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ENVIRONMENTAL ASSESSMENT

of the

RURAL ELECTRIFICATION I PROJECT

in

INDONESIA

prepared for the

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Embassy of the UNITED STATES OF AMERICA

Jakarta, Indonesia

by

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EXECUTIVE SUMMARY

This environmental assessment views rural electrification as an energy project which introduces energy in a form previously unavailable in rural areas. Earlier assessments of other AID-sponsored projects have taken a more limited view of rural electrification and have restricted their analysis to the impact of the construction of the physical facilities necessary to bring the electricity into rural areas. This limited point of view prevented a serious consideration of alternative energy projects as is called for by AID environmental regulations. However, this assessment concerns itself with the impact of the introduction of a new energy source on rural energy use, particularly on the use of those fuels which are of significance in the rural environment. Unlike previous efforts this assessment considers the full range of rural energy needs and possible energy programs from an environmental viewpoint. The aim of this assessment is to articulate the environmental aspects of rural energy use so that they can become factors in the design of rural energy projects.

The questions addressed in this assessment concern how planners can evaluate the priority of need for different forms of energy in rural areas. The underlying premise of this assessment is that the progress of rural development is increasingly threatened by both the sharply rising cost of energy in the form of imported fuels and the steadily deteriorating supply of local, traditional fuels such as firewood and crop residues. Since most current rural energy needs are met by use of biomass fuels, the stability of local natural resource systems has an important influence on the pattern of energy use in rural areas. This assessment makes the conservative assumption that further growth in energy use in rural areas must build upon a secure local supply base. Therefore, a high priority must be given to efforts to assure the continued adequacy of current sources, many of which, such as forested upper watersheds, must be maintained in good health for overall environmental stability.

In order to determine the adequacy of rural energy resources, a survey was made of energy use in three rural electrification projects. Based on the survey results, the assessment describes in detail the pattern of current energy use in both the rural household and industrial sectors. Before any questions concerning the stability of the local resource base could be answered, the relationship between present and future rural energy needs and local supplies had to be analyzed carefully.

A major finding growing out of the survey is that the energy supply-use relationship in rural areas follows a particular set of rules. These rules are sufficiently different from those heretofore described that they warrant a new name, "rural energy involution." The term involution is appropriate because the phenomenon described embodies the seeming paradox that as demand on local sources of traditional fuels increases, the efficiency with which these sources are exploited also increases. Unfortunately, this beneficial aspect of energy involution is counterbalanced by two major negative effects which over time will blunt the impact of rural development efforts. One effect is that the removal of crop residues from fields threatens the productivity of rural agriculture. The other effect is that the increased time and effort needed by rural

household members to use fuels of ever-lower quality ties up household labor in activity that is of little productivity.

If the deterioration in the natural resource base implied by involution is not checked, the impact of rural development activities such as rural electrification will be undermined. It is this realization which leads to the main recommendation of this report which is that if a rural electrification project is successful in achieving its stated aims of an improved quality of life or increased rural productivity, it must be part of a comprehensive rural energy program.

A comprehensive rural energy program begins with the understanding that rural energy needs will continue to be met in the foreseeable future by two different kinds of sources and supply systems: 1) Indigenous, traditional, low-quality biomass based fuels will continue to be necessary for household cooking and for the majority of existing industries as a cheap source of heat energy. 2) Imported high-quality fuels, such as kerosene, petroleum and electricity, will be needed in greater quantities, and at cheaper rates, if possible, to improve the quality of rural life, and to allow the growth of new industries exploiting new markets. The relative emphasis placed on these two kinds of energy in a comprehensive energy program depends on many factors, chief among which are population density and the condition of local energy resources.

For the foreseeable future both high and low quality fuels will have their place in rural life. Rural development, which is environmentally sound in the sense of being sustainable over the long-term, requires an assured supply of both kinds of fuel. Electricity, whether centrally or regionally generated, makes a clear contribution to the quality of life in rural areas, and on that basis alone must at some point be a part of rural energy programs. However, if the local resource base is threatened, energy planning should give first emphasis to programs which work to ensure a stable, cheap supply of lower quality fuels.

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I. IMPACT SUMMARY AND RECOMMENDATIONS

I-1 Introduction

This document is an environmental assessment of the Rural Electrification I Project in Indonesia. This project involves the development of the infrastructure necessary to supply electrical energy for seven project areas in Central Java and one project area in each of three outer island provinces, Lampung, South Sulawesi, and Western Nusa Tenggara. The United States Agency for International Development (AID) is a major financier of this project.

This assessment is the result of a collaborative effort between the consultants and the State Electricity Corporation, Perusahan Listrik Negara (PLN), and the Development Technology Center (DTC) of the Bandung Institute of Technology (ITB) to fulfill the intent of AID Regulation 16, which states that the purpose of environmental assessments conducted by AID are to "insure that the environmental consequences of proposed AID-financed activity are identified by AID and the host country...."

This document is not the first environmental assessment that has been made of rural electrification projects financed by AID. Previous assessments have been made in the Philippines and Pakistan. These environmental assessments have examined both the direct and indirect impacts of these rural electrification programs. This environmental assessment does not duplicate these earlier analyses but rather analyses the impacts of rural electrification from a different point of view.

The Indonesian rural electrification program is designed as a general energy development project, which along with other development efforts, is intended to improve the quality of rural life and stimulate rural employment. This assessment considers rural electrification as an energy project and therefore examines its impacts in terms of the consequences for rural energy use. It analyses these consequences in comparison with other possible alternative or complementary energy development projects. As this assessment was begun after Rural Electrification I was underway, and several demonstration villages already electrified, it can have no direct impact on the planning of Rural Electrification I. Therefore this study is written to guide the design of future rural energy projects, by providing information about the environmental aspects of rural energy use.

I-2 Direct impacts

Large scale development projects of whatever type involve two kinds of change. The first kind is physical and is associated with construction of works such as, in the case of rural electrification, transmission lines and generating stations. Physical changes usually take place over a short period of time. For rural electrification these changes are relatively minor compared to those of other infrastructure projects. All of the direct physical changes expected for rural electrification projects have already been examined in the previous assessments (Luken, 1978). These changes are largely associated with impacts on vegetation along the rights-of-way of transmission lines. These impacts have been judged to be minor by

previous environmental assessments, and there is no unique situation in Indonesia which would change this finding. The only possible exception is the possibility of loss of a few clove trees, one of the most valuable tree crops grown in home gardens. However, this impact is solely economic and is usually confined to at most a few trees owned by a new beneficiary of rural electrification.

For Rural Electrification I, the impact of the effluents of the process of fuel combustion for power generation is confined to the vicinity of large power stations which supply the grid in Java and the vicinity of relatively small power stations with a capacity of a few megawatts for the isolated systems in the outer islands of Sumatra, Sulawesi, and Lombok. The impacts of large scale power stations are examined by environmental assessments conducted by the agencies involved in planning for these installations. Therefore, analysis of these impacts is considered to be outside the scope of this assessment. The smaller generating facilities on the outer islands have only inconsequential emissions from diesel generator exhaust fumes. The only significant direct impacts of future rural electrification projects would be from construction of dams and other works for hydroelectric power generation.

I-3 Method of assessment of indirect impacts

The second type of change associated with all infrastructure projects concerns the uses made by the human population of the new facility. In the case of past rural electrification projects, specific secondary impacts have been examined if the rural electrification project was justified on the basis of a particular use of the electrical energy thereby provided. An example of such a use is the powering of electric pumps for irrigation in India and other countries. Earlier environmental assessments for these projects examined the impacts of new water regimes on water table levels and on the need for drainage. Although no such specific use of electrical energy is called for in this rural electrification project, human activity will vary in response to both project-related and other changes in environmental and socio-economic conditions. Only through understanding the changing interrelationships between the rural population, the rural natural resource base, and the pattern of energy use, can environmental factors be identified and described well enough so that they can have a proper influence on the planning of rural energy projects.

Once the rural energy supply-use relationships are known, then meaningful answers to questions about the future energy needs of rural populations can be obtained. One important question concerns the continued stability of the rural natural resource base. Are firewood supplies in jeopardy, are rural poor being forced to walk long distances to get fuels, etc.? To get information relevant to this kind of question it was necessary to conduct a survey of selected project areas to determine the existing pattern of energy use and the current state of the natural resource base.

The rural energy and natural resource survey was conducted under the auspices of the Development Technology Center of ITB. Students from ITB were employed as surveyors. The survey instrument was the product of a

collaborative effort between the consultants and DTC staff. The survey findings serve as the basis for an analysis of the interrelationships between the state of local natural resources and the rural population's changing pattern of energy use. This analysis provides the context for assessing a range of alternative rural energy projects, including rural electrification, in terms of their impact on the rural environment.

I-4 Findings of the energy survey

The results of the energy survey are examined in detail for households in Section II and for rural industries in Section III. These sections explain the methods and assumptions used to interpret survey findings. Listed below are the principal survey findings, followed by predicted impacts of rural electrification. General observations about overall rural energy use are presented first, followed by specific findings which define the role of rural electrification.

The findings are presented for the three project areas surveyed: Klaten in Central Java, Luwu in South Sulawesi, and Lombok in Western Nusa Tenggara. These three areas were chosen to represent a range of village firewood resources, with Lombok having the least and Luwu the most.

Energy use in households

1. For cooking, a broad middle range of families uses between 7.5 and 11 kg of firewood-equivalent (these weights include a 20% moisture content) per week per person in all surveyed areas. The only significant deviations are a high of 19 in the highest income stratum in Klaten and a low of 5 in the lowest stratum in Lombok. For cooking one liter of kerosene was found to be replaceable by 4.8 kg of firewood in a series of kitchen measurements.

2. Virtually the only purchased cooking fuels are firewood and kerosene, which together constitute 32% of total cooking fuel in Klaten, 35% in Luwu, and 43% in Lombok. Kerosene constitutes 24% of total cooking fuel use in Klaten, 2% in Luwu, and 19% in Lombok. Commercial firewood constitutes 6% of total cooking fuel use in Klaten, 32% in Luwu, and 24% in Lombok.

3. Self-gathered fuels, which constitute the remainder of cooking fuels, consist mostly of home garden "trash" and agricultural wastes from local village sources and are rarely "stemwood," or conventional firewood, most of which has its origin outside the village. Most houses have two or more stoves suited not to different foods but to different fuels, with the simplest "stoves," usually three rocks and a pot, for the lowest quality fuels.

4. Because electricity is more expensive for cooking than currently used fuels, it is unlikely to substitute firewood and kerosene use. The current pattern of fuel use for cooking will not be affected directly by rural electrification.

5. Household lighting is by kerosene lamp in all areas except the three villages in Klaten which were electrified two months at the time of the survey (July, 1979). Households which use kerosene for lighting consume 1.0 liter per week per person in Klaten, 0.8 in Luwu and 0.5 in Lombok. Kerosene used for lighting constitutes 31% of total household energy use in Klaten, 29% in Luwu, and 25% in Lombok.

6. In Klaten, electrified households initially consumed 1.6 kwh per week per person for lighting. This electricity usage provides the equivalent of 3 times the previous light levels from kerosene lamps at 2½ times the previous cost to the household. Electricity for Klaten, which is supplied by the Central Java grid, is generated by combustion of petroleum fuels. Generation of this amount of electricity consumes 80% of the petroleum fuel formerly burned in lamps. After a few months' bills the average dropped to 1.2 kwh.

7. The only other present household uses of electricity, for radios, tape cassettes, etc., consume energy in amounts insignificant compared with lighting.

8. In Klaten, Luwu and Lombok only 40% of the households regularly spend for all fuels at least as much as the minimum required for electric lights only.

9. If poorer families are forced by local firewood scarcity, even seasonally, to buy fuel for cooking, the expense will make it very difficult to maintain a year-round electrical hookup.

Energy use in rural, small scale, and household industries

1. Klaten is the most industrialized rural kabupaten in Central Java. The 1974/75 Industrial Census found that 16% of all of the small-scale industries in Central Java are in Klaten even though it has only 4.5% of the population of Central Java. Klaten, with a population of 1,100,000, has an estimated 52,000 home industries and 7,600 small-scale industries, which together employ the equivalent of 67,000 and 11,000 full-time workers respectively.

2. The volume of fuel use in industries is approximately 1/3 the volume of domestic fuel use in Klaten. In the other two surveyed areas the fraction is much less.

3. Most rural small industries produce goods only for local markets from local raw materials and with local biomass fuels. However, in Klaten approximately 70% of total industrial fuel needs, including both firewood and petroleum-based fuels, are imported from outside the kabupaten.

4. Although electricity can substitute 31% of current household energy use in Klaten, it can substitute only 10% of current industrial fuel use. The substitutable fuels are diesel and gasoline which are used to supply energy for rotating machinery.

5. However, the substitutable fuels are used by industries which are relatively more labor intensive than energy-intensive and thus these industries account for 22% of industrial employment in Klaten.

6. The profitability of many of the energy intensive industries is threatened by rising fuel costs. In Klaten the price of stemwood firewood has risen 300% in five years compared with general price inflation of 100%. In Lombok the rise has been 400%.

7. There are a number of industries which are so labor-intensive that they cannot employ workers at more than Rp. 300/day or are so energy-intensive that they cannot use fuel priced more than Rp. 40 per liter-equivalent (approximately Rp. 20 per kwh) and still be profitable. Examples are paper, pottery, sugar, bricks, lime, etc.

8. A major goal of Rural Electrification I is the promotion of rural employment through stimulation of rural industrial productivity. Productivity in any existing industry can be increased by improving products or marketing systems or by reducing the cost of production. The choice of fuels, including electricity, and the efficiency of energy and labor use play a direct role in only the cost of production and not in marketing or in product quality.

9. Electricity is too expensive to substitute for fuel for most existing industries. These industries employ 78% of the Klaten industrial labor force. Electricity is profitable for these industries only if it can be used in combination with new machinery and new manufacturing methodology to reduce labor input, thereby reducing the total cost of production.

10. In the face of the rapid increase in all fuel prices the only alternative for industries which are not able to improve their fuel or labor efficiency is to substitute cheaper, lower grade fuels such as agricultural wastes. Since such fuels are of local origin this substitution would put industry into direct competition with households for an increasingly scarce local supply of low grade fuels.

Energy and local natural resources

1. Local resources of renewable combustible material (biomass) meet 58% of total need in Klaten for domestic cooking and industrial process heat energy. Imported fuel makes up the rest: 33% from kerosene, 7% from imported firewood and 2% from charcoal.

2. Local sources are relatively more important for domestic cooking use (supplying 68% of demand) than for industrial use (supplying 33% of demand). In Luwu 65%, and in Lombok 57% of domestic needs are met from local sources. For most households there seem to be only two reasons anyone buys cooking fuel: insufficient local supply or a high value on family labor, usually because of a home industry.

3. In Klaten and Lombok, villagers use every type of biomass for fuel. At different seasons they use coconut leaves, bamboo roots, corn

stalks, rice straw, leaves, twigs, etc., as well as stemwood. In Luwu where forests are abundant, stemwood is the common fuel.

4. The dense rural populations of Klaten and Lombok use a significant portion of the total local renewable biomass resources as fuel. A rough estimate is 40% to 60%. Because of its pattern of land use (more home gardens) and agriculture (more irrigation) Klaten has more than twice the productivity of biomass than does Lombok.

5. In Lombok, where garden and agricultural wastes are in short supply, some of the poorest families must purchase fuels brought in from outside the village at an expense which takes up as much as 20% of their cash income. However, in Luwu and Klaten this point has not been reached and the poorest can still gather almost all of their cooking fuel.

6. To ease the fuelwood supply scarcities in Lombok energy intensive industries are being required to use kerosene which, with recent price increases, is more expensive than alternative fuels such as firewood. This fuel policy results from a growing awareness of the hardship caused by inadequate supplies of biomass fuels of local origin.

7. However, in Lombok, as well as in Klaten, poorer villagers rarely use stemwood such as is still used by many industries, but tend more and more toward use of lower grades of biomass, e.g. agricultural wastes, etc.

8. The trend toward using lower grades of fuel is analagous to "agricultural involution" and hence is called energy involution. It means that villagers are taking an ever-increasing percentage of the total annual local biological productivity (biomass) for fuel. Aside from the worry that these resources can be exhausted, there is a concern for the long-term impact on soil structure and fertility resulting from the loss of the organic matter and nutrients contained in the agricultural wastes which are removed from fields.

9. Since low grade fuels require more tending in cooking, family labor input increases, and in highly involuted areas, such as Klaten and Lombok, families spend 4 times as much time tending fuels as in gathering them. This extra labor has a partial reward as well-tended fires use less fuel.

10. As Klaten industries are being forced out of the stemwood market and are beginning to compete for low quality fuels of local origin, the share of total local biomass resources used for fuel which they take could rise from the present 15% (∿ 65,000 tons) to 47% (∿ 200,000 tons). Such an increase would affect severely the poorest 25% of villagers who gather virtually all of their cooking fuel.

I-5 Recommendations for future rural electrification projects.

1. Let local conditions set the priorities for rural energy programs. A major goal of rural electrification is the improvement of the quality of life in rural villages through increasing per capita energy consumption in rural areas. To this end the major use of electricity is to provide electric household lighting affordable by a significant percentage of villagers. An increasing threat to villagers' ability to pay for electricity comes from decreasing supplies of local renewable resources usable for cooking fuel. If these resources, now gathered for free, run out, then the poorest families will be forced to spend as much as 20% of their cash income on commercial cooking fuel. Such a severe drain on their financial resources will make it very difficult for the poorest to pay for electricity year-round.

   The state of local renewable energy resources should be evaluated prior to designating a rural electrification project area and programs should be designed to ensure adequate supplies of cooking fuel in project areas. If found to be necessary these programs should either preceed or accompany rural electrification programs.

2. Develop cheaper sources of electrical energy. A second major goal of rural electrification is the stimulation of rural industrial employment. Unless included as a component of a comprehensive program for development of new products and new markets, rural electrification by itself is likely to cause a decrease in rural employment by encouraging the adoption of labor saving manufacturing methods.

