughout the 1980s, is not included in projections for Ethiopia after 1992.

Table A4.16 Stove Ownership in Addis Ababa, September 1994

Average family size of sampled households	7.11
% of sample households with an open fireplace	86%
% of sample households regularly cooking injera on an open fireplace	45%
% of sample households owning a charcoal stove	91%
% of sample households owning a Lakech stove	22%
Lakech as % of all charcoal stoves in Addis Ababa households	18%
Average number of charcoal stoves in households using charcoal	1.40
% of sample households owning a kerosene stove	91%
Average number of kerosene stoves in households cooking with kerosene	1.14
% of sample households owning an LPG stove	17%
% of sample households using electricity	97%
% of sample households with a metered connection	73%
% of sample households sharing a meter	24%
% of sample households owning an electric mtad	62%
% of sample households owning an electric mtad and no fireplace	9%
% of sample households owning a small electric stove	3%

Source: Fuel & Stove Survey conducted by CEINFM enumerators for the main Energy Assessment mission, September, 1994.

Table A4.17 Ethiopia Household Fuels Consumption Forecast

Population Growth Rate Projections				*Population Projections (thousands)*			
	Rural	*Urban*	*Addis*	*Rural*	*Urban*	*Addis*	*Tot Urb*
1980	2.8%	5.6%	5.6%	33,762	3,109	1,098	4,208
1981	2.8%	5.6%	5.6%	34,707	3,284	1,160	4,443
1982	2.8%	5.6%	5.6%	35,679	3,467	1,224	4,692
1983	2.8%	5.6%	5.6%	36,678	3,662	1,293	4,955
1984	2.8%	5.6%	5.6%	37,705	3,867	1,365	5,232
1985	2.8%	5.6%	5.6%	38,761	4,083	1,442	5,525
1986	2.8%	5.6%	5.6%	39,846	4,312	1,523	5,835
1987	2.8%	5.6%	5.6%	40,962	4,553	1,608	6,161
1988	2.8%	5.6%	5.6%	42,109	4,808	1,698	6,506
1989	2.8%	5.6%	5.6%	43,288	5,078	1,793	6,871
1990	2.8%	5.6%	5.6%	44,500	5,362	1,893	7,255
1991	2.9%	4.9%	4.9%	42,980	4,234	2,013	6,247
1992				44,247	4,442	2,112	6,553
1993	2.9%	4.9%	4.9%	45,551	4,659	2,215	6,874
1994	2.9%	4.9%	4.9%	46,894	4,888	2,323	7,211
1995	2.9%	4.9%	4.9%	48,276	5,127	2,437	7,564
1996	2.9%	4.9%	4.9%	49,700	5,378	2,557	7,935
1997	2.9%	4.9%	4.9%	51,165	5,642	2,682	8,324
1998	2.9%	4.9%	4.9%	52,673	5,918	2,813	8,732
1999	2.9%	4.9%	4.9%	54,226	6,208	2,951	9,160
2000	2.9%	4.9%	4.9%	55,825	6,513	3,096	9,609
2001	2.9%	4.9%	4.9%	57,470	6,832	3,248	10,079
2002	2.9%	4.9%	4.9%	59,164	7,166	3,407	10,573
2003	2.9%	4.9%	4.9%	60,909	7,518	3,574	11,091
2004	2.9%	4.9%	4.9%	62,704	7,886	3,749	11,635
2005	2.9%	4.9%	4.9%	64,553	8,272	3,933	12,205

1980 - 1990 populations estimated by assumed annual growth rates.
1991 - 2005 projections @ 3.2% national growth, 4.9% urban growth.