   High priority should be given to candidate areas which have developable hydropower and geothermal potential so that electricity can be provided at a fraction of its current cost, which is expensive because it is generated from combustion of petroleum fuels. More so than ever before cheap energy will stimulate productivity and employment almost anywhere, and therefore a local resource potential should be an overriding factor in project site selection.

3. Use rural electrification to enhance local energy resources. Indonesian rural areas face a steadily worsening crisis of energy quality as well as supply. Local renewable energy resources, which are already under pressure, will face more pressure as many energy intensive industries are driven to seek lower quality fuels from local sources. The use of lower quality fuels may eventually lead to lower quality industrial products and a worsening market position.

   Rural electrification projects should be tied to specific productive uses which increase or enhance local energy resources. Examples of such uses are: a) hydropower; b) pump irrigation, which increases crop productivity and thereby production of agricultural wastes which can be used as fuels; and c) pyrolysis, which can increase the useful value of local resources such as wastes by turning them into labor-saving charcoal briquets, suitable for both domestic and industrial use. However, all of these suggested productive uses,

if called for in the project paper, should be examined for their potential environmental consequences.

4. Institute energy conservation practices. Electrification for household lighting is a more efficient use of scarce petroleum supplies than direct combustion in a pump pressure lamp by a factor of three or more. However other possible uses of electricity, for example cooking, are not as efficient as direct combustion of a petroleum derived fuel.

From the beginning of an electrification project, information should be made available to potential customers concerning which electrical appliances are energy conserving and which are not. Electricity rates should not be so subsided that scarce non-renewable energy resources are wasted as would be the case if electricity were so cheap that it became commonly used for cooking instead of kerosene.

II. ENERGY USE IN THE HOUSEHOLD--

II-1 Rationale of the household energy survey

Since the aim of this environmental assessment is to examine environmental aspects of rural energy use, a survey was made to determine the relationship between rural energy use and natural resources. This survey was conducted to determine present energy use in households and industries in three rural electrification project areas so chosen to represent a range of natural resource conditions. The description of energy use patterns resulting from the survey serves as the background for understanding the changes likely to result from electrification. It is only with this knowledge of likely impacts from electrification that comparison of alternative projects can be meaningful.

The household survey was not designed to make a before and after project evaluation of the socio-economic impacts of electrification, as is being done in the Phillipines (NEA, 1978), but rather to identify the fundamental patterns of household energy use in relation to household income, labor availability, etc. The survey paid particular attention to the differences between households that consume large amounts of energy and those that consume small amounts of energy, and to the differences between households which purchase most of the energy that they use and households which depend more on gathered fuels. Survey questions were used to examine factors which influence the choice of fuels for particular purposes and to variables which seem strongly related to total volume of fuel consumption. These factors help to predict the impact of electrification which affects energy use by: 1) substituting electricity for existing fuels; and 2) allowing the growth of new demands for energy dependent upon electricity.

A goal of the survey is to relate the patterns of household energy consumption to demand on local natural resources. To this end several experiments were carried out under field conditions to measure the efficiency of conversion to fuels into forms of energy usable for household needs. Experiments were conducted on rates and efficiencies of fuel consumption of both lamps and stoves with the same fuels actually in use by survey area residents.

The three areas surveyed were chosen from among the ten project areas because of the widely varying availability of local natural resources presently used or potentially usable as energy resources. Although these local conditions are described in detail in section IV, a brief summary is presented here to provide a context for the analysis of household energy use.

Klaten in Central Java is representative of much of Java as it has a high population density which is supported by the increasing productivity of modern, intensive rice agriculture. As a consequence of the high density of population there is almost no forested land within the project area borders. However, the villagers of Klaten cutivate home gardens in addition to rice paddies and dry land crops, and traditionally they obtain a large amount of their cooking fuel from these home gardens as well as from agricultural crop residues. The forests, which are the main sources of commercial firewood, are so distant that the firewood is imported only through organized marketing channels.

Lombok has a lower population density than Klaten, but a much less productive agricultural base. Since there is not the same tradition of home garden cultivation in eastern Lombok as there is in Klaten, the sources of combustible material for cooking fuels are less convenient, being limited to crop residues and firewood brought from forests in nearby mountainous areas by independent small traders.

Luwu in South Sulawesi presents a third set of natural resource conditions. Luwu is experiencing rapid development as a consequence of the transmigration of Javanese and Balinese people. Since the land still has forests and since the population density in Luwu is the lowest by comparison with the other two areas, conveniently located fuelwood is readily available. However, in the future it is likely that Luwu will grow increasingly dependent on firewood gathered from home gardens, grown in local woodlots, or bought from traders who will bring it from mountain forests or coastal mangrove swamps.

In summary, the agriculture in all three areas is predominantly rice cultivation with the highest productivity and consequent greatest wealth found in Klaten. Luwu has both the most abundant and most convenient resources of firewood or other combustible materials while Klaten has much less abundant resources but still more than in Lombok. These differences have important implications as will be seen for determining the per capita energy consumption and the pattern of cooking fuel use in the three areas.

For each project area three villages were surveyed, with the exception of Klaten where six villages were surveyed to include three additional villages which were then recently electrified as a demonstration project. Outside of the three demonstration villages, villages were chosen to represent the range of local socio-economic conditions. The final choice of village was made by the supervisor after discussions with local officials. Within each village 15 households were chosen by agreement between the local village headman and the surveyor. The 15 households were selected to represent the distribution of land ownership in the community. Since there were so many landless families in Klaten, a number of such families were included so as to have a better representation of the community. Inclusion of the landless in the survey is important as they have less direct access to agricultural residues, an important fuel source, than do the landed.

The two supervisors and twelve surveyors were recruited from faculty and students at the Bandung Institute of Technology (ITB) and Padjajaran University. One student was assigned to each village for a period of a month during which time he conducted measurements and interviews with the 15 families selected. At the end of the field survey, the surveyors returned to Bandung where the data were analyzed in cooperation with the Development Technology Center at ITB. Design of the survey questionnaire and preliminary data analysis were the responsibility of John H. Arnold, Jr.

II-2 Household consumption of energy for cooking

The results of the survey of household use of cooking fuel are shown in figure II-1 and in table II-1. There are three different ways average values are calculated. The value given in the table for average household use is the sum of the values of per capita consumption of each household divided by the number of households in the sample. The number of households in the sample average excludes those households in which there is a home industry consuming fuel and in which that industry's fuel use is inseparable from domestic cooking use. Although the energy use of home industries is analyzed fully in section III, those homes with an industry producing food for sale and consumption in the local community are placed in a separate category in table II-1 and are ultimately included in the total sample average as their fuel use is legitimately considered to be a component of the community need for cooking fuel. The average individual value given in table II-1 is the sum of the total energy used by households in the sample divided by total number of the members of sampled households.

Each household's energy use, operationally defined as the amount of fuel used, was measured daily over a three to five day period. The amount of firewood and agricultural wastes used was weighed with calibrated scales, and the kerosene used was measured with volumetric bottles. These daily records were then averaged and converted to firewood equivalents by the following conversion factors: one kilogram of agricultural residue or home garden combustible material is considered the equivalent of 0.8 kilogram of "stemwood" firewood in its utility for cooking and one liter of kerosense is considered the equivalent of 4.8 kilograms of firewood. The firewood equivalent conversion factors are based on relative stove efficiency measurements conducted during the course of the survey. It should be emphasized that these equivalencies are based on measurement of fuel replacement, not of actual calorific value of fuels. These measurements are described in section II-6.

There are several reasons why the distribution of values of household energy consumption varies as widely as seen in the histogram of figure II-1. Significant differences between households arise with differences in the ages of household residents, the kind of food cooked, and most importantly, the number of people eating at each meal. In the histogram of Klaten households ranked by consumption of cooking energy, the distribution shows a double peak if households with home food industries are excluded. This can be explained by the fact that higher income households in Klaten almost invariably have greater land holdings and therefore regularly feed agricultural laborers, thus increasing the apparent per capita consumption of cooking fuel in that particular household if the calculation is made on the basis of the number of persons domiciled. Conversely households with little or no land possessions often send one, two, or even three household members to work elsewhere where they are fed a large midday meal, thereby lowering their apparent per capita consumption. This double peak is not seen in the Lombok histogram where land ownership is more nearly universal, as can be seen in table II-2, and where presumably agricultural labor requirements are more uniform as well. The Luwu histogram would closely match the shape of Lombok's histogram except for the inclusion of Sukamaju where only half the villagers farm their land, the other half preferring to engage in trade.

TABLE II-1

HOUSEHOLD USE OF COOKING ENERGY

(Kilogram Firewood Equivalents Per Week Per Capita)

Village	Sample Size	Average Household Use	Standard Deviation	Number of Individuals	Average Individual*
Klaten					
Karang Anon	10	8.7	3.9	75	8.0
Jonggrangan	13	10.0	3.9	96	9.9
Gergunung	15	8.2	5.4	85	7.5
Cokro	14	8.5	1.6	84	8.2
Ngaran	13	10.9	2.6	68	10.5
Krajan	13	7.7	3.9	73	7.7
Klaten (All)	78	9.0	3.8	481	8.6
Lombok					
Aikmel	15	7.1	1.9	89	6.7
Pohgading	13	5.2	2.1	89	5.1
Anjani	14	7.1	2.3	104	6.9
Lombok (All)	42	6.5	2.2	282	6.3
Luwu					
Ketulungan	12	10.2	3.4	69	9.4
Sukamaju	13	10.9	4.3	89	9.9
Sukaraya	15	9.8	5.7	75	8.4
Luwu (All)	40	10.3	4.6	233	9.4
All	160	8.7	3.9	996	8.2
Households with Home Food Industries	19	19.2	16.4	116	16.7
TOTAL SAMPLE	179	9.9	7.3	1,112	9.0

* Total energy used by all surveyed households divided by total number members of household. See text for discussion of how averages are calculated.

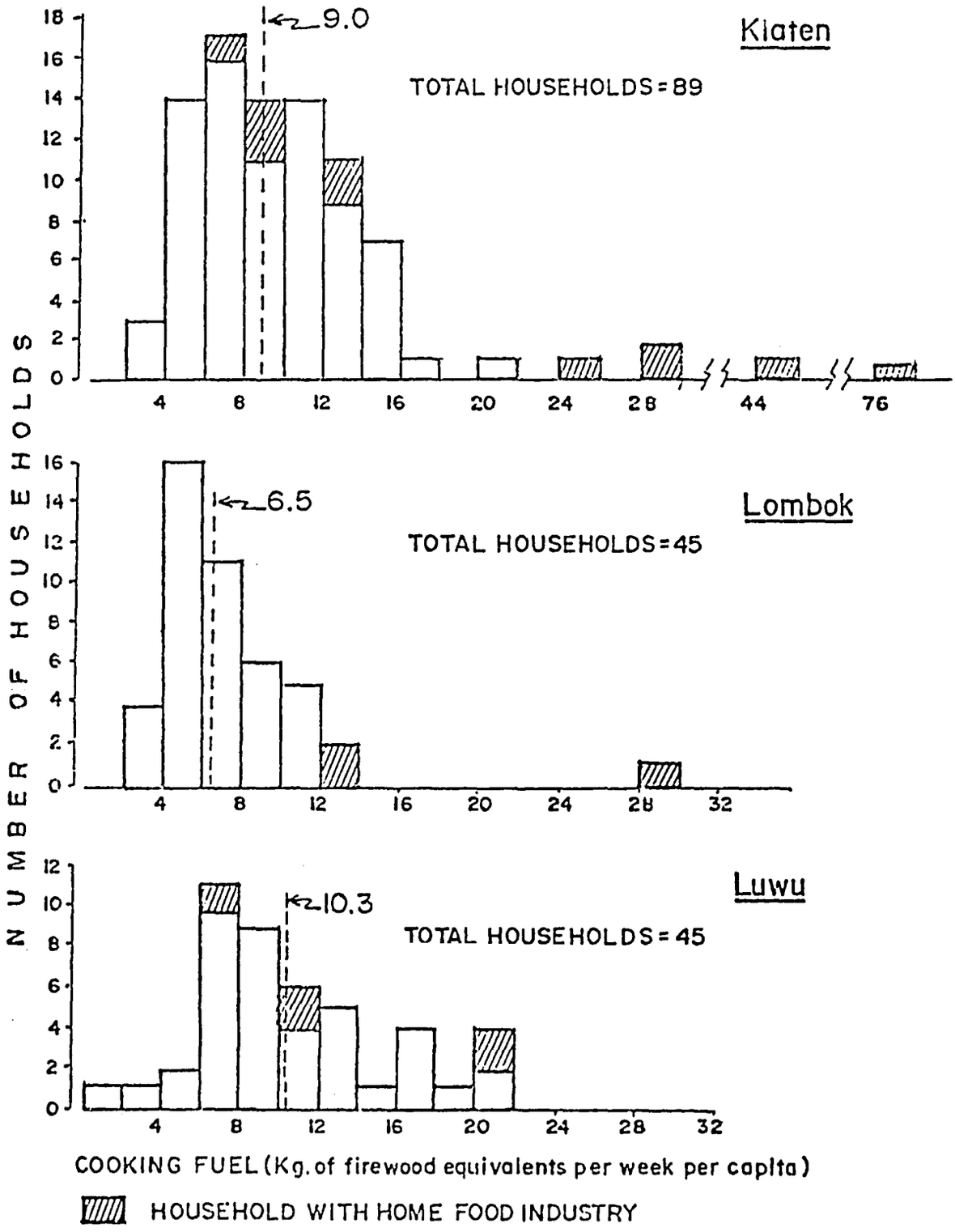
TABLE II-2

AGRICULTURAL LAND OWNERSHIP AND GATHERED FUELS

	Klaten	Lombok	Luwu
1.00 or more hectares owned			
Number of households in this group	9	9	37
(% of households surveyed)	(10)	(20)	(82)
Average land holdings in hectares	2.47	2.60	1.97
Of holdings of surveyed hh this group owns	58%	62%	93%
Of its cooking fuel this group gathers	72%	60%	64%
From 0.5 up to 0.99 hectare owned			
Number of households in this group	11	12	5
(% of households surveyed)	(12)	(27)	(11)
Average land holdings in hectares	0.59	0.65	0.88
Of holdings of surveyed hh this group owns	17%	21%	6%
Of its cooking fuel this group gathers	87%	67%	91%
From 0.30 up to 0.49 hectare owned			
Number of households in this group	16	11	0
(% of households surveyed)	(18)	(24)	
Average land holdings in hectares	0.41	0.40	
Of holdings of surveyed hh this group owns	17%	12%	
Of its cooking fuel this group gathers	66%	56%	
Less than 0.30 hectare owned			
Number of households in this group	16	9	3
(% of households surveyed)	(18)	(20)	(7)
Average land holdings in hectares	0.19	0.21	0.25
Of holdings of surveyed hh this group owns	8%	5%	1%
Of its cooking fuel this group gathers	78%	58%	51%
No land holdings			
Number of households in this group	38	4	0
(% of households surveyed)	(42)	(9)	
Of its cooking fuel this group gathers	53%	13%	
Total number of households owning land	52	41	45
Average holdings of those owning land in hectares	0.74	0.91	1.45

FIGURE II-1

HOUSEHOLD ENERGY USE FOR COOKING



The average per capita consumption shown in figure II-1 for each of the three areas is the total community energy use for cooking, including households which have home industries producing food for local consumption, divided by the total population of persons domiciled in those households. Significant error could be introduced by the unrepresentativeness of home food industries among the households surveyed. In this survey 13% of households reported an energy consuming home industry making food for sale. Earlier surveys (IPB, 1977) report 8% of Klaten households as having a home industry. Although the sample of this survey varies in this respect from the IPB sample, the difference when averaged over the whole population does not change overall averages more than five percent.

In figures II-2, 3, & 4 is shown the distribution of households arranged by increasing energy use from the lowest 10% (or 20%) to the highest 10% (or 20%). The most striking fact about this distribution is the great difference in all areas between the highest and lowest. In Klaten the highest 20% of households uses 4.8 times as much energy as the lowest 20%. In Lombok and Luwu the same ratio is 4.2 and 3.9 respectively. These figures mean that in Klaten the top 20% of households consume 38% of the total community use of cooking energy, whereas the bottom 20% consume only 8%. In Luwu the proportion is 35% for the top 20%, and 9% for the bottom 20%, and in Lombok 38% for the top 20%, and 9% for the bottom 20%. A contributing factor to the disparity between the highest energy consuming families and the lowest is the number of people resident in the household. From a comparison of the number of household residents one can see that the more energy consuming households have more family members by factors of 1.4, 1.5, and 1.6 respectively for Klaten, Luwu and Lombok. On a per capita basis, the top 2% consume 3.4 times as much as the lowest in Klaten, 2.4 times as much in Luwu, and 2.6 times as much in Lombok.

The values for consumption of cooking fuels found in this survey are similar to values reported by other Indonesian field surveys. Wiersum (1975) reported 2,350 kg. firewood per household per year in the upper Solo river basin in Central Java. Sumarna and Sudiono (1973) report 2000 kg per household per year in East Java. Haeruman (1979) reports approximately 5000 kg per houshold per year in West Java, but Kalo et. al. (1979) report a range of 1200 kg to 3000 kg per household per year in another area in West Java. According to Kalo the lower figure is in an area where the people use kerosene for cooking. The use of kerosene was not measured. Other firewood analyses have attempted to obtain averages for rural Java. Hadi et. al. (1979) estimate an average of approximately 3000 kg per household per year (1.0 m^3 per capita per year). A more exhaustive list of survey results was made preparatory to a survey with a very large sample by Soesastro (1980) who cites 24 surveys of rural firewood consumption. The average of all these surveys is approximately 2500 kg per household per year. The results of this present survey of rural electrification project areas found a range in all three areas from 1000 to 5500 kg per household per year, with averages of 2300 kg to 3000 kg. The differences among all these surveys are easily explained by a combination of three factors: 1) non-representative samples, 2) measurement of volume rather than weight coupled with inaccurate estimates of the density of the wide variety of agricultural wastes and wood fuels used in rural areas, 3) widely varying assumptions about replacement equivalencies between kerosene and firewood.

PATTERN OF COOKING ENERGY USE
by 10 % Percentiles

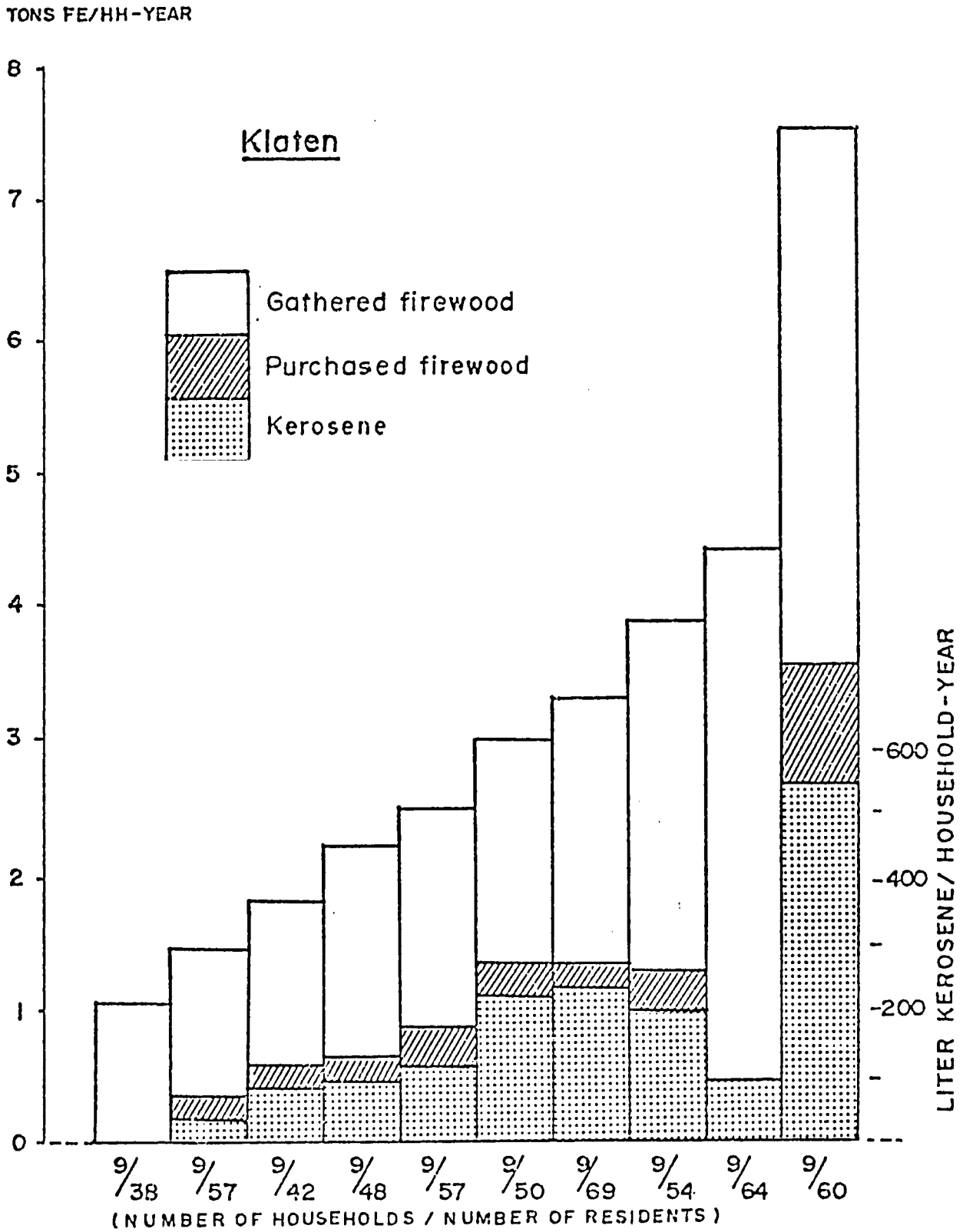


FIGURE II-3

PATTERN OF COOKING ENERGY USE
by 20% Percentiles

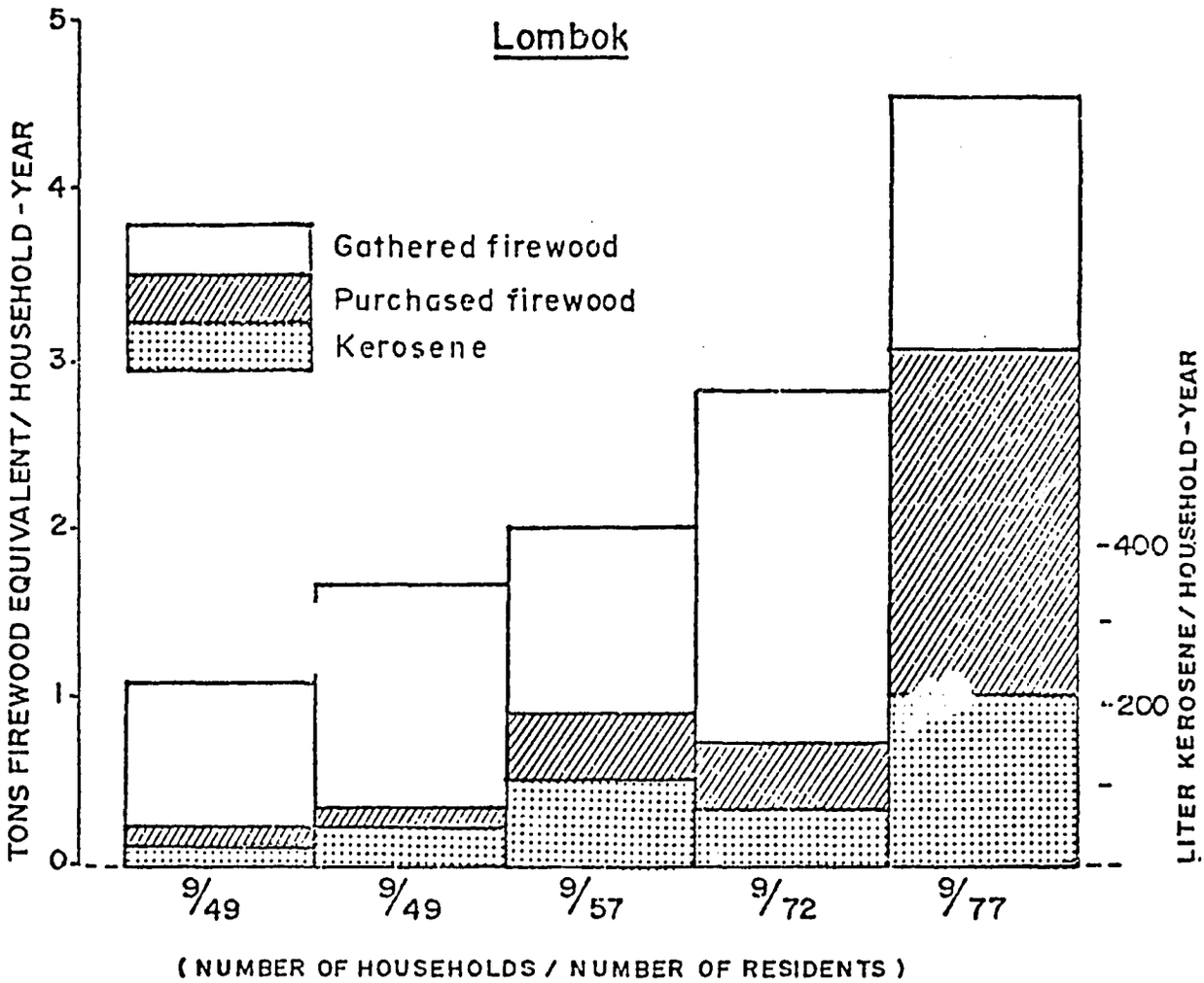
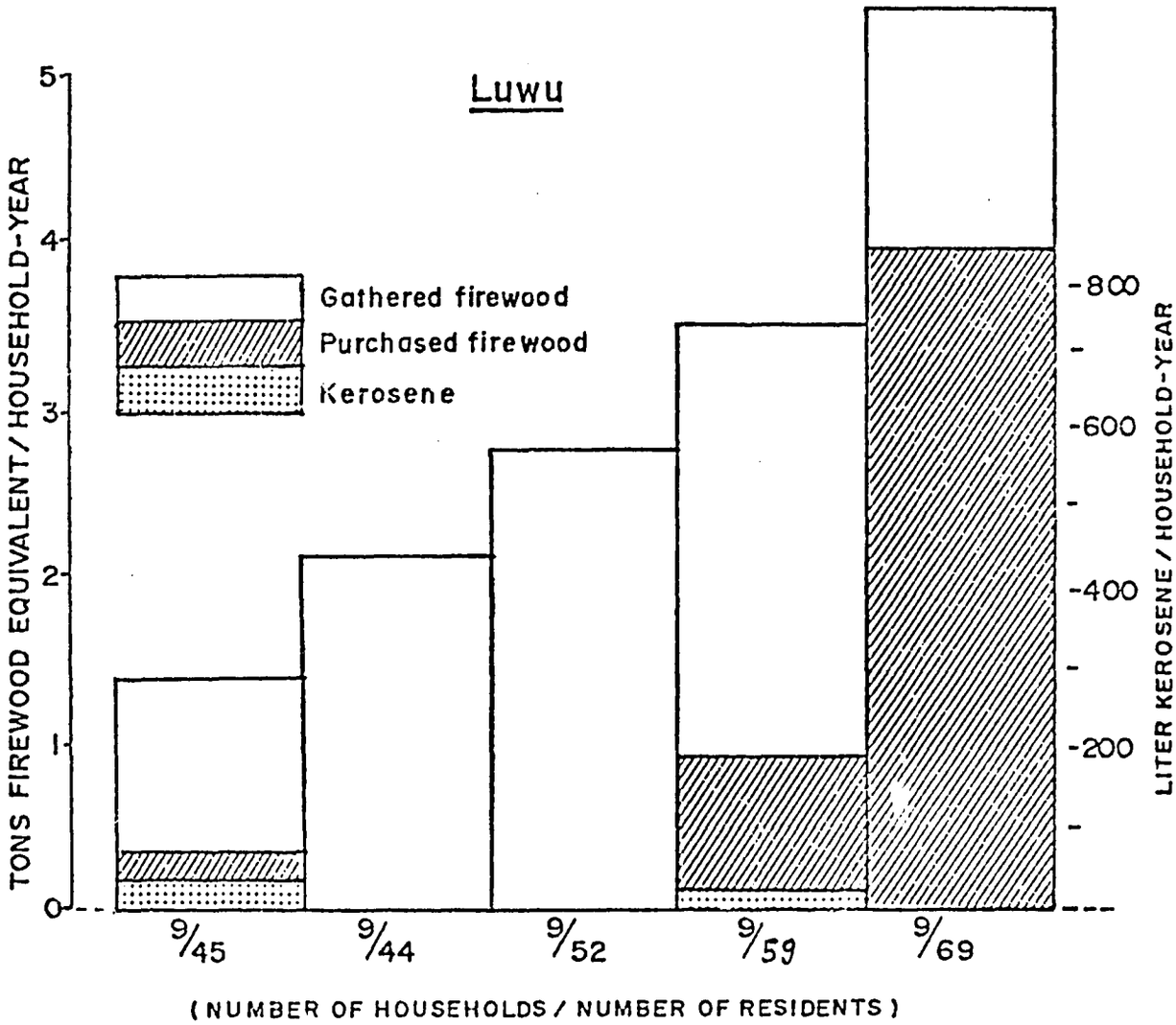


FIGURE II-4

PATTERN OF COOKING ENERGY USE
by 20% Percentiles



One important observation to be made from figures II-2, 3, and 4, is the increasing amount of commercial fuels used with increasing household consumption. This is not necessarily to be expected since larger consuming households, which are also bigger households, have more labor available to gather their fuel than smaller households where surplus labor is scarce. However, this is not the case in any of the three areas. In Klaten while the top 20% purchase 35% of the fuel they use for cooking, the bootom 20% purchase only 17%. In Luwu the top 20% purchase 74% and the bottom 20% only 21% of their cooking fuel. In Lombok the top 20% purchase 65% and the bottom 20% only 18% of their cooking fuel. In terms of the local market of commercial fuels used for household cooking, the top 20% purchase 40% of total fuels sold for cooking in Klaten, 77% in Luwu and 60% in Lombok. The top 40% purchase 64% of the total in Lkaten, 94% in Luwu and 73% in Lombok.

There is a tendency to purchase more fuel with income and status, this may indicate a greater value placed on household labor especially in the upper 20% of energy consuming household, most of which have a home food industry, or which have family members who are engaged in trade, or who are salaried. Approximately 80% of households headed by someone listing their primary occupation as salaried worker (government civil servant, schoolteacher, etc.) and approximately 60% of households headed by a tradesman (storekeeper, peddler, etc.) purchase commercial fuels at least some of the time as opposed to households headed by farmers or laborers of which fewer than 40% ever purchase commercial fuels.

Of major interest from the point of view of natural resource use for fuel is the relative importance of gathered and commercial fuels for cooking. In Klaten 33% of total cooking fuel use is commercial fuel, and three quarters of that is kerosene; or expressed in terms of the total, 24% of total cooking fuel is kerosene. In Luwu 34% is commercial but only 2% of the total is kerosene. In resource scare Lombok 42% of the total is commercial and 19% of the total is kerosene. The percentage breakdown for kerosene and wood is based on a replacement of 1.0 liter of kerosene by 4.8 kg of wood.

The energy use pattern that emerges from these data pictures the households which consume the largest amount of energy as being slightly larger than the average and typically headed by a salaried worker or a tradesman, or a farmer with larger than average landholdings. The households which consume the least are headed by laborers or farmers with small holdings and have smaller families. It can be inferred that the higher energy consuming households are also more economically prosperous as they have a greater reliance on purchased fuels. The exact relation of income and energy use is discussed in the next section; however, it can be noted here that energy consumption is more practically, and probably more accurately, measured than income in a field survey. It is this accuracy together with the significance of the pattern of cooking energy use for management of local natural resources that make a detailed analysis of fuel selection valuable for assisting the determination of the choice of location and type of energy development activities.

II-3 Cooking fuel selection

The choice of fuels for cooking food is dependent upon an interacting set of factors which for this analysis are discussed under four headings: 1) availability, 2) consumer preference and tradition, 3) relative expense, and 4) income and labor availability. Before examining the relative importance of these factors in determining fuel choice a brief description of the variety of fuels used is useful to show the complexity surrounding fuel choice by the individual householder.

The most fundamental observation about cooking fuel use in the three survey areas is that virtually every household uses firewood. Of the houses surveyed less than 10% use kerosene only for cooking. However, it must be emphasized that the definition of "firewood" in this analysis is broad and is not limited to "stemwood" or "roundwoods." It includes virtually every combustible material found in rural areas. The range of type and quality of firewood in common use is enormous--even just within one household. Many of those materials not normally thought of as firewood are usually not burned by themselves as the sole fuel in the cooking fire but are usually mixed with higher quality firewood, e.g., leaves and small branches. Table II-3 shows the range of materials being used in surveyed households. The differences between the areas are instructive in that the firewood used in the frontier area of Luwu mostly fits the conventional definition, i.e. stemwood, whereas in Klaten and Lombok, both areas with resource scarcity, a much greater variety of lower quality combustible material is used.

The widespread use of lower quality fuels means that Klaten and Lombok residents must pay closer attention to fuel choice. They are potential exploiters, and hence managers, of all local resources that are burnable. Any examination of the factors influencing their fuel choice must also recognize competing demands on the local resource base.

Availability of combustible materials is the most important constraint influencing the choice of cooking fuels. Moreover, it is the availability of non-commerical biomass fuels that places a constraint. In all project areas kerosene and firewood as commercial fuels are available at all seasons. The only exception to this availability is the occasional shortages of kerosene in Luwu caused by road washouts. However, these shortages are not a great problem as very few people in Luwu use kerosene as a cooking fuel and commercial firewood is locally available. Both Klaten and Lombok have reliable supplies of commercial fuels as both areas have good all weather road networks.

Non-commercial firewood is the most important fuel and its local abundance and accessibility are critical determinants of its use. Table II-4 describes the characteristics of firewood supply for the three areas surveyed. Of these three areas only in Luwu do the residents actually walk to a forested area recognizable as such and obtain firewood which fits the usual definition of firewood. Even in Luwu this is only true of two villages as most of the people of the third village, Sukamaju, purchase firewood. Many Sukamaju villagers are engaged in trade and do not have time available to walk even the modest distances shown in table II-4. In most areas of Luwu local firewood resources are perceived by surveyed

TABLE II-3

TREE PARTS USED FOR COOKING FUEL*

	Sample Using Fire-Wood	Cut Twigs	Cut Branches	Fallen Twigs & Branches	Trunk	Tree Root	Bark	Leaves	Husks
Klaten	77	70	61	39	40	2	5	7	18
Percentage	100	91	79	51	52	3	6	9	23
Lombok	43	26	17	9	18	-	6	2	9
Percentage	100	60	40	21	42	-	14	5	21
Luwu	44	27	17	26	29	-	-	-	-
Percentage	100	61	39	59	66	-	-	-	-

* At the time of the survey all villagers interviewed in Sukamaju were taking advantage of nearby land clearings operations as a source of fuel.