Table A4.18 Ethiopia Household Fuels Consumption Forecast

	Dung (T)			Crop residues (T)			Woody biomass (T)			Charcoal (T)		
	Rural	*Oth Urban*	*Addis*	*Rural*	*Oth Urban*	*Addis*	*Rural*	*Oth Urban*	*Addis*	*Rural*	*Oth Urban*	*Addis*
1980	3,090,252	173,249	10,753	2,213,424	84,049	30,624	21,315,348	1,052,156	298,382	53,099	59,387	44,741
1981	3,176,779	182,882	11,249	2,275,400	88,722	32,035	21,912,178	1,110,652	312,131	54,585	62,681	47,143
1982	3,265,728	192,992	11,777	2,339,111	93,627	33,540	22,525,719	1,172,056	326,788	56,114	66,128	49,859
1983	3,357,169	203,738	12,413	2,404,606	98,840	35,352	23,156,439	1,237,313	344,445	57,685	69,807	53,454
1984	3,451,169	215,127	13,074	2,471,935	104,365	37,235	23,804,819	1,306,480	362,789	59,300	73,716	57,359
1985	3,547,802	227,186	13,677	2,541,150	110,215	38,950	24,471,354	1,379,713	379,499	60,960	77,865	60,998
1986	3,647,141	239,806	14,005	2,612,302	116,338	39,886	25,156,552	1,456,358	388,624	62,667	82,189	62,860
1987	3,749,261	253,101	13,904	2,685,446	122,787	39,598	25,860,936	1,537,097	385,821	64,422	86,744	61,837
1988	3,854,240	266,877	13,599	2,760,639	129,470	38,730	26,585,042	1,620,760	377,356	66,226	91,420	59,552
1989	3,962,159	281,088	12,951	2,837,937	136,365	36,882	27,329,423	1,707,065	359,357	68,080	96,187	55,000
1990	4,073,099	296,412	12,939	2,917,399	143,799	36,850	28,094,647	1,800,131	359,042	69,986	101,402	55,181
1991												
1992												
1993	4,169,350	255,248	12,689	2,986,339	123,829	36,136	28,758,546	1,550,137	352,088	71,640	87,074	55,148
1994	4,292,262	265,950	12,422	3,074,377	129,021	35,376	29,606,348	1,615,131	344,682	73,752	90,479	54,081
1995	4,418,798	276,981	12,563	3,165,009	134,373	35,777	30,479,143	1,682,127	348,590	75,926	93,974	55,900
1996	4,549,064	287,722	12,479	3,258,314	139,583	35,540	31,377,669	1,747,353	346,274	78,165	97,233	56,045
1997	4,683,171	296,620	11,850	3,354,369	143,900	33,748	32,302,682	1,801,394	328,815	80,469	99,432	52,185
1998	4,821,231	304,748	10,341	3,453,256	147,843	29,451	33,254,965	1,850,756	286,949	82,841	101,151	41,905
1999	4,963,360	313,916	9,569	3,555,058	152,290	27,251	34,235,322	1,906,430	265,512	85,283	103,366	36,745
2000	5,109,680	324,010	9,401	3,659,861	157,187	26,772	35,244,579	1,967,732	260,848	87,798	106,032	35,750
2001	5,260,314	334,134	9,197	3,767,753	162,099	26,192	36,283,589	2,029,220	255,199	90,386	108,689	34,338
2002	5,415,388	344,371	8,950	3,878,827	167,065	25,489	37,353,229	2,091,389	248,349	93,050	111,405	32,450
2003	5,575,033	354,757	8,651	3,993,174	172,104	24,637	38,454,403	2,154,464	240,043	95,794	114,229	30,022
2004	5,739,385	365,275	8,289	4,110,893	177,206	23,605	39,588,038	2,218,338	229,992	98,618	117,188	26,982
2005	5,908,582	375,855	7,852	4,232,082	182,339	22,361	40,755,094	2,282,590	217,872	101,525	120,286	23,253

For sources and assumptions, see Tables A4.4-

Projections assume that the number of injera per capita and the amount of energy delivered for non-injera cooking remain unchanged throughout the projection period.