TABLE II-4

FIREWOOD SUPPLY CHARACTERISTICS

Name of Desa	Supply of wood in Householder's Opinion Was		Time to Reach Source of Collected Firewood (Minutes) Now					5 Years ago the Supply Was in Householder's Opinion		
	Stable	Diminishing	10	11-20	21-40	41-60	60	Nearer?	Same?	Farther?
Klaten										
Jonggrangan	13	2	14	-	-	1	-	-	9	6
Gergunung	15	-	9	6	-	-	-	-	15	-
Karanganom	13	-	12	-	-	-	1	-	10	3
Cokro	12	2	14	-	-	-	-	-	14	-
Ngaran	-	13	11	2	-	-	-	-	13	-
Krajan	14	1	14	-	1	-	-	-	15	-
Luwu										
Sukamaju	6	-	-	2	4	-	-	5	1	-
Sukaraya	1	14	1	4	5	3	2	15	-	-
Ketulungan	3	11	-	4	3	5	2	11	3	-
Lombok										
Anjani	5	10	9	3	1	1	-	-	12	3
Aikmel	6	7	2	4	2	-	5	3	9	1
Pohgading	4	5	5	2	2	-	-	1	8	-

householders as diminishing and more distant than was the case five years ago. The resource is being depleted by the extensive land clearing in Luwu to prepare for the transmigration of people from Java and Bali. As this process continues, forests will lose their prominence as a source of non-commercial firewood for the average Luwu villager. High-grade stemwood then will become almost exclusively commercial and will have to be transported a longer distance from forested areas outside the transmigration settlements. As stemwood becomes more commercial Luwu will become more like Lombok and Klaten in that it will become more dependent on sources of combustible materials such as agricultural wastes and gathered twigs, leaves, barks, and sticks, etc.

In Klaten, and to a lesser extent in Lombok, individual householders are faced almost daily with a decision as to what fuel they will use for cooking, unlike Luwu householders who almost always use stemwood of a high grade. In Klaten the individual householder setting out to collect combustible material for cooking fuel first must decide where to search and second, he must decide what kinds of materials are to be taken. In answering the first question the householder has several choices. He can take materials from his own garden, which typically surrounds his house, he can search along water courses which are well vegetated, he can look for more organized planting of trees (such as turi, Sesbania grandiflora) along paddy bunds and roadsides, he can scavenge in more distant uncultivated hilly areas, or he can collect agricultural wastes, if in season.

If the householder chooses his home garden, he has a wide range of materials he can use. Table II-5 lists various kinds of fruit and/or tree crops in home gardens in each area. Of these crops particularly important as sources of fuel are coconut trees, bamboo, and woody fruit trees such as jackfruit, mango, and guava (jambu). By contrast, Lombok which has very poorly developed home gardens has very few of those species which also serve as sources of cooking fuel. Although the Luwu households which were surveyed have begun home gardens in the Javanese tradition, not surprisingly since most of the householders come from Java, they as yet do not cultivate their home gardens as intensively as do the Klaten residents. Moreover, in Luwu more space in the home garden is given to woody tree crops which are not good sources of fuel, such as cloves and coffee.

Even if the householder chooses to gather combustible material from his home garden there is still the problem of drying the material before it can be burned. This can range from a few days to two weeks for twigs or small branches from trees, up to two or three weeks for coconut husks. Even if the villager chooses to look farther for combustible materials in other areas, such as along water courses, he still has the problem of drying. For example, one of the more commonly used combustible materials taken from stream banks is the root of bamboo plants which can take five weeks or more to dry to the point where they burn properly. However, these times are less than what is required for larger sizes of stemwood of a commerical grade which can take up to three months to dry to an accepted moisture content of 20%-30% on a dry weight basis (Earl, 1975).

The other source of cooking fuel is the waste of agricultural crops. The wastes chiefly used in households are rice hulls and straw, corn cobs and stalks, tobacco stalks. These have a definite seasonal pattern of

TABLE II-5

PLANTS GROWN IN HOME GARDENS IN SURVEYED VILLAGES

Plant Species	Klaten	Lombok	Luwu
Cocos nucifera: Coconut	33	1	34
Gigantochloa spp: Bamboo	21	-	-
Artocarpus heterophyllus: Jackfruit	8	4	15
Mangifera indica: Mango	21	2	11
Citrus spp: Orange	3	7	12
Psidium guajava: Guava	12	10	8
Coffea spp: Coffee	-	-	26
Eugenia caryophyllus: Cloves	-	-	14
Manihot esculenta: Cassava	13	-	7
Ananas comosus: Pineapple	-	-	9
Musa spp: Banana	26	29	18
Carica papaya: Papaya	20	2	7
Number of households	90	45	45

NOTE: Each datum is the number of householders in each surveyed area reporting a plant species as now growing in his home garden.

availability which is dependent upon the planting cycle. Nonetheless, when these fuels become available they are used by many households in Klaten and Lombok as a supplement to better grades of firewood for the cooking fire. However, in some very poor households entire meals are cooked with nothing but corn stalks. The exclusive seasonal use of agricultural wastes, such as millet straw as cooking fuels has been reported in Upper Volta (Ernst, 1978). There is also the problem of drying with agricultural wastes. Rice stalks usually are dry within two or three days but corn stalks can take a week and tobacco stalks several weeks before they are combustible.

The use of home garden and agricultural wastes as fuel sources is stable as is reflected by the answers of the householders in Klaten to questions about the supply of wood. In Klaten these questions were interpreted in the broad sense to include every kind of biomass fuel such as coconut husks, bamboo roots, etc. Most Klaten villagers report that the time to reach the main source of firewood is less than ten minutes indicating that the gathering sites are very close to the house if not the home garden itself. Moreover, a significant number of Klaten villagers report that five years ago they used to go farther for their fuel. This report in a backhanded way indicates an increasing dependence on the home garden as a source of fuel. In Lombok, the home garden is not so significant and many villagers spend significant amounts of time searching for cooking fuels along roadsides and river banks, locations which are farther from the home.

There seems to be little doubt that Klaten villagers manage the resources under their direct control with consideration of their potential use as cooking fuels. This is particularly true of the choice and cultivation of plants in home gardens, hedgerows, and paddy bunds. In the case of home gardens most research to date, e.g., Soemarwoto (1979) has described their multiple uses--source of food, cashcrops, medicine, etc., however, given evidence of an increasing dependence on home gardens as a source of firewood, it would seem prudent for future research to examine the sacrifices in these other uses caused by the rising demand for fuel.

Consumer preference and tradition play an important role in determining the householder's choice of fuel. Often this preference is associated with one kind of cooking versus another. For example, rice that is cooked over a wood fire is preferred to rice cooked over a kerosene flame as the latter imparts a definite oily taste to the rice. However, for other kinds of cooking, such as heating a small amount of water for tea or coffee, a kerosene burner is definitely preferred. Although consumer preference was not analyzed in such detail by the survey, general questions concerning preference were asked. In Luwu and Lombok 75% of the respondents indicated firewood as their first preference for a cooking fuel and approximately 20-25% indicated kerosene as their second preference. A small percentage, less than 5%, indicated a preference for other fuels such as coconut husks from home gardens. In Klaten an overwhelming 90% of the people preferred firewood and only 10% preferred kerosene as a cooking fuel.

Respondents were also asked to list a second preference for cooking fuel. Firewood is either a first or second preference of more than 90% of people in all areas, kerosene of 50% in Klaten and Lombok and slightly less

than 20% in Luwu. Interestingly over 40% of the people in Klaten listed a home garden waste or an agricultural residue as their first or second preference. This was not the case in Lombok and Luwu where less than 10% listed these fuels as a first or second preference. In all cases charcoal is not considered an alternative cooking fuel even though it is available on the local markets. Its use is confined strictly to ironing and cooking specialty foods such as sate (barbecued meat) which are usually only available in small eating stands and are not everyday foods.

The respondents from each area were asked to give reasons why they did not use the major fuels locally available. The reasons are presented in table II-6. The differences between the areas are indicative of local availability and tradition. For example, Luwu residents frequently cite the adequacy of the firewood supply as a reason for not using other fuels. In Klaten, and to a lesser extent in Lombok, concern for the burning characteristics of the fuel reflects a high degree of discrimination by users as to the purpose to which the fuel is suited. This implies that local residents in Klaten are very sophisticated in tending fires using a variety of fuels to cook a variety of foods. By contrast, in Luwu this kind of knowledge is not as extensive as in Klaten as can be seen in the frequently cited reason that "these fuels are not commonly used."

An important area for future research is the suitability of different fuels for different ways of cooking food. Burning characteristics, amount of smoke given off, and time required for fire tending are all considered each time a fuel is selected for cooking a particular food. As Rachmatsjah (1979) suggests, the wealth of tradition and experience behind this decision must be thoroughly understood before one ventures to intervene in rural energy use by changing either fuel supply or cooking stoves. A lack of such pre-project research has hindered the introduction of new stoves such as the well publicized Lorena stove (Evans, 1979). In attempts to introduce this stove and other similar models in Indonesia, areas were selected which had limited supplies of high grade stemwood. These stoves, because of their enclosed firebox cannot use low-grade fuels such as corn stalks.

Relative expense of cooking fuels is a major determinant of fuel choice. In all areas market prices were obtained and checked by asking residents who purchased fuels what price they paid. Table II-7 gives the market price of fuels in each of the three areas and a calculation of the actual cost to the householder of using that fuel for cooking. The complicated appearance of Table II-7 reflects the difficulty which confronts the householder who has to make a choice between the different fuels available. A meaningful comparison of the relative cost of different fuels is not straightforward and requires making assumptions about the efficiency of the use of the fuel in cooking. These assumptions are spelled out in Table II-7 and are examined in great detail in section II-6, which deals with stove efficiencies. Even though these assumptions are of critical importance in determining demand on natural resources, they are not so important for the purpose of discussion about which of the various fuels available are cheaper.

In all cases the cheapest fuel available is that which is gathered by each family whether firewood of a relatively high quality or home garden

TABLE II-6

NUMBER OF RESPONDENTS GIVING REASONS FOR NOT USING DIFFERENT COOKING FUELS

	Fuel Too Expensive	Lack of Supply	Undesirable Burning Characteristic	Stove Too Expensive	Not Commonly Done	Adequate Firewood Supply
Klaten						
Kerosene	42	-	1	10	11	2
Charcoal	66	18	16	2	7	1
Padi Husk	1	19	47	-	6	1
Wood Wastes	2	56	17	-	12	1
Agricultural Wastes	1	12	36	-	4	1
Lombok						
Kerosene	16	-	4	6	-	3
Charcoal	-	7	-	1	26	1
Padi Husk	-	-	2	-	28	-
Wood Wastes	-	7	1	-	27	-
Agricultural Waste	-	5	22	-	6	-
Luwu						
Kerosene	26	1	4	22	3	6
Charcoal	10	23	-	-	8	10
Padi Husk	-	8	7	-	13	10
Wood Wastes	1	10	2	-	9	11
Agricultural Waste	-	7	1	-	7	10

TABLE II-7

RELATIVE COST OF DELIVERED HEAT ENERGY
AS A FUNCTION OF FUEL TYPE AND LOCAL FUEL PRICES

Fuel	CV (kcal/kg)	SE (%)	Klaten P (Rp/kg)	Klaten C (Rp/1000 kcal)	Lombok P (Rp/kg)	Lombok C (Rp/1000 kcal)	Luwu P (Rp/kg)	Luwu C (Rp/1000 kcal)
Purchased firewood:								
average	3500	12.5	12	27	14	32	8	18
teak splits	4000	12.5	16	32				
leucaena sticks	3500	12.5	18	41				
Collected fuels:*								
firewood	3500	12.5	4.5	10	9	21	6	14
garden wastes	3500	12.5	4	7				
Charcoal	7100	20	75	53	50	35	25	18
Kerosene (per liter)	8900	24	40	19	45	21	55	26
Kerosene plus stove+ cost (per liter)	8900	24	50	23	55	26	65	30

The calculation of the cost, C, for each fuel is from the following:

C = P/(CV:SE), where

P = local price of fuel;

SE = stove efficiency derived from field experiments, Singer (1961) and Franklin (1978)

CV = calorific value. For firewood and home garden wastes, the oven dry calorific value is reduced by an assumed 20% moisture content (mc) on a wet weight basis, e.g., teak's oven dry CV is 5000 kcal/dry kilogram with a 20% mc the wet weight calorific value is:

$$\frac{5{,}000 \text{ kcal}}{\text{dry kg}} \times (100\% - \text{mc}) \frac{\text{dry kg}}{\text{wet kg}} = \frac{4000 \text{ kcal}}{\text{wet kg}}$$

A moisture content of 20% is an average value for dry wood.

*See Table II-8 for calculation of costs of collection; note that the cost will vary ± 25% depending on the rate of collecting allowed by the resource and local tradition.

+Stove cost: single burner kerosene stove, Rp. 3000, interest 1½ per month, pay back 6 months. Monthly kerosene use is 50 liters.

wastes. Table II-8 shows the collection costs of firewood and home garden wastes in the three areas. In Klaten and Lombok, kerosene is the next cheapest followed by various grades of firewood, with charcoal being the most expensive. However, in Luwu charcoal and purchased firewood are approximately equal in price and both cheaper than kerosene. The explanation for this seeming anomaly probably lies in the relative convenience of kerosene for the limited use to which it is put in Luwu. In Klaten & Lombok the choice of commercial fuel used (see figures II-2 and II-3) reflects the relative cost of kerosene and firewood.

The type of stove that must be used is a constraint on the selection of fuels, not because stoves are not available in the market place but because of the relative greater expense of stoves for kerosene. Table II-9 shows the types of stoves used in homes in the three project areas surveyed. In virtually every home a wood stove of one kind or another was available. In most project areas that stove is typically of a simple type; however, in Klaten 23% of the kitchens had more elaborate enclosed brick or stone stoves which are suited to the use of commercial high-grade stemwood. Lower quality agricultural wastes are burned in very simple stoves which are often only three rocks and a pot. Such a simple stove allows easy access to the fire for the constant tending these fuels need.

Kerosene stoves were found in 41% of Klaten kitchens but much less commonly in Lombok and Luwu. Almost invariably the kerosene stoves that were found were the metal type which is known as a "kompor" in Indonesia. As these stoves are relatively expensive their purchase price is taken into account in Table II-7 in which the cost of the metal type of kerosene stove, amortized over six months, is added into the average fuel cost for cooking in those households that use kerosene with this type of stove. This increases the price of kerosene by about 20%. Alternatively the cost of simple wood stoves, in some cases as cheap as Rp. 25, is not a significant deterrent to the use of wood.

The differences in cost of delivered calories between kerosene and firewood or between charcoal and firewood are less than the difference between the cheapest and most expensive grades of firewood observed in the survey areas. Are these differences truly significant, and if so what factors contribute to the wide range? In an effort to assess significance, careful weighing of 30 or more bundles of each of several different firewood grades were made at three different firewood dealers in Klaten. The price differences between grades were found to be consistent in each dealer's stock. Customers observed during the visit, all of whom were buying for home use, were making careful selection among the grades, e.g. buying twenty bundles of teak splits, and ten bundles of leucaena sticks, and were not just buying the "cheapest." These dealers, although large, in general do not sell to small-scale industries, and therefore it is reasonable to suppose that the differences between firewood grades are important in home use, whether for domestic cooking or for home industries.

Interviews with customers identified one important characteristic that accounts for the higher cost per delivered calorie of lemtoro (Leucaena leucocephala) sticks over teak splits. That characteristic is the great uniformity of size and shape of lemtoro sticks. Further evidence for this view comes from the segregation of the lemtoro sticks into two size

TABLE II-8

DATA FOR COMPUTING THE COLLECTION COST OF FIREWOOD

	Time to reach collecting site (minutes)	Amount collected per trip (kg)	Percent of children collecting firewood	Marginal costs of labor[1] (Rp/8hr)	Collection costs of firewood[2] (Rp/kg)
	T	X		L	CC
Klaten:					
firewood	5	25	18	400	3.7 - 5.3
home garden wastes[3]	5	15	-	-	4.0
Lombok	15	20	20	650	7.4 - 10.2
Luwu	30	40	30	450	5.2 - 7.0

1) Local cost for daily agricultural labor

2) $CC = \frac{L\ (2T/60 + X/r)}{X}$ with

r = rate of collection
= 10 - 15 kg/hr

3) Data is from a village in Klaten which uses home garden wastes as a fuel for kilns for roof tiles. The rate of collection is approximately 20 kg/hr, and the collector receives Rp. 60 per 15 kg basket load. Eight or more baskets can be collected in a single day.

TABLE II-9

NUMBER OF HOUSEHOLDS OWNING STOVES ACCORDING TO TYPE

	Klaten	Lombok	Luwu
Wood Stoves			
of clay or mud	67	42	42
of stone	6	-	2
of metal	-	2	1
of brick	15	-	-
TOTAL	88	44	45
Kerosene stove			
of metal	35	13	4
of brick	1	-	-
of stone	1	-	-
TOTAL	37	13	4
Rice straw and/or sawdust stove			
of clay or mud	1	-	-
Charcoal stove			
of clay or mud	6	-	-
Number of households surveyed	90	45	45
TOTAL STOVES ALL TYPES			
AVERAGE NUMBER OF STOVES/HH	132	57	49

categories, with no significant price difference between the categories. It is not the size itself but the uniformity which is the most important factor. (The uniformity of lemtoro stems from its management as a firewood crop by coppicing, a technique which allows the grower to cut large numbers of uniformly sized shoots). Understanding the value of uniformity also explains why grades of commercial firewood which are of a single species such as teak, mahagony, or rubber are more costly than the "average," which includes brush wood as well as the results of occasional village tree fellings, and which vary in species and in size from week to week and from market to market.

Why does uniformity in size and species, such as leucaena sticks, command a cost of delivered calories differential of 30% to 50% (see Table II-7)? It is not because of a competing demand for lemtoro charcoal, as teak charcoal is the most expensive charcoal in the Klaten market, but likely because of the labor saving resulting from the reliable fire such uniformity yields. Less time is spent in drying and preparing the fuel, and in tending a fire of lemtoro sticks than of teak splits or a mixed species "average" grade.

Since lemtoro is the tree of choice in many regreening projects it is worth speculating as to whether its price will decline as the supply increases as a result of extensive planting. Such speculation depends on a market analysis for which at the moment there is no data available. However, in Klaten at least it is likely consumed in the more energy consuming households which are more affluent or have a home industry requiring firewood or both. Although the amount of lemtoro sold is only a fraction of the total commercial firewood market, which in turn supplies less than 10% of the total cooking fuel consumed in Klaten, it is likely that these affluent or productive households have a strong preference for higher quality firewoods, such as lemtoro. If this preference has its origins in a higher value being placed on household labor, then it may be that lemtoro sticks are a first alternative to kerosene. In that case the rapid removal of the kerosene subsidy will push more households into the commercial firewood market. This new market force will likely demand top quality firewoods, thereby ensuring a strong price for lemtoro even as its supply increases.

The most likely alternative to this scenario is the development of a charcoal market. Although it is possible to import charcoal from the outer islands to the coastal cities of Java (there is already such a trade from Sumatra to Malaysian coastal cities, e.g. from Dumai to Malacca), the interior cities would likely be supplied from closer sources - again lemtoro (and/or other high quality species).

Income and labor availability affect fuel choice. The survey obtained two measures of income: 1) heads of households were asked to estimate average monthly household expenditures; and 2) a detailed questionnaire was used to estimate household income from farming, salaries, home industries, and other sources. The household income used for the following analysis is the average of these two estimates. Since these two figures often differed significantly, the income figures cited in the following tables are considered to be less accurate than the per capita energy figures which are derived from measurements and are free of bias either from the surveyor or

the respondent. The error in the estimates of income is likely to be greater in the higher income strata as such households' incomes are more difficult to estimate accurately than in smaller households. Nonetheless, the income figures serve to indicate general trends in the measure of energy in households.

Average (mean) and median incomes are shown in table II-10 for all three survey areas, with the Klaten data given in two categories: the three demonstration villages and the other three villages not yet electrified by PLN. Incomes are calculated both on a per capita and a per household basis directly from the original data. This is done both to facilitate comparisons with benchmark surveys of Indonesian income (e.g. IBRD, 1979) as well as to relate household characteristics such as appliance ownership to household income rather than household per capita income.

Tables II-11, 12, and 13 present the pattern of energy use for cooking as a function of household per capita income. The data of table II-11 show that per capita cooking fuel consumption increases with increasing income, but the increase is not related simply to income. Over a broad middle range income is not too important a determinant of cooking fuel use--the average man uses 8 to 11 kilogram firewood equivalents more or less independent of income. In Luwu where fuel is abundant this figure holds true for all income levels; however, at both high and low income levels there are significant deviations in other areas from this average. In Klaten the very top stratum of households, those earning more than Rp. 14,000 per capita per month, consume nearly 19 kilograms firewood-equivalent per person per week. These households are by and large the same prosperous group that have home food industries requiring extra cooking fuel, thereby accounting for the relatively greater per capita consumption of fuel. The other significant deviation is in Lombok where the lowest income stratum consumes only 5.3 kilograms per capita per week.

In Lombok the reason for the low consumption is twofold: local resources are scarcer than in Klaten and poorer householders are unable to purchase the average amount of commercial firewood or kerosene. The difficult choice facing the lowest two income groups in Lombok can be seen in table II-12 by comparing with the lowest groups in Klaten and Luwu. The lowest two income strata in Klaten and Luwu can and do cook their food almost exclusively with gathered firewood, agricultural wastes, etc., whereas the lowest strata in Lombok as a group purchase approximately one third of their cooking fuel. However, a close look at the data of table II-12 shows that these households are not supplementing gathered with commercial fuel but rather have gone over completely to commercial fuels. It is this sort of dichotomous choice that massed average data obscure.

Unfortunately, in the case of the Lombok poorer households the data are many too few to use to test hypotheses--rather the data serve to stimulate questions. What forces these households into a complete dependence on the commercial fuel market when in other areas, and in other households in Lombok as well, virtually everyone else can manage with self-gathered fuel with small supplements of commercial fuel? Is the local community resource base not only bad, but spotty in its provision? Or is access to the "community" resource base restricted by land ownership? If

TABLE II-10

MONTHLY INCOME IN PROJECT AREAS

Area	HH/Cap	Mean Income - June 1979 Per Capita	Mean Income - June 1979 Per Household	Median Income - June 1979 Per Capita	Median Income - June 1979 Per Household
Klaten Demonstration Villages	45/293	9,700	63,100	5,700	33,300
Klaten Nonelectrified Villages	45/250	6,600	36,800	5,000	26,500
Luwu	45/269	4,800	28,900	3,900	20,000
Lombok	45/304	4,500	30,400	3,800	23,500
Indonesia Rural		4,700*			

* Estimated from 1976 rural per capita income (IBRD, 1979) inflated by 12% for 1977, 7% for 1978, and 24% for 1979 (IMF 1979).

TABLE II-11

COOKING ENERGY USE VERSUS INCOME BY REGION

(Number of Households)

Income level (Rp/Capita/Month)	Sample* Size	Kilogram Firewood Equivalent Per Capita Per Week ≤6.8	6.9 - 10.4	≥10.5	Average Use Kg/Cap/Wk
Klaten					
Less than 3,000	24/153	10	10	4	7.3
3,000 to 4,999	18/113	6	7	5	8.4
5,000 to 7,999	25/149	8	8	9	9.3
8,000 to 13,999	12/ 70	1	3	8	10.8
14,000 and more	10/ 54	-	2	8	18.9
TOTAL	89/539	25	30	34	
Lombok					
Less than 3,000	18/124	13	5	-	5.3
3,000 to 4,999	12/ 73	6	4	2	7.1
5,000 to 7,999	10/ 68	3	5	2	7.7
8,000 and more	5/ 39	2	2	1	10.5
TOTAL	45/304	24	16	5	
Luwu					
Less than 3,000	19/110	8	5	6	8.7
3,000 to 4,999	7/ 39	-	3	4	11.4
5,000 to 7,999	11/ 79	1	4	6	11.3
8,000 and more	8/ 41	2	2	4	10.4
TOTAL	45/269	11	14	20	
GRAND TOTAL	179/1112	60	60	59	

* Sample size: Number of households/number of residents.

TABLE II-12

COMMERCIAL VS. TRADITIONAL FUEL FOR COOKING

AS A FUNCTION OF PER CAPITA INCOME

Income Level (Rp/Capita/Mo)	Sample Size	Commercial Fuel only	Commercial and Gathered Fuel	Gathered Fuel only	% Gathered Fuel*
Klaten					
Less than 3,000	24	-	1	23	99
3,000 to 4,999	18	4	4	10	71
5,000 to 7,999	25	4	10	11	64
8,000 to 13,999	12	3	5	4	51
14,000 and more	10	2	7	1	43
Lombok					
Less than 3,000	18	3	-	15	75
3,000 to 4,999	12	4	2	6	50
5,000 and more	15	6	5	4	46
Luwu					
Less than 3,000	19	-	1	18	97
3,000 to 4,999	7	1	-	6	69
5,000 and more	19	8	3	8	42

* This percentage is of the total cooking fuel consumption by all households of one income stratum.

TABLE II-13

HOUSEHOLD PER CAPITA ENERGY BUDGETS

	By Income level in Rp/capita/month					
	Less than 3,000		3,000 up to 4,999		5,000 or more	
Klaten with PLN electrification						
Number of households/residents		8/59		6/45		24/147
Firewood -gathered (kg/cap/wk)	(77)	7.9	(53)	6.1	(52)	7.8
-purchased (kg/cap/wk)			(5)	0.6	(7)	1.0
Kerosene -cooking (l/cap/wk)			(11)	0.24	(11)	0.36
Electricity -lighting (kwh/cap/wk)	(23)	1.02	(31)	1.51	(30)	1.93
	(100)		(100)		(100)	
Klaten without electrification						
Number of households/residents		12/66		8/44		16/87
Firewood -gathered (kg/cap/wk)	(66)	6.7	(49)	6.6	(23)	4.5
-purchased (kg/cap/wk)	(2)	0.2	(11)	1.5	(6)	1.2
Kerosene -cooking (l/cap/wk)			(1)	0.02	(43)	1.83
-lighting (l/cap/wk)	(32)	0.69	(39)	1.11	(28)	1.19
	(100)		(100)		(100)	
Luwu						
Number of households/residents		19/110		7/39		19/120
Firewood -gathered (kg/cap/wk)	(75)	7.9	(50)	7.9	(28)	4.8
-purchased (kg/cap/wk)			(22)	3.5	(37)	6.1
Kerosene -cooking (l/cap/wk)	(2)	0.04			(2)	0.06
-lighting(l/cap/wk)	(23)	0.51	(28)	0.85	(33)	1.11
	(100)		(100)		(100)	
Lombok						
Number of households/residents		18/124		12/23		15/107
Firewood -gathered (kg/cap/wk)	(54)	4.8	(40)	3.7	(35)	3.9
-purchased(kg/cap/wk)	(11)	0.8	(27)	2.5	(20)	2.2
Kerosene -cooking (l/cap/wk)	(7)	0.10	(13)	0.26	(21)	0.48
-lighting (l/cap/wk)	(28)	0.43	(20)	0.40	(24)	0.55
	(100)		(100)		(100)	

NOTE: Numbers in parentheses are percentages calculated on the basis of the following equivalencies: 1 liter of kerosene to 4.8 kg air dry firewood, and 1 kwh electricity to 0.50 liter of kerosene. These ratios are derived from field experiments on substitution of fuels in cooking and from an estimate of petroleum fuel consumed to generate electricity (see text).

TABLE II-13 (continued)

HOUSEHOLD PER CAPITA ENERGY BUDGETS

(Area Averages)

		Fuels Used per cap per week	Percent* of total useful energy	Percent$^{\phi}$ of total energy content
Klaten with PLN electrification				
Firewood	-gathered	7.5 kg	56 %	69 %
	-purchased	0.7 kg	5 %	6 %
Kerosene	-cooking	0.25 ℓ	9 %	6 %
Electricity	-lighting	1.64 kwh	20 %	19 %
	TOTAL		13.4 kg-eq/wk	38,300 kcal/wk
Klaten without electrification				
Firewood	-gathered	5.7 kg	37 %	51 %
	-purchased	0.9 kg	6 %	9 %
Kerosene	-cooking	0.8 ℓ	26 %	18 %
	-lighting	1.00 kwh	31 %	22 %
	TOTAL		15.3 kg eq-wk	39,300 kcal/wk
Luwu				
Firewood	-gathered	6.4 kg	46 %	54 %
	-purchased	3.2 kg	23 %	27 %
Kerosene	-cooking	0.04 ℓ	2 %	1 %
	-lighting	0.83 ℓ	29 %	18 %
	TOTAL		13.9 kg-eq/wk	41,600 kcal/wk
Lombok				
Firewood	-gathered	3.9 kg	43 %	52 %
	-purchased	1.7 kg	19 %	23 %
Kerosene	-cooking	0.27 ℓ	14 %	9 %
	-lighting	0.47 kwh	24 %	16 %
	TOTAL		9.1 kg-eq/wk	26,100 kcal/wk

* use equivalency of fuels: 4.8 kg biomass/liter kerosene
2.0 kwh/liter kerosene

ϕ kcal content of fuels: 3500 kcal/kg biomass
8900 kcal/liter kerosene
4450 kcal/kwh (the calorie content of petroleum fuel used to generate one kwh)

the latter is true then a well intentioned firewood tree planting project could backfire if land formerly open to firewood scavenging were turned into a money producing lemtoro tree farm. Escalating energy prices likely will force the poorer households into the commercial cooking fuel market where they will receive quite a shock. The result will be both a strained household budget and inadequate cooking energy.

Table II-12 does show in most cases a definite tendency to use more commercial cooking fuel with higher income. Although all the poorer households (except Lombok) may be entirely dependent on gathered fuel, the richer ones rarely move in the opposite direction and become exclusively dependent on the commercial fuel market--only 15% in Klaten, 29% in Lombok and 20% in Luwu do so. On average in even the richest households gathered fuels account for 40% or more of total cooking fuel consumption. Even in resource poor Lombok and densely populated Klaten, the overall majority of cooking fuels are gathered by individual household members. Thus, a potentially important constraint on use of noncommercial fuel is labor availability in the household.

It is a widely accepted hypothesis that households with a labor surplus, being usable for gathering firewood, should tend to buy less of their cooking fuel. A painstaking attempt was made to demonstrate such a relationship by calculating the amount of labor available per household, but no correlation was found in any survey area. Only for the village of Sukamaju in Luwu was there a positive correlation. In Sukamaju there is a shortage of labor due to a high employment in trade. There the percentage of firewood purchased is greater than any other village surveyed. Their success in trading was a fortunate result of the enterprise of new transmigrants who were given land with inadequate irrigation. While waiting for full technical irrigation many would-be farmers discovered and exploited a regional need for small traders. But in general labor availability is not a constraint as might be deduced from a knowledge of the relatively short times (see table II-4) needed to collect in most areas. Almost any household member can spare the time required to collect firewood in most villages.

Table II-14 shows the patterns of labor use for firewood collecting in the three survey areas. In Lombok and Luwu men are almost twice as likely to collect firewood as women whereas in Klaten both sexes regularly perform this chore. In Lombok and Klaten children are less likely to collect firewood than in Luwu. The sex difference may be explained by the greater distances required in Lombok to reach adequate firewood resources, and the age difference explained by the relatively greater responsibility placed on the firewood collector in a resource scarce area. The firewood resources in home gardens and along village roadsides require management experience which only adults have. Also adults are more likely to observe the necessary social niceties in collecting firewood in areas where practically any combustible resource is likely to be used for firewood and where ownership is not clear.

Although labor availability in general is not a constraint for the gathering of fuels, it may in some cases be important in the use of the fuels in the kitchen. As is pointed out in section II-2, what is called firewood in this survey covers the whole gamut of home garden wastes and

TABLE II-14

FAMILY MEMBERS COLLECTING FUELS

	MEN				WOMEN			
Age	5-8	9-13	14-18	19+	5-8	9-13	14-18	19+
Klaten								
Number	3	14	19	59	5	13	14	62
%	2	7	10	31	3	7	7	33
Lombok								
Number	5	11	6	40	2	1	4	23
%	5	12	7	43	2	1	4	25
Luwu								
Number	1	13	9	29	3	30	5	12
%	1	16	11	35	4	12	6	15

agricultural residues. The less uniform and the more cumbersome to prepare and use these lower quality combustible materials are, the more time is required to cook with them. If for example tobacco stalks are used to cook they have to be fed into the fire constantly so that the proper flame is maintained underneath the cooking pot. Although no detailed study of cooking techniques was made as part of the survey, in many kitchens where these low quality fuels were being used it was observed that one family member was constantly tending the fire. As the quality of the fuel decreases up to four times, more time is spent in preparing and tending the fire than in gathering the fuel.

The time required to use these lowest quality fuels in cooking causes households with relatively less labor available and/or relatively higher incomes to begin to substitute with commercial fuels such as kerosene and higher grades of firewood. A demand for labor-saving fuels by more prosperous households is perhaps one of the reasons why lemtoro firewood is the most expensive firewood in the market as was discussed in the previous section on relative expense of cooking fuels. However, the converse may also be true. That is that poorer households use the poorest grade of firewood which will adequately cook a particular food. In this case labor input in fire tending compensates up to a point for lack of uniformity and reliability in the firewood. The use of available household labor allows for maximum exploitation of the community resources--even small leaves, cornstalks, etc.

Summary - There is a complex of factors affecting the decision of an individual householder in selecting among the alternatives available to him for cooking fuels. Among the important ones are the availability of combustible material within easy reach of his household, the relative expense of alternative commercial fuels such as firewood, kerosene, and charcoal and the need for greater quantities of fuel if the family is large, employs many day laborers, has a home food industry, or is engaged in trade. Such families require more energy and are more likely to purchase this extra energy from the commercial fuel market. Finally, the choice between the two principal commercial fuels, kerosene and firewood, seems to be in part determined by consumer preference of a particular fuel for a particular type of cooking.

The complexity of the factors surrounding fuel choice means that any single-minded effort to alleviate rural energy problems, such as introducing new stoves or planting village woodlots, will fail unless it is carefully matched to local conditions and traditions.

II-4 Household consumption of kerosene for lighting

In the households without electricity kerosene was the only fuel used for lighting with the exception of one well-to-do householder in Lombok who had his own small gasoline powered generator for electric lights (see figure II-5). In houses with electric lights kerosene lamps are still maintained and are used during power failures and for supplementary lighting should social functions require. At the time of the survey (July, 1979) most of the houses with electricity had been electrified for only a month or two and sufficient time had not passed for meaningful observations to be made concerning the residual demand of kerosene for lighting in electrified households. This section therefore is concerned only with the volume and patterns of kerosene use for lighting in households which have not yet been electrified.

The consumption of kerosene for lighting is shown in figures II-5, II-6 and II-7 for the nonelectrified households in Lombok, Luwu and Klaten respectively. These figures also show the cash expenditures of these households for firewood and kerosene for cooking, which together with kerosene for lighting constitute the total cash budget for commercial fuels.

In these figures the cash expenditures for energy of all non-electrified households are calculated and ranked from least to most by percentiles of household. The lowest bar in the figure represents the average energy cash budget of those households in the lowest 20% of the ranking. These figures are to be constrasted with figures II-2, II-3, and II-4 which show the total household cooking energy use in which different fuels are added together in terms of their estimated firewood equivalents defined by their actual useful caloric yield in cooking. The data in figures II-5, II-6, and II-7 are free of any such estimates or assumptions.

Together these two sets of figures provide a convenient characterization of the three areas by showing how the patterns of energy use vary from low to high consumers. One almost invariant observation is that households which consume lesser amounts of commercial energy spend all of their cash energy budget for lighting fuel; their food is cooked using only gathered firewood. However, rather abruptly there is a transition in the spending pattern of households which purchase relatively greater quantities of energy to spend more for cooking fuels than for lighting. These proportions hold for the top 40% of households in Lombok and in the top 20% in Klaten and Luwu. Moreover in the top 40% of houses in Lombok kerosene used for cooking is approximately the same as kerosene used for lighting. Since there is a shortage in the Lombok project area of combustible materials such as firewood and home garden wastes within walking distance of the villages, it is likely that the villagers have to spend scarce cash on cooking fuels at the sacrifice of house lighting.