Table A4.19 Ethiopia Household Fuels Consumption Forecast

	Kerosene (T)			*LPG (T)*			*Electricity (GWh)*		
	Rural	*Oth Urban*	*Addis*	*Rural*	*Oth Urban*	*Addis*	*Rural*	*Oth Urban*	*Addis*
1980	119	2,054	214	0	208	3,953	0	46	77
1981	239	4,059	478	0	272	4,259	0	47	80
1982	509	8,451	1,222	0	385	4,423	0	56	95
1983	582	8,968	2,096	0	440	3,960	0	54	91
1984	867	11,613	4,853	0	438	3,212	0	52	88
1985	1,080	13,394	7,129	0	392	2,509	0	57	96
1986	1,684	19,678	12,314	0	378	2,165	0	57	96
1987	2,269	25,272	17,831	0	336	2,585	0	60	102
1988	2,688	29,090	21,980	0	483	3,384	0	61	104
1989	3,496	38,478	27,938	0	694	5,023	0	68	115
1990	3,651	37,682	31,690	0	736	4,582	0	74	125
1991							0	74	165
1992							0	106	206
1993	4,513	37,478	48,260	0	273	3,594	0	149	252
1994	5,130	42,598	54,872	0	290	3,810	0	158	267
1995	5,460	45,348	58,395	0	307	4,038	0	169	285
1996	6,006	49,883	64,234	0	325	4,281	0	182	308
1997	6,607	54,871	70,657	0	1,926	7,706	0	199	336
1998	7,267	60,358	77,723	0	4,075	16,300	0	219	369
1999	7,994	66,394	85,496	0	5,087	20,349	0	241	406
2000	8,794	73,033	94,045	0	5,153	20,612	0	265	447
2001	9,673	80,336	103,450	0	5,223	20,891	0	291	492
2002	10,640	88,370	113,795	0	5,297	21,187	0	320	541
2003	11,704	97,207	125,174	0	5,375	21,501	0	352	595
2004	12,875	106,928	137,691	0	5,458	21,833	0	387	654
2005	14,162	117,620	151,461	0	5,546	22,185	0	426	720

For sources and assumptions, see Tables A4.4-5

Projections assume that the number of injera per capita and the amount of energy delivered for non-injera cooking remain unchanged throughout the projection period

Substitution Assumptions

Rural	*Oth Urb*	*Addis*	
317	159	159	kg/cap/yr biomass for hh preparing injera with woody biomass
143	143	143	kWh/cap/yr for hh preparing injera with electricity
100%	95%	90%	share of households preparing injera at home.
969	850	939	utilized MJ/cap/yr for non-injera cooking (fit to 1984 total fuel use estimes from CESEN 1986).
		932	utilized MJ/cap/yr for non-injera cooking from CSO 1980.
12%	15%	15%	dung cooking conversion efficiency.
14%	17%	17%	woody biomass and agricultural residues cooking conversion efficiency.
5%	5%	5%	share of charcoal used for ironing.

Addis Ababa injera estimates from CEINFMP Laboratory Tests, EEA, October 1993.
kWh for injera from CEINFMP Analysis of Second Low Cost Electric Mtad Impact Assessment, EEA, March 1993.
See assumptions for each year above for share of households preparing injera on electric mtads.
See assumptions for each year above for share of household kerosene used for cooking.

1984 rural and urban traditional fuel use estimates from CESEN Main Report, 1986, p. 37 and CESEN Supplementary Report #14, 1986, pp. 7-11, 237-240.
1984 dung, agricultural residues, woody biomass, and charcoal consumed in Addis Ababa are mission estimates.
Addis share of national fuelwood and charcoal (from EPTAP Table C.19) x total consumption (from EEA 1994).
All historical estimates maintain the relative shares of each fuel in each area identified in CESEN 1986 and EEA February 1994.
All historical estimates utilize population growth estimates and the assumptions below.

Projections are based on population growth and substitution effects of conventional fuel supply growth.

Conversion Factors

Kerosene			
	Heating Value	35.3	MJ/liter
	Specific gravity	0.82	kg/liter
	Stove Efficiency	42%	
LPG			
	Heating value	45.2	MJ/kg
	Stove Efficiency	55%	