What households spend for lighting varies widely from one project area to another and within a project area. A few statistics will serve to highlight these differences. The 40% of households which spend the least amount of money on energy (the bottom or lowest 40%) spend Rp. 4,600 per year per household in Lombok for lighting, Rp. 6,600 per year per household in Luwu, and Rp. 7,700 in Klaten. By contrast the top 40% in Lombok spend

FIGURE II-5

HOUSEHOLD COMMERCIAL FUEL BUDGETS

LOMBOK

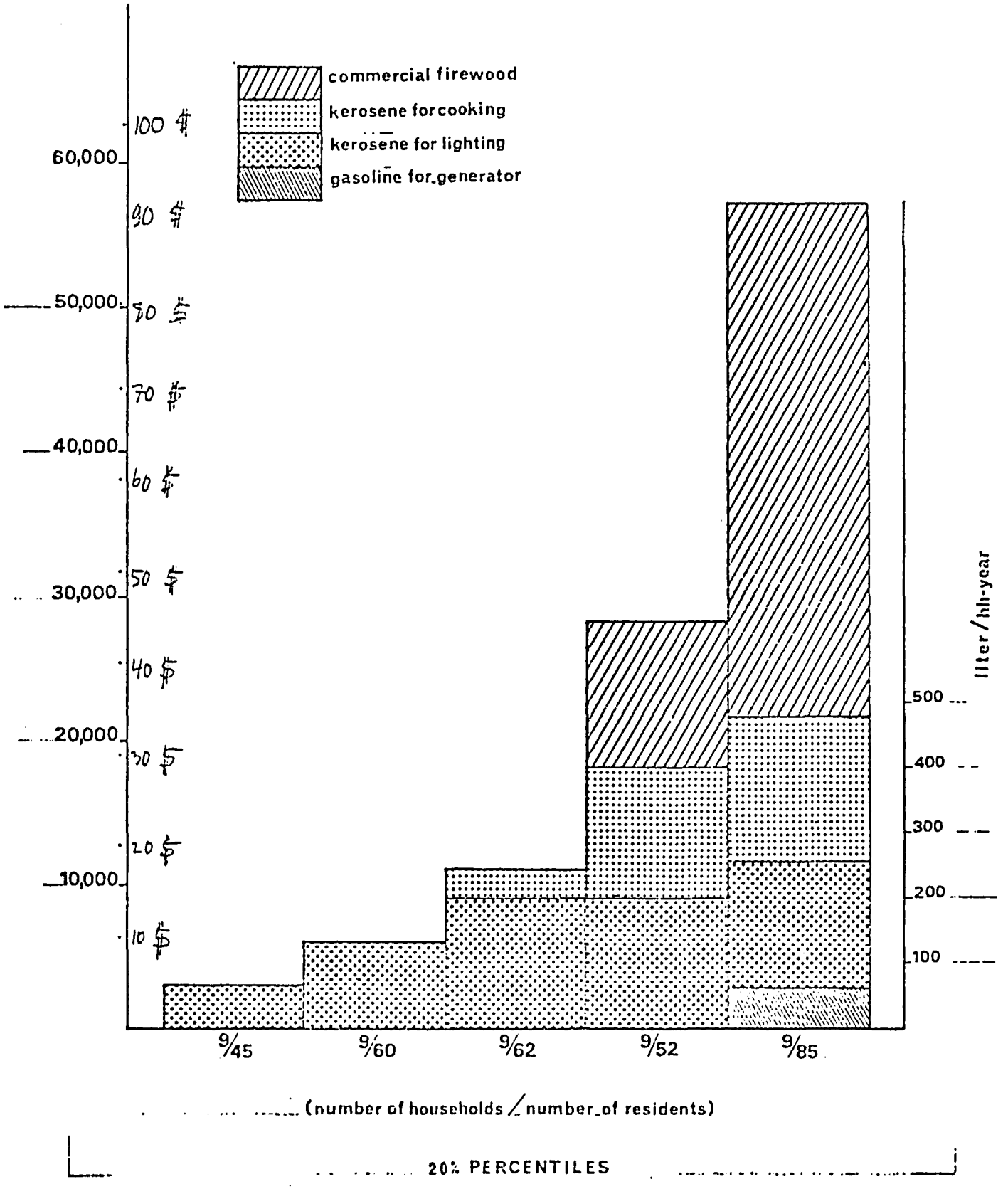
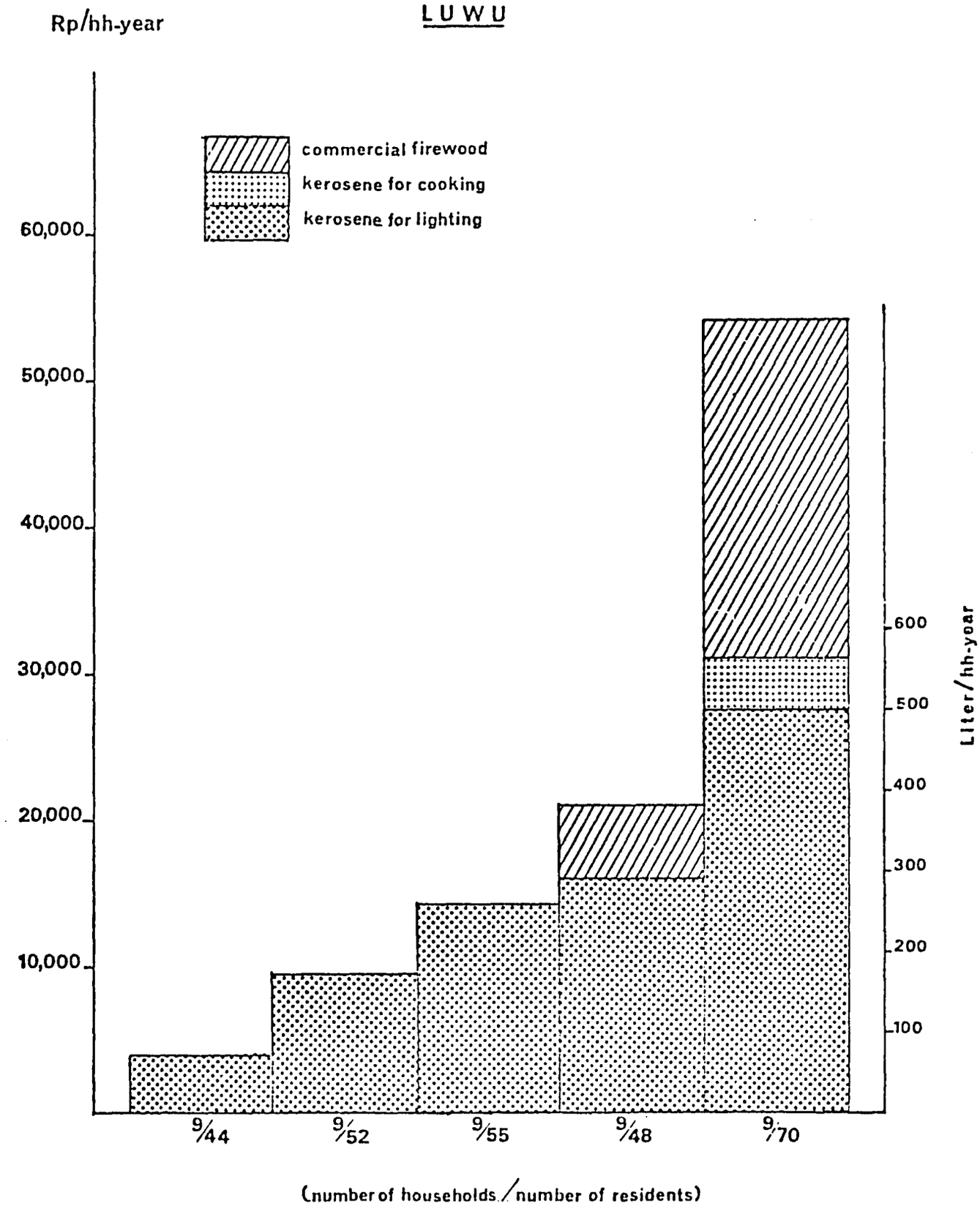


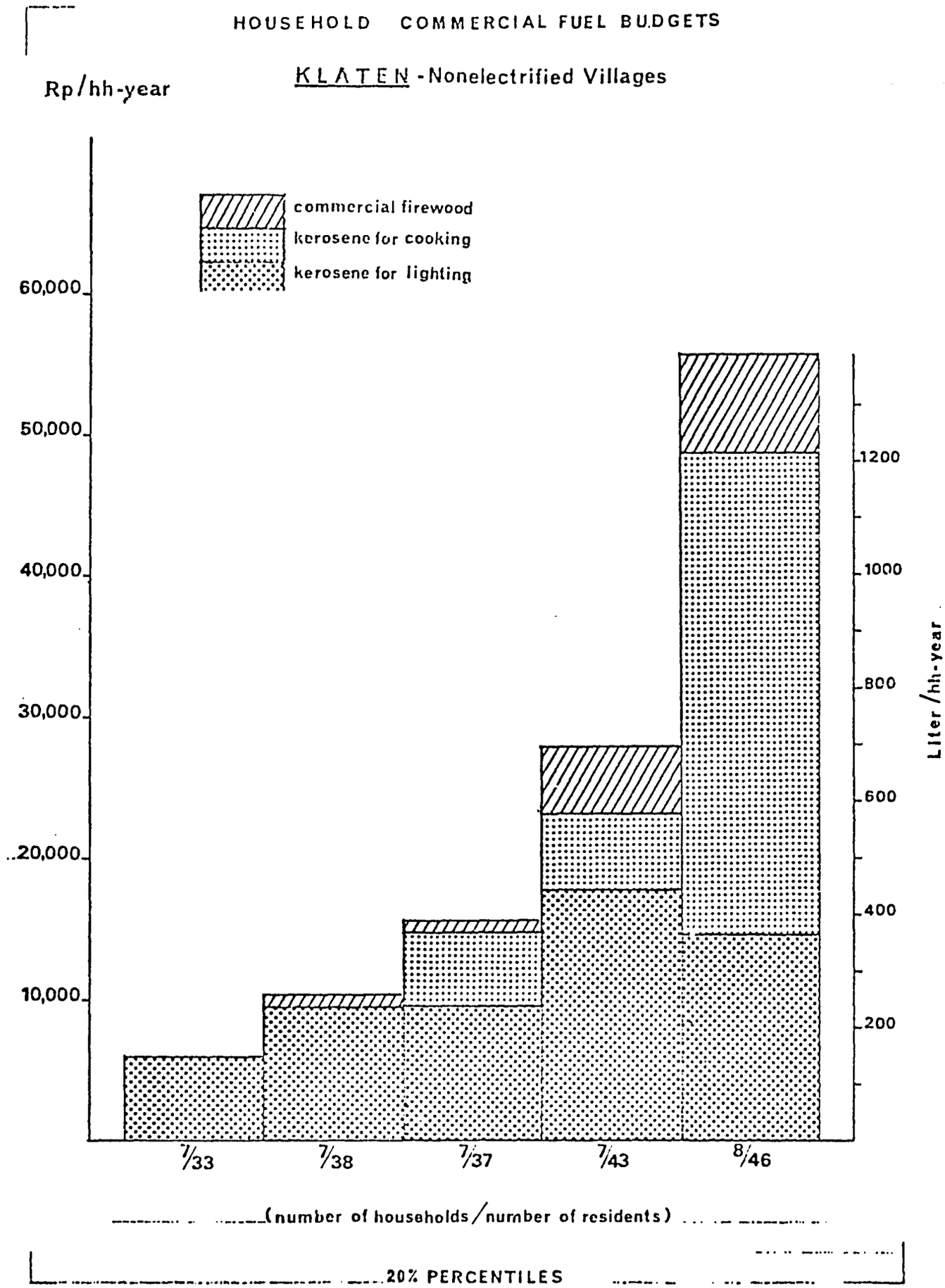
FIGURE II-6

HOUSEHOLD COMMERCIAL FUEL BUDGETS



20% PERCENTILES

FIGURE II-7


HOUSEHOLD COMMERCIAL FUEL BUDGETS
KLATEN - Nonelectrified Villages
Rp/hh-year
commercial firewood
kerosene for cooking
kerosene for lighting
60,000
50,000
40,000
30,000
20,000
10,000
1200
1000
800
600
400
200
Liter/hh-year
7/33
7/38
7/37
7/43
8/46
(number of households/number of residents)
20% PERCENTILES

Rp. 9,500 per household per year, in Luwu Rp. 21,500, and in Klaten Rp. 16,000 for kerosene for lighting. Because prices vary in the three areas these expenditures buy different amounts of kerosene--in Luwu and Lombok the expenditure of the bottom 40% buys 70 liters per year per household but in Klaten it buys 150 liters per year per household. For the top 40% these figures are approximately 200 liters per household per year in Lombok, 500 liters in Luwu and 440 liters in Klaten.

The average per capita consumption of kerosene for lighting among the surveyed households varies in the different survey areas in the following way (with total kerosene use for both lighting and cooking in parenthesis): approximately 25 liters/capita/year (39 liters) in Lombok; 43 liters/household/year (45 liters) in Luwu; and 53 liters/household/year (93 liters) in Klaten. These figures can be compared with an overall Indonesia per capita consumption of 39.7 liters in 1976 (Soesastro, 1979). If the annual growth rate of 9.1% in national kerosene consumption was maintained since 1976, the figure for the time of the survey would be 47 liters/capita/year at the beginning of 1979. However, as the price of kerosene was increased substantially in early 1979, it is expected that the national per capita consumption fell slightly, so that at the time of the survey it was approximately 45 liters. A careful breakdown of kerosene into the rural and urban household and industrial sectors has been made by Atje (1979). He estimates an average consumption of 28 liters/capita/year in 1976 in rural Java households based on official statistics. This figure, even if increased by the 9% national trend to 33 liters, is less than the average consumption of the surveyed households in all of the three areas.

There are two other data sources on kerosene consumption that can be used to compare with these figures. One is a kerosene dealer who claims to supply 70% of the households in Klaten. His per capita average is 42 liters/year in 1977 (P.T. Panca Daya, 1977), which would be approximately 50 liters in 1979 if the rate of growth in kerosene use in Klaten followed the national trend. The other date source is the survey by IPB (1977) which obtained values for lighting only of 64 liters/capita/year in Klaten, 73 liters in Luwu, and 64 liters in Lombok. These values are likely to be the least accurate as they do not result from measurements, being only responses during a short interview.

Although the range of kerosene consumption is great, the range of variation of lighting it can produce is even greater. Typically, the kerosene in the bottom 40% of households is burned in wick or bottle lamps which produce light less efficiently than the petromax lamp which is found more frequently in the top 40% of energy purchasing households. Only one in two households of the bottom 40% ranked by income, which is correlated with cash expenditures for lighting energy, own a petromax. In the top 40% on the average each household owns slightly more than one petromax. In addition each household in the bottom 40% on the average owns 2½ wick or bottle lamps whereas the top 40% owns 4 such lamps. A comparison of the fuel consumption rate of these lamps gives an estimate of the quantity of light which can be produced by these levels of kerosene use. The lowest rate of fuel consumption rate is approximately 0.01 liters of kerosene per hour in bottle lamps or small wick lamps. The highest rate for a large wick lamp is about 0.06 liters of kerosene per hour; and the consumption of

a petromax lamp is approximately 0.1 liter of kerosene per hour. This means that if one of the minimal fuel consuming households of Lombok or Luwu burns all their kerosene in a petromax they would get only 700 hours per year of light or approximately two hours per night. If on the other hand this same minimal fuel consuming household burns all of its kerosene in a bottle or wick lamp they would receive from 1200 to 7000 lamp hours per year or approximately from three to twenty lamp hours per night. By contrast, the higher figures of 440 liters and 500 liters are enough kerosene to keep two petromax lamps burning six hours each for every evening of the year.

The many factors which influence the choice of lamp used and the time for which it is used, in short the amount of light in a house, interact in a complex way to determine kerosene use. Extensive questioning on this interaction by the surveyors emphasized a number of variables potentially relevant to the household need for light, such as purpose of lighting, household income, size of house, number of rooms, etc. The factors leading to the choice of a petromax were stressed as petromax lamps consume more fuel and are a viable, and for some uses preferred, alternative to electric lights. The reasons given by respondents for using petromax lamps can be contrasted with general uses of lighting as follows. In all areas 82% of the respondents report using lighting for general household purposes such as reading, studying, sewing, etc. Approximately 45% reported that lighting was used for night work that produces an economic return; whereas 33% cited social activity and entertainment as a need for light. These responses are to be contrasted with petromax owners of whom only 66% stated that they use the petromax for general house lighting, only 27% for night work, but 49% for social activity, entertainment, etc. Thus the petromax is more likely to be reserved for special purposes such as social activities rather than used for general purpose lighting. Therefore, the amount of kerosene used by petromax owners in this relatively more fuel consuming lamp is not necessarily related directly to income, housing size, or number of rooms.

Although it is difficult to pinpoint causual relationships which could lead to prediction of lamp use, there are some general trends. Tables II-15 and II-16 show respectively lighting fuel use as a function of household income level and the relationships of lamp ownership to housing characteristics such as size and the number of rooms. In table II-15, as one would expect, there is an increase in fuel use with income and in table II-16 an increase in lamp ownership with larger housing. Another way of stating the statistics in table II-15 is that 72% of the families in the bottom 40% by income use less than 4 liters of kerosene per week while of the top 40% by income only 20% are using less than this amount. By contrast the number of respondents using more than 5 liters per week increases from 10% for the bottom 40% income group to 43% for the top 40% income group. On an average basis the top 40% uses 6.0 liter/household/week or twice as much as the bottom 40% which uses 2.9 liter/ household/week. This range is only slightly less than the difference between the top and bottom 40% groups constituted on the basis of commercial fuel purchases. These groups range from 2.7 liter/household/ week to 7.0 liter/household/week.