Table A4.20 Ethiopia Household Fuel Substitution

	HH using electricity for injera			*Electricity for Injera (MWh)*			*Biomass for preparing injera (T)*		
	Rural	*Oth Urb*	*Addis*	*Rural*	*Oth Urb*	*Addis*	*Rural*	*Oth Urb*	*Addis*
1980	0%	0%	8%	0	283	13,072	10,703,905	467,953	142,134
1981	0%	0%	10%	0	365	16,427	11,003,614	494,085	147,179
1982	0%	0%	12%	0	470	20,542	11,311,715	521,659	151,871
1983	0%	0%	14%	0	607	25,545	11,628,443	550,750	156,095
1984	0%	0%	16%	0	782	31,565	11,954,040	581,435	159,736
1985	0%	0%	19%	0	1,008	38,728	12,288,753	613,792	162,687
1986	0%	0%	22%	0	1,300	47,145	12,632,838	647,904	164,856
1987	0%	0%	25%	0	1,675	56,901	12,986,557	683,850	166,180
1988	0%	0%	28%	0	2,159	68,053	13,350,181	721,712	166,636
1989	0%	0%	32%	0	2,782	80,612	13,723,986	761,570	166,248
1990	0%	0%	35%	0	3,584	94,550	14,108,258	803,500	165,087
1991	0%	1%	38%	0	3,452	110,529	13,626,393	633,818	164,364
1992	0%	1%	42%	0	4,414	126,246	14,028,099	663,993	160,972
1993	0%	1%	45%	0	5,644	142,822	14,441,647	695,403	157,315
1994	0%	1%	48%	0	7,212	160,104	14,867,387	728,043	153,597
1995	0%	1%	51%	0	9,210	177,950	15,305,678	761,890	150,012
1996	0%	2%	54%	0	11,753	196,236	15,756,889	796,898	146,733
1997	0%	2%	56%	0	14,986	214,867	16,221,402	832,993	143,905
1998	0%	2%	58%	0	19,088	233,778	16,699,609	870,068	141,643
1999	0%	3%	60%	0	24,284	252,935	17,191,914	907,968	140,025
2000	0%	3%	62%	0	30,846	272,332	17,698,731	946,489	139,106
2001	0%	4%	63%	0	39,111	291,985	18,220,490	985,363	138,912
2002	0%	5%	64%	0	49,482	311,933	18,757,630	1,024,251	139,452
2003	0%	6%	65%	0	62,444	332,226	19,310,605	1,062,732	140,720
2004	0%	7%	66%	0	78,559	352,929	19,879,881	1,100,299	142,700
2005	0%	8%	67%	0	98,479	374,109	20,465,940	1,136,358	145,373

Table A4.21 Ethiopia Household Fuel Substitution

	% of kerosene for cooking			*Cooking kero & LPG (Util TJ)*			*Biomass for non-inj cooking (Util TJ)*		
	Rural	*Oth Urb*	*Addis*	*Rural*	*Oth Urb*	*Addis*	*Rural*	*Oth Urb*	*Addis*
1980	0%	0%	0%	0	5	98	32,717	2,638	933
1981	0%	0%	1%	0	7	106	33,633	2,784	983
1982	0%	0%	1%	0	10	110	34,575	2,937	1,040
1983	0%	1%	3%	0	12	100	35,543	3,101	1,114
1984	0%	1%	7%	0	12	86	36,538	3,274	1,196
1985	0%	1%	15%	0	12	82	37,561	3,458	1,272
1986	0%	1%	29%	0	15	119	38,613	3,651	1,311
1987	0%	2%	49%	0	17	221	39,694	3,853	1,289
1988	0%	3%	68%	0	27	353	40,805	4,061	1,242
1989	0%	4%	82%	0	44	537	41,948	4,272	1,147
1990	0%	5%	90%	0	54	628	43,122	4,504	1,150
1991	0%	7%	94%						
1992	0%	10%	96%						
1993	0%	13%	96%	0	93	930	44,141	3,868	1,150
1994	0%	17%	97%	0	136	1,054	45,443	4,019	1,128
1995	0%	22%	97%	0	184	1,123	46,782	4,174	1,165
1996	0%	27%	97%	0	253	1,232	48,161	4,319	1,168
1997	0%	33%	97%	0	379	1,430	49,581	4,416	1,088
1998	0%	40%	97%	0	538	1,768	51,043	4,493	874
1999	0%	47%	97%	0	686	2,005	52,548	4,591	766
2000	0%	53%	97%	0	826	2,162	54,097	4,710	745
2001	0%	58%	97%	0	979	2,334	55,692	4,828	716
2002	0%	63%	97%	0	1,143	2,522	57,333	4,948	677
2003	0%	67%	97%	0	1,316	2,730	59,024	5,074	626
2004	0%	70%	97%	0	1,498	2,958	60,764	5,205	563
2005	0%	73%	97%	0	1,689	3,208	62,555	5,343	485