Although there is a correlation of income and kerosene use for lighting, a careful inspection of the data of table II-15 shows that low

TABLE II-15

LIGHTING FUEL USE BY INCOME LEVEL

(Number of Households)

Level of Income Rp/Household/Month	Sample Size	Kerosene Use for Lighting* (Liters/Household/Week) ≤ 2	2< & ≤4	4< & ≤5	> 5	Average Use
Less than 18,000	51	18	19	8	6	2.9
18,000 to 29,999	26	4	6	7	9	4.7
30,000 to 59,999	31	3	8	9	11	5.5
60,000 and more	18	-	3	5	10	6.8
All	126	25	36	29	36	4.5

* Nonelectrified households only; in Klaten only 36 of 90 households surveyed use kerosene exclusively for lighting.

TABLE II-16

RELATIONSHIP OF LAMP OWNERSHIP TO HOUSING CHARACTERISTICS

(Number of Households)

	Number of Lamps				
House Size (m^2)	1	1½-2	2½-3	3 or more	Sample size
Less than 45	11	21	7	1	40
46-75	4	19	14	1	38
76-100	1	6	9	3	19
More than 100	-	3	10	13	26
ALL	16	49	40	18	123
Number of Rooms					
1	3	6	6	1	16
2	7	16	4	2	29
3	3	14	12	5	34
4 or more	2	11	20	11	44
ALL	15	47	42	19	123

income is not an absolute barrier to relatively high levels of lighting. On the average the percentage of household income spent on lighting rises from less than 2% for those households with incomes more than Rp. 60,000 per month to more than 4% for the two lowest income groups. A number of the lowest income group, those below Rp. 18,000/household/year, even consume an amount of kerosene for lighting costs them more than 6% of household income. The removal of the kerosene subsidy, a policy move much discussed (e.g. Tobing, 1979), would affect these lowest groups severly, causing a drop in kerosene consumption and a loss of quality of life.

II-5 Impact of electrification on energy use for household lighting

Two months before the field survey was conducted in July, 1979, three villages in the Klaten project area were electrified as a demonstration project in advance of the main electrification program. These three villages which were surveyed are Gergunung, Jonggrangan, and Karang Anom. In addition to these three villages one other village that has been electrified for five years was surveyed. This other village, Cokro, has a system of three hundred houses connected to a small hydropower installation. It was developed as an independent system and does not conform to PLN standards or rates. This section examines household electricity use in these three villages contrasted with electricity use in houses serviced by the Cokro system. The use of electricity for lighting will be compared with the use of kerosene for lighting in the non-electrified villages in Klaten.

Electricity consumption in three demonstration villages in Klaten.

As these villages were already electrified at the time of the survey, there was no opportunity to make a direct analysis of the changes that occur with electrification. However, with due caution a number of observations and inferences can be made about the likely magnitude of these changes. One caution about the Klaten villages is that more power is used in the first month or two after electrification than would be the average after a few months. The initial eagerness to have a light burning in every room is tempered as the energy cost becomes evident after the first bills are received. At the time of the survey, none of the villagers had yet received his first bill.

The major change resulting from electrification is a switch from the use of kerosene for lighting to the use of electricity for lighting. Although a number of low power appliances, such as radios, televisions, and tape recorders, which before had been battery powered, are now powered by the PLN supplied electricity, the power consumption of the small number of such appliances (see Table II-17) found in the electrified households is trivial compared to the demand for electricity for lighting. Therefore the following analysis can be confined only to the substitution of electricity for kerosene for lighting without any inaccuracy as there are as yet no appliances with significant power consumption. The fundamental questions about the initial transition are: How much more light is available in the house after electrification? What is the increased cost of that light? And, what is the quantity of petroleum fuel required to generate the electricity for that light relative to the quantity of kerosene used before electrification?

The electricity use statistics, shown in table II-18 for the three villages recently electrified, represent a significant increase in the amount of light in the house in comparison with the light produced by kerosene lamps. Table II-18 gives the characteristics of household lighting in terms of total bulb wattage, bulb sizes, number of bulbs, and hours bulbs are lit. An average value for kerosene consumption for lighting in other villages in Klaten is approximately 290 liters per year per household (see figure II-7) which if burned in petromax lamps would be approximately 3,000 lamp hours per year or approximately 8 petromax lamp

TABLE II-17

NUMBER OF HOUSEHOLDS OWNING APPLIANCES BY INCOME

Level of Income (Rp/HH/Month)	Radio	Tele-vision	Manual Sewing Machine	Charcoal Iron	Sample Size
Klaten					
Less than 18,000	13	-	5	5	26
18,000 to 29,999	13	1	5	6	19
30,000 to 49,999	21	5	6	12	24
50,000 and more	22	9	13	17	21
TOTAL	69	15	29	40	90
Lombok					
Less than 18,000	3	-	1	1	17
18,000 to 29,999	1	-	1	3*	11
30,000 t0 49,999	3	-	3	2**	11
50,000 and more	3	2	1	2	6
TOTAL	10	2	6	8	45
Luwu					
Less than 18,000	13	-	-	-	21
18,000 to 29,999	6	-	1	1	8
30,000 t0 49,999	6	-	4	2	8
50,000 and more	7	-	3	3	8
TOTAL	32	-	8	6	45
GRAND TOTAL	111	17	43	54	180

* Note that two of these irons are borrowed.

** Note that one of these irons is borrowed.

TABLE II-18

DATA ON ELECTRICITY SYSTEMS

	Jonggrangan	Karang Anom	Gergunung	Cokro
Operator	PLN	PLN	PLN	Desa
Voltage	220	220	220	110
Frequency	50	50	50	50
Hours	12	12	12	13
Tariff				
Per kwh	Rp. 27	Rp. 27	Rp. 27	-
Per watt	-	-	-	Rp. 7.5
Hookup	Rp. 5,000- Rp.30,000-	Rp. 5,250- Rp. 6,200	Rp. 5,000	Rp. 2,500- Rp.10,000
Capacity (Watts)				
Average	450	450	450	45
Range	-	-	-	25-100
Household Consumption (kwhr)/Month				
Average	64	39	40	17
Range	28-120	11-86	21-78	10-39
Average Month Bill	Rp. 3,000	Rp. 2,300	Rp. 2,300	Rp. 320
Number of Bills				
Average	6.8	6	6.8	3.5
Range	3-10	3-18	3-15	1-7
Bulb Hours				
Average	44.5	52	50	44
Range	18-64	36-120	20-108	13-78
Average Bulb Size Per Household				
Average	45	25	30	12.5
Range	25-63	10-40	18-38	7-15
Total Bulb Wattage				
Average	260	125	175	43
Range	43-540	73-360	120-375	25-100

hours per night. Since the light given off by a petromax is approximately equivalent to that from a 60 watt incandescent bulb, the households in the electrified villages, which now consume on the average 1.3 to 2.1 kwh (22 to 35 hours of a 60 watt bulb) per night, have approximately three to four times as much illumination after electrification. This is a substantial increase in lighting levels both during evening hours and during the night when the household residents are asleep. The average number of hours that lights are lit (see table II-18) is 7 to 8 hours per night which implies that approximately one third of the lights in the house are left on all night long. In non-electrified households petromax or large wick lamps are burned only when the family is awake; night lights are provided by small bottle or wick lamps. Thus electrified households, at least in the first few months of electrification, not only are better lit, but use a greater fraction of total lighting energy during the sleeping hours.

The amounts of electricity (30 kwh/connection/mo) used in the three demonstration villages, although 50% more than predicted by the AID Project Paper (AID, 1977), are close to the initial demand in other developing country rural electrification projects: 33 kwh in the Philippines (Abadian, 1978); 33 to 58 kwh in Northeast Brazil (Anderson, 1976); and 35 kwh in El Salvador (Anderson, 1975). Future usage is forcast by the AID Project Paper to be 60 kwh in 15 years. A recent project in Thailand forecast usage of 100 kwh in 20 years (Abadian, 1978). In the Philippines average residential connection is forecast to use 90 kwh by the year 2000 (Abadian, 1978). This usage level has already been exceeded in one well established Philippine cooperative, Albay, where the average connection used 105 kwh in 1978 (ALECO, 1979). Abadian (1978) predicts consumption in electrified households in the Philippines to be 200 to 300 kwh per capita per year by 2010.

Even though these levels of use, if achieved in Indonesia, represent a substantial increase in energy consumption, they are still much less than present usage levels typical of developed countries with their energy dependent high quality of life. Charpentier (1976) estimates the per capita average of total energy use in developed countries to be approximately 40 times that of developing countries. The value of 300 kwh per capita per year is also much less than electricity use in "modern" households in Indonesia. For example, the average electricity consumption of 200 American families living in Jakarta in air-conditioned homes is more than 16,000 kwh per capita per year (OMF, 1980)!

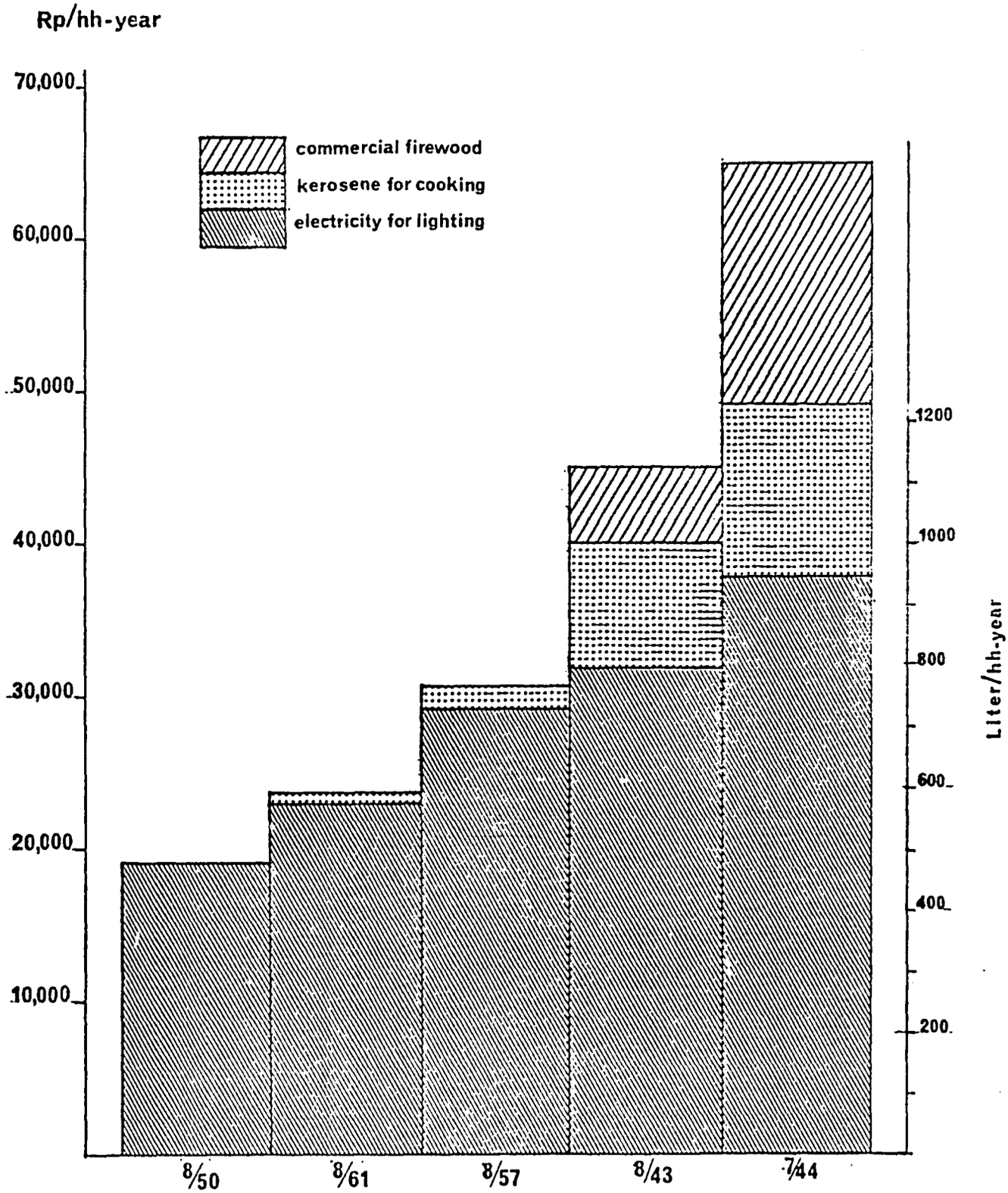
Relative economic and energy cost of electricity and kerosene for lighting.

The three to fourfold increase in household lighting costs the average household substantially more than the previous average expenditure for kerosene. If previous kerosene use in the households of the three demonstration villages is comparable to the pattern shown in figure II-7, then the average expenditure per year for electric lighting of approximately Rp. 28,300, as shown in figure II-8, is 2½ times the average expenditure of Rp. 11,500 in the non-electrified households as shown in figure II-7. This is an increase in annual expenditures and does not include the average initial outlay of Rp. 6,000 to Rp. 7,000 for light bulbs (see table II-19). However, the yearly cost of lighting for the electrified households does include a Rp. 1,035 per month charge for housewiring and systems connection.

FIGURE II-8

HOUSEHOLD COMMERCIAL FUEL BUDGETS

KLATEN - Electrified Villages



20% PERCENTILES

TABLE II-19

PRICE FOR LIGHTING APPLIANCES

(In Rupiahs)

	Klaten	Lombok	Luwu
Kerosene Lamps			
Petromax	7500-12500	2500-12500	7500-16500
Wick Lamp:			
Small	250-400	350-500	300-400
Large	500-700	600-1200	750-1400
Electrical Lamps			
Incandescent Light Bulbs:			
10W	1000	-	2000
20W	-	-	2500
Fluoresent Fixture	1000	-	2000-2500
10W light bulb	450-500	-	1000
20W light bulb	-	-	1500
Starter	100	-	250

This charge will be terminated after four years and at that time the annual lighting cost will be less, unless of course there is an increase in the rate of energy charges as a result of escalating energy costs.

If in the average household electricity provides 3 to 4 times the light at 2½ times the cost as kerosene, what is the amount of petroleum based energy required to support this increase? This amount can be calculated in several ways as is discussed in detail in a later section. For the purposes of comparison here the ratio of efficiency of light output from a petromax and an incandescent bulb lit by electricity from a thermal power plant is approximately 3.5. This ratio includes line and transmission losses of 25% (Stichenwith, 1978). Therefore, the amount of petroleum fuel burned to produce lighting for one household is approximately the same as the amount of kerosene used before on a per household basis. From the point of view of conservation of non-renewable petroleum energy resources rural electrification does not imply a net energy savings mainly because the householders surveyed in these three villages want to see a substantial increase in the amount of light in their household after electrification. Overall the household energy budget in the demonstration villages remains at the beginning of electrification substantially the same as in the non-electrified villages (see Table II-13), meaning that electricity substitutes only about thirty percent of the household energy budget.

The desire for more light may be tempered somewhat by the realization of the expense of high light levels. Table II-20 shows a decline in the average bill from Rp. 2,648 in September 1979, to Rp. 2,053 in January 1980, corresponding to a drop from 53 to 30 kwh/household/month. This is equivalent to a drop in light level which is only 2 to 3 times the average kerosene user's level at a cost which is 2.1 times the kerosene user's cash outlay for lighting fuel. At this level of use the amount of petroleum fuel used to generate electricity for lighting is 70% of the previous amount--a savings of 30%. However, if the use of any energy consuming electric appliances, which many consider necessary for an improved quality of life, such as irons, hot plates, fans, refrigerators, etc., begins to be commonplace, this 30% savings will quickly disappear. That is to say that if rural electrification achieves its goals of an improvement in quality of life in rural villages, it will be at a cost of increased per capita consumption of nonrenewable energy resources starting with the first hook-up.

Comparison of village hydropower system with PLN system.