Table A4.22 Ethiopia Household Conventional Fuel Supply

	Household kerosene consumption (T)				Household LPG consumption (T)				GWh			
	Rural	Oth Urb	Addis	National	Rural	Oth Urb	Addis	National	Rural	Oth Urb	Addis	National
1978	314	5,591	377	6,282	0	148	2,810	2,958	0	36	62	98
1979	132	2,296	211	2,639	0	176	3,339	3,514	0	42	71	113
1980	119	2,054	214	2,388	0	208	3,953	4,161	0	46	77	123
1981	239	4,059	478	4,776	0	272	4,259	4,531	0	47	80	128
1982	509	8,451	1,222	10,182	0	385	4,423	4,808	0	56	95	151
1983	582	8,968	2,096	11,647	0	440	3,960	4,400	0	54	91	145
1984	867	11,613	4,853	17,333	0	438	3,212	3,650	0	52	88	141
1985	1,080	13,394	7,129	21,603	0	392	2,509	2,900	0	57	96	153
1986	1,684	19,678	12,314	33,676	0	378	2,165	2,543	0	57	96	153
1987	2,269	25,272	17,831	45,372	0	336	2,585	2,921	0	60	102	162
1988	2,688	29,090	21,980	53,758	0	483	3,384	3,867	0	61	104	165
1989	3,496	38,478	27,938	69,911	0	694	5,023	5,717	0	68	115	184
1990	3,651	37,682	31,690	73,023	0	736	4,582	5,317	0	74	125	200
1991									0	74	165	239
1992									0	106	206	312
1993	4,513	37,478	48,260	90,250	0	273	3,594	3,867	0	149	252	400
1994	5,130	42,598	54,872	102,600	0	290	3,810	4,099	0	158	267	424
1995	5,460	45,348	58,395	109,203	0	307	4,038	4,345	0	169	285	454
1996	6,006	49,883	64,234	120,123	0	325	4,281	4,606	0	182	308	491
1997	6,607	54,871	70,657	132,135	0	1,926	7,706	9,632	0	199	336	535
1998	7,267	60,358	77,723	145,349	0	4,075	16,300	20,375	0	219	369	588
1999	7,994	66,394	85,496	159,883	0	5,087	20,349	25,436	0	241	406	647
2000	8,794	73,033	94,045	175,872	0	5,153	20,612	25,765	0	265	447	712
2001	9,673	80,336	103,450	193,459	0	5,223	20,891	26,114	0	291	492	783
2002	10,640	88,370	113,795	212,805	0	5,297	21,187	26,484	0	320	541	861
2003	11,704	97,207	125,174	234,085	0	5,375	21,501	26,876	0	352	595	947
2004	12,875	106,928	137,691	257,494	0	5,458	21,833	27,291	0	387	654	1,042
2005	14,162	117,620	151,461	283,243	0	5,546	22,185	27,732	0	426	720	1,146

Historic Estimates
95% of national retail kerosene and LPG sales is assumed to be consumed in households.
95% of kerosene and all LPG consumed in households is assumed to be in urban areas as reported in Table 1, CESEN Main Report, 1986.

Projections
Residential kerosene consumption in Addis Ababa and other urban areas projected @ 10% annual growth.
5% of residential kerosene is consumed in rural areas.
National residential LPG consumption projected @ 6% plus expected production from Calub.
Calub is projected to produce 21,000 TPA beginning in 1997 (95% to be consumed in households).
As in 1993, it is assumed that 93% of residential LPG will be absorbed in the Addis Ababa market before Calub production and 80% thereafter.
National Residential EELPA sales projected using assumptions of Load Forecast Scenario 1: Lower Domestic Growth.
1994 annual growth rate = 6%, 95 = 7%, 96 = 8%, 97 = 9%, and 10% thereafter.
All residential electricity sales are assumed to be urban in the same ratio (Addis/other urban areas) as in 1980.

Conversion Factors

Heating value kerosene	35.3	MJ/liter
Specific gravity kerosene	0.82	kg/liter
Heating value LPG	45.2	MJ/kg

Table A4.23 Addis Ababa HH Fuel Consumption, CSO 1979/1980

	units /cap /mo	*unit*	*MJ/unit*	*baking injera % fuel*	*units/hh /month*	*Primary MJ/hh /month*	*eff*	*utilized MJ /hh /month*	*utilized MJ /capita /yr*	*non-injera cooking % fuel*	*units/hh /month*	*Primary MJ/hh /month*	*eff*	*utilized MJ /hh /month*	*utilized MJ /capita /yr*	*utilized energy*
dung	0.57	kg	12	44%	1.23	14.71	11%	1.62	3.95	56%	1.58	18.95	15%	2.84	6.93	1%
ag res	1.75	kg	15	44%	3.76	56.45	11%	6.21	15.14	56%	4.85	72.71	17%	12.36	30.15	4%
tiftif (pickings)	4.45	kg	11	44%	9.57	105.27	11%	11.58	28.24	56%	12.33	135.59	17%	23.05	56.21	
BLT	13.26	kg	15	44%	28.52	427.74	11%	47.05	114.75	56%	36.73	550.94	17%	93.66	228.42	
wood	4.15	kg	16	44%	8.92	142.80	11%	15.71	38.31	56%	11.50	183.92	17%	31.27	76.25	47%
charcoal	3.82	kg	30	0%	0.00	0.00		0.00	0.00	95%	17.86	535.69	34%	182.14	444.19	39%
kero	0.02	liters	35.3	0%	0.00	0.00		0.00	0.00	5%	0.00	0.17	42%	0.07	0.18	0%
LPG	0.3	kg	45.2	0%	0.00	0.00		0.00	0.00	100%	1.48	66.72	55%	36.70	89.50	8%
electricity	5.86	kWh	3.6	19%	5.40	19.44	45%	8.75	21.33	0%	0.00	0.00	60%	0.00	0.00	2%
Total cooking MJ						766.41		90.91	221.72			1,564.70		382.09	931.82	473.00

Avg HH size 4.92

Source: per capita averages and family size from Central Statistical Office, Report on the 1979/80 Household Energy Consumption Survey of Addis Ababa, July 1984.

1,098,000 1980 Addis Ababa population estimated from 1992 population estimate of 2,111,500 (CSA Statistical Abstract, 1990) at 5.6% annual growth rate.

assumptions:

80% of households prepare injera on a traditional biomass mtad. These households use an average of 60 kg of biomass fuel/mo for preparing injera (see below).

10% of households prepare injera on an electric mtad. These households use an average of 54 kWh of electricity/mo for preparing injera (see below).

10% of households purchase injera.

5% of charcoal is used for ironing.

95% of kerosene is used for lighting.

Injera cooking requirements		*fuel/hh/mo*	*fuel/cap/yr*	*efficiency*	*useful MJ/injera*
BLT	0.35 kg/injera	69.6	184	10%	0.46
wood	0.25 kg/injera	50.4	133	11%	0.44
electricity	0.27 kWh/injera	54.0	143	45%	0.44

calculations assume average of 25 injera/session & 2 sessions/week.

sources: CEINFMP Report on Laboratory Tests of the Biomass Injera Mtad, EEA, October 1993.

CEINFMP Analysis of Second Low Cost Electric Mtad Impact Assessment, EEA, March 1993.

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	103/89
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
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
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
Comoros	Energy Assessment (English and French)	01/88	7104-COM
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
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	09/95	175/95
Ethiopia	Energy Assessment (English)	07/84	4741-ET

Region/Country	*Activity/Report Title*	*Date*	*Number*
Ethiopia	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	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
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	--
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
	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
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95

Region/Country	Activity/Report Title	Date	Number
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
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
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Energy Assessment (English and French)	07/91	8017-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
	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, Vol. 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	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
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
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
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

Region/Country	Activity/Report Title	Date	Number
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
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
Zambia	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
	Petroleum Management Assistance (English)	12/89	109/89
	Power Sector Management Institution Building (English)	09/89	--
	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)	12/94	--

EAST ASIA AND PACIFIC (EAP)

Region/Country	Activity/Report Title	Date	Number
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
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

Region/Country	*Activity/Report Title*	*Date*	*Number*
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
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	--
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
	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
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
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84

Region/Country	*Activity/Report Title*	*Date*	*Number*
Nepal	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 Fomulation 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	--
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
	Industrial Energy Conservation Study (English)	03/86	054/86

EUROPE AND CENTRAL ASIA (ECA)

Eastern Europe	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
Portugal	Energy Assessment (English)	04/84	4824-PO
Turkey	Energy Assessment (English)	03/83	3877-TU

MIDDLE EAST AND NORTH AFRICA (MNA)

Morocco	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
	Energy Sector Institutional Development Study (English and French)	05/95	173/95
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
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

LATIN AMERICA AND THE CARIBBEAN (LAC)

LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	National Energy Plan (Spanish)	08/91	131/91
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92

Region/Country	*Activity/Report Title*	*Date*	*Number*
Bolivia	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
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
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
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
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU

Region/Country	*Activity/Report Title*	*Date*	*Number*
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

GLOBAL

	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	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
	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	11/95	177/95

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