In contrast to the PLN system in the three demonstration villages is the hydropower system in Cokro, where the cost of electricity (see figure II-9) is much cheaper, on average Rp. 19/kwh. The households which consume the smallest amount of power pay only Rp. 2,250 per year for 25 watt service. The average household in Cokro spends only Rp. 3,800 per year for an average service of 45 watts. The relatively smaller scale of the Cokro system is described in Table II-18. The average monthly energy usage is approximately 17 kwh in Cokro compared with Karang Anom and Gergunung where at the time of the survey average household usage was approximately 40 kwh, but which subsequently dropped to 30 kwh. Electricity usage in Cokro, primarily for lighting, costs the householder 15% of the PLN system costs;

TABLE II-20

ENERGY USE AND BILLING IN

THREE KLATEN DEMONSTRATION VILLAGES

	June	July	Aug	Sept	Oct	Nov	Dec	Jan
Karang Anom								
Total households connected		637	853	928	937	947	955	973
Average Kwh per month		16	48	52	40	32	35	32
Average rate (Rp/kwhr)		52	32	30	32	33	32	33
Energy charage per month (Rp)		828	1538	1567	1265	1073	1132	1049
Average bill (Rp)*		1863	2573	2602	2300	2108	2167	2084
Bergunung								
Total households connected			339	452	468	481	498	533
Average Kwh per month			20	64	52	29	29	29
Average rate (Rp/kwhr)			47	29	29	35	34	34
Energy charge per month (Rp)			944	1877	1535	1011	996	984
Average bill (Rp)*			1977	2912	2570	2046	1931	2019
Jonggrangan								
Total households connected		216	292	314	319	320	326	332
Average Kwh per month		16	55	43	32	30	29	29
Average rate (Rp/kwhr)		52	31	32	34	33	35	34
Energy charge per month (Rp)		825	1687	1370	1091	993	1007	983
Average bill (Rp)*		1860	2742	2405	2126	2028	2042	2018
All Areas								
Total households connected		852	1484	1694	1724	1748	1779	1838
Average Kwh per month	15	16	43	53	42	31	32	30
Average rate (Rp/kwhr)	48	52	33	31	31	34	33	34
Energy charge per month (Rp)	727	828	1431	1631	1307	1041	1071	1018
Average bill (Rp)*	1762	1861	2466	2666	2342	2076	2106	2053

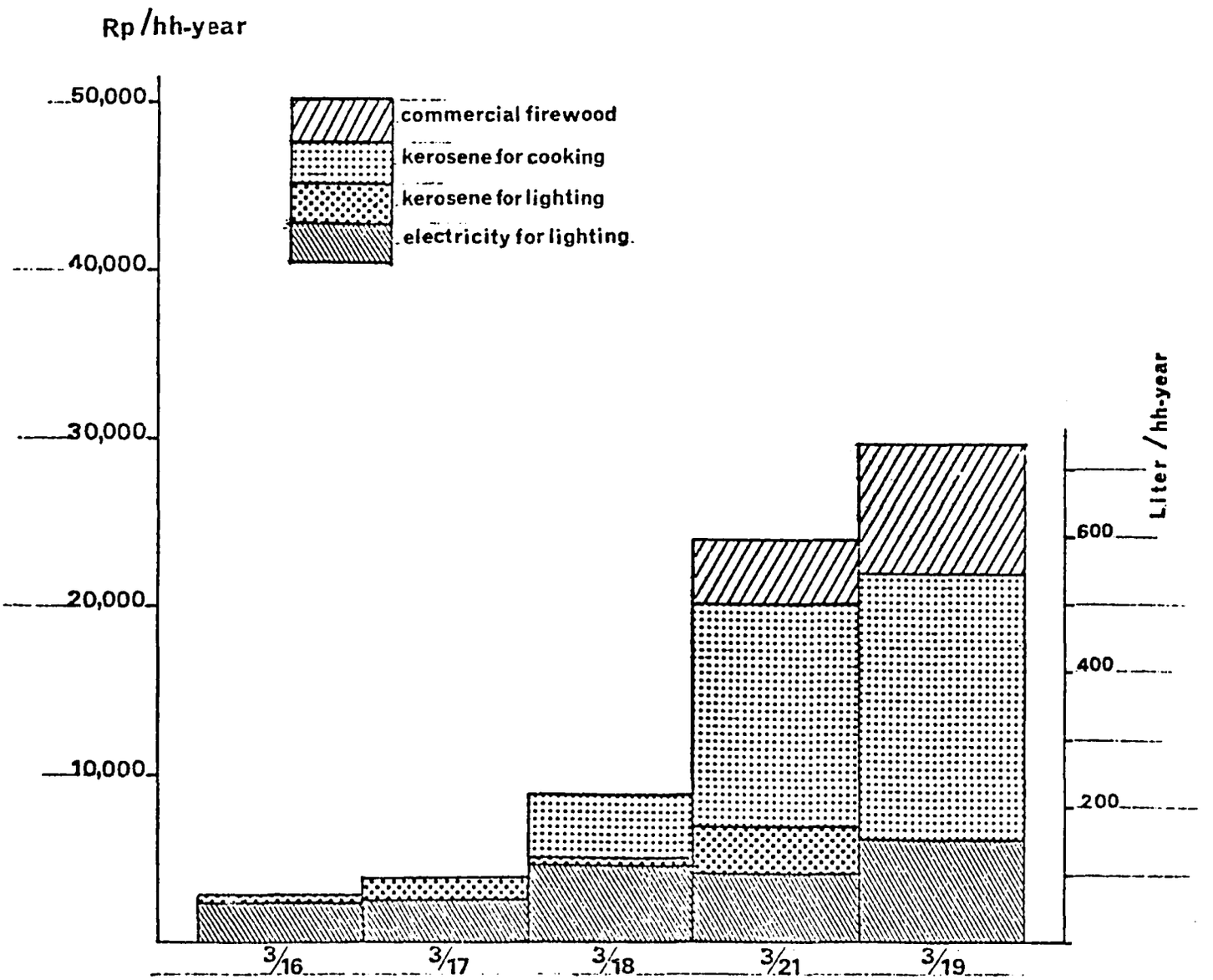
Source: NRECA letter and personal communication with PLN Regional Office, Semarang

* All bills include a charge of Rp. 1035 per month (for 48 months) to pay for housewiring and connection costs.

FIGURE-II-9

HOUSEHOLD COMMERCIAL FUEL BUDGETS

KLATEN - Cokro



however, the Cokro system provides 40% to 60% of the energy to the average Cokro household that the PLN system provides to its average household.

Since the rate structure in Cokro is fundamentally different, the pattern of use is different. There are no meters on the houses and the charge is only for the power capacity of the connection. Any capacity from 25 watts on up can be connected and is charged at the rate of Rp. 7.5 per month per watt. Therefore, there is no incentive to use less electricity and all light bulbs are left burning the entire time the generator is in operation--approximately 13 hours per night. Of course, from the point of view of resource conservation this is of no consequence as hydropower is the energy source of the system and no nonrenewable resource is being consumed.

The Cokro system provides energy at a cheap rate for a number of reasons - the most important of which is the use of a renewable resource which is independent of escalating world energy costs. Also the initial investment was minimized because of the particularly favorable location of the water drop at a large spring issuing out of a steep hillside. Since the construction cost of headworks are often as much as 90% of the initial investment of small scale hydropower, this favorable location meant that the capital investment was particularly low. And although precise figures are difficult to obtain, a subsidy was contributed by the kabupaten for the cost of the 50 kilowatt turbine. Other reasons for the inexpensive service are the lower standards of lines, poles and housewiring. The last factor is the absence of the need to finance the construction of long lines to bring the power from a remote large generating plant. This expense can contribute approximately US $50/kw (Kalhammer, 1979) to the initial system investment.

When the Klaten grid system enters the village of Cokro, the villagers will likely be reluctant to change to PLN and pay a large increase in electric bills (compare figure II-8 and figure II-9). The average villager in Cokro now obtains per night about 9½ hours of 60 watt illumination, which as calculated before is equivalent to the illumination of a petromax lamp. In the households of the nonelectrified villages shown in figure II-7, the kerosene consumed is considered equivalent on the average to 8 hours of a petromax. The average household in the bottom 20% of households (on the basis of cash outlays for energy) spends approximately Rp. 3,000 per year for lighting as compared with Rp. 6,000 in the comparable group of non-electrified households in Klaten. Therefore for the last four years Cokro villagers have enjoyed a slight improvement in illumination at half the previous cost. As PLN enters, the minimum charge which this lowest group will have to pay is Rp. 18,000 or Rp. 19,000 a year, a sixfold increase over the current expenditure for only a doubling of the present level of illumination in the household. As these householders could have doubled the illumination under the existing Cokro system with only a doubling of the annual expenditure of Rp. 3,000, it is unlikely that they will be receptive to the advent of the PLN system. The greater cost for Cokro villagers could be compensated somewhat by the prospect of greater reliability of the PLN system as the Cokro system fails twice a month on the average.

The reluctance of the Cokro villager to connect to the PLN system presents an example of what will be a problem for PLN in many areas in Central Java. The Cokro system is but one of the many indigenous systems which dot the Central Java landscape, which more typically are powered by small diesel generators owned by a village headman. These systems can supply anywhere from a few dozen to a few hundred households at a level of service that is both less expensive and of smaller capacity than the minimum PLN can provide. Since the villagers who are using these systems already have electric lights and the possibility of using small low power appliances in their households, they will naturally be reluctant to pay a substantial amount more for an uncertain increase in benefits and reliability from a PLN system.

Affordability and utility of electricity in the household.

Questions concerning the benefits from the electrification depend upon the ability of villagers to afford a connection and the service. The question of affordability has been discussed in papers by Strout (1978) and McCawley (1978) and has been reviewed by AID sociologist Crystal (1980) and economist Gellerson (1980). Affordability is addressed from the perspective of the economics of energy use.

Before predictions about affordability can be made, the representativeness of the surveyed villages should be examined. The three demonstration villages in Klaten are all near the main transportation access of Central Java between Jogyakarta and Solo which includes a highway and a major railroad line. This ready accesss to markets affords opportunity for a number of small industries, service occupations and trading enterprises such as storekeeping to flourish. This economic activity makes villages along this transportation corridor more prosperous than those at a distance from it. In the non-electrified villages and in Cokro only the top 40% of households are now spending an amount of money for all forms of commercial energy comparable to the minimum payment for lighting only in the electrified villages. Similarly, reference to figure II-5 and 6 for Lombok and Luwu respectively show that the same statistic is true for the top 40% of households surveyed. Even if this top 40% reallocates all of the cash portion of its energy budget to electricity (for lighting) then that portion of its cooking fuel that it heretofore purchased must now be gathered. While a return to a greater reliance on gathered firewood may be possible in Luwu and Klaten, it is not an option open to most households in Lombok as the local resources base is already intensively used. However, the local scarcity of firewood resources is not the only reason that households purchase commercial cooking fuels.

In all three areas households which purchase large amounts of cooking fuels are those with high economic productivity. In figures II-2 through II-9 it can be seen that the majority of commercial fuels is purchased by the top 20% of energy consuming households, the same households that typically feed day laborers or have a home industry. The activities of these households require a greater supply of higher quality fuel than they could gather on their own. Their productivity depends on the continued supply of such affordable fuel. In fact fuel is often the most critical cost of many home and small scale industries such as tobacco drying, tile or brick making, blacksmithing, or sugar making.

Since the fuels purchased by high energy consuming households are all used for cooking or heating energy, electricity is not a viable substitute. Not only is the cost of electric cookers or heaters high, the cost of usable kilocalories from direct combustion of a fuel will always be relatively cheaper than the more inefficient two step conversion from using heat energy from fuel combustion to generate electricity and then converting back to heat energy again. Therefore electricity cannot contribute in a direct way to increased household economic productivity by substituting or increasing the current use of energy. Rather it is the already existing high productivity of these households that allows them to afford electricity and the consequent increase in quality of life from electric lighting.

Concern for productive uses of energy in rural areas must start with the energy requirements of already existing sources of community economic productivity, which include small scale and home industries (discussed in Section III). Before a community can begin to develop productive uses of a new form of energy such as electricity, it must take care to assure that the energy needs of its existing productivity will continue to be met in the fact of substantial price increases in kerosene and commercial biomass fuels. Klaten is particularly vulnerable in this respect, as it already imports much of the firewood and charcoal for its small scale and home industries from outside the Kabupaten - from even as far as East Java.

II-6 Conversion efficiencies: useful energy and fuel demand

In all surveys and analyses of rural energy use there are a number of sources of error that can limit the accuracy of the results as well as the comparability of different studies. The source of these errors lie in estimations, assumptions, and measurements, both in the field and in the laboratory. In order to make the results of this survey as useful as possible to other researchers, a careful effort was made to minimize the sources of error. Further, the assumptions and estimations that have been used to calculate survey results are separated from field measurements so that other researchers can easily use their own assumptions to recalculate this survey's results directly from measured quantities. Unfortunately earlier Indonesian surveys have not always made clear which of their "results" are actually from measured data and which are from estimations. Strout (1978b) as well as Soesastro (1980) discuss the varied assumptions concealed in the results of previous Indonesian rural energy studies.

The "error" in the results of this survey is minimized both by the technique of field measurements and by the way equivalencies for different fuels are derived. All measurements of fuel use were made by surveyors using calibrated bottles and scales. No firewood or agricultural residue volume measurements or estimates were ever made or used by surveyors. The error in weighings is less than 5%, probably on the order of 3%. Firewood weighings were made no more than two days before use so that the variance in weight due to moisture content would be minimal as the wood was already air-dry to the point where it burned readily.

The equivalencies between different fuels used for energy budget calculations are based on simple field experiments designed to determine what quantity of one fuel replaces another. In some cases for the sake of comparison with other studies, energy budgets are also calculated (as in table II-13) on the basis of caloric content, or "energy input." However, such budgets are less accurate because of the wide range in the calorific value of different biomass fuels (see Golley, 1961, and Paine, 1971). Such budgets are also less useful as further assumptions about fuel combustion efficiencies are necessary to make any statement about questions of fuel substitution, for example the amount of firewood needed to substitute kerosene in domestic cooking. To be useful for these questions the equivalency factors used in this report are based on replacement factors determined in field rather than in laboratory experiments. These field experiments are described below:

Stoves - An experiment was conducted in Luwu to compare the fuel consumption of three different types of stoves all burning the same type of firewood, air-dried mangrove wood. The stoves were of the open clay type, the closed clay, and open metal type. The cooking was done in three different homes by the household members who normally use the stove and who are accustomed to using mangrove wood. The cook was given 2½ kilograms of air-dried mangrove wood which was found by oven drying to have a moisture content of 18%. The wood was used to make a fire under a covered aluminum pot containing three liters of water at room temperature. The wood was burned to exhaustion and the amount of water evaporated was measured. The quantity of captured heat was determined as the sum of the heat energy required to heat the water from the initial measured temperature to 100°C

(all experiments were conducted within 50 meters of sea level) and the heat of evaporation at 100°C for the volume of water lost. Efficiencies were calculated on the assumption that the calorific value of oven dry mangrove wood used is 4800 kcal/kg (Earl, 1975). The wood stove efficiencies range from 12-15% as compared with 26% for a kerosene stove under the same experimental conditions, but starting with one half liter of kerosene.

These efficiencies imply a useful energy equivalency (for cooking) between kerosene and mangrove stemwood of approximately 4.8 kg air-dry firewood to 1.0 liter kerosene. Agricultural residues were estimated to have a calorific value of approximately 80% of that of stemwood, so their equivalency of useful energy is estimated to be 6.0 kg air-dry residue to 1.0 liter kerosene. These are the factors used in the energy budgets of this report. Other studies have found that 1.0 liter of kerosene is replaceable by 5.8 kg of wood in West Java (Atje, 1979) or by a range from 5.5 to 10 kg of wood in India (NCAER, 1978).

The equivalency estimates used in this study are based on wood stove efficiencies of 12% to 13%. This is a high value compared with the efficiencies of traditional stoves reported in the literature (Evans, 1979; Argal, 1978; Knowland and Ulinski, 1979). The most detailed study of various types of traditional Indonesian stoves is by Singer (1961) who reported that laboratory measurements of traditional open stoves were in the range of 6% to 8%, whereas modified stoves with enclosed fire boxes were 10% to 28% efficient. It is likely that the difference between Singer's and this study's measure of traditional stove efficiency is due to greater care being exercised in fire tending in the experiments described here. The extra labor input in fire tending, which is only possible in a stove with an open fire box, raises fuel efficiency.

Lamps - Kerosene lamps of three types (petromax, and small and large wick lamps) were compared with a 60 watt unglazed electric light bulb by the use of a calibrated photometer. The approximate equivalencies and kerosene consumption rates are: petromax, approximately 100% of 60 watt bulbs light output at 0.1 liters/hour of kerosene consumption; large wick at 12% of the light at 0.08 liters/hour; small wick at 3% of the light at 0.01 liters/hour. Thus in terms of useful light one kwh of electricity replaces 1.7 liters of kerosene if burned in a petromax.

The electricity used for lighting is generated mostly by petroleum fuel. Official statistics (BPS, 1976) show the following generation efficiencies, line losses, and overall efficiencies to the consumer: PLN region VII (supplies Luwu) generation requires 0.38 liter petroleum fuel per kwh, which with line losses of 35.7% gives an overall efficiency of 0.59 liter per kwh; PLN region XI (supplies Lombok) generation - 0.36 liter/kwh, losses - 23.5%, overall - 0.48 liter/kwh; PLN region XII (supplies Klaten) generation - 0.42 liter/kwh, losses - 25.2%, overall - 0.56 liter/kwh. For this study an overall average of 0.5 liter per kwh was used.

III. ENERGY USE IN THE COMMUNITY -

III-1 Energy consumption and productivity in rural industries

A major goal of the rural electrification project is the development of productive uses of electrical energy. The term "productive uses" has two meanings which refer to two different points of view concerning measures of project success. The first meaning stems from PLN's need for customers who will be interested in purchasing energy in the form of electricity from the rural electrification project power lines. Meeting the economic goals of the project requires that a significant percentage of electrical energy be sold for community uses beyond household lighting. The second meaning of the term stems from the desire to generate employment in local industries as a result of electrification.

The two meanings of "productive uses" are related in that pre-existing or prospective industries in rural areas must 1) be able to use electricity, 2) see the advantage of purchasing it from PLN lines and 3) through the resulting increase in productivity from the use of PLN supplied electricity be able to hire more employees or give more regular full-time work to current employees. This section examines the entire chain of events from provision of an electricity supply to employment generation to provide the understanding necessary to evaluate the impacts of electrical energy substitution on rural industry. Section IV examines the ultimate impacts on the local natural resource base.

The same surveyors who made the survey of household energy use also conducted interviews with a wide range of local industries in all three areas. The products of these industries include food, construction materials, and other goods and services. In homes that were surveyed which had a home industry a separate questionnaire was filled out for that industry. In other cases both home and larger scale industries located outside of surveyed households were interviewed.

One of the purposes of the survey is to characterize rural industry in terms of energy and raw material needs, and value of finished product. Data from the questions about what percent of input to a particular industry is energy and about what form that energy must be in are used to calculate "production factors" for each kind of industry. Examples of production factors per unit of output in food industries surveyed in Klaten, Lombok, and Luwu are shown in table III-1. More detailed data for non-food industries are shown in table III-2.

Although production factors are an important way to characterize industry, a further distinction is necessary between industries which use fuels for direct combustion to produce heat, for processing or for cooking, and those which use fuels to power rotating machinery either through direct generation of shaft power or indirectly through electricity generation. This distinction is important as it is economical only for industries with a significant need for rotating machinery to substitute PLN electricity for their fuel needs.

TABLE III-1

ENERGY REQUIREMENTS FOR HOME FOOD INDUSTRY

Product	Energy Requirement		
	Type	Amount	Per Unit Product
Tempe*	Firewood	1.0-2.1 kg	Kilogram
	Agricultural Waste, leaves and twigs	1.5 kg	Kilogram
Tahu*	Firewood, sawdust	1.0-3.0 kg	Kilogram
	Rice hulls, agricultural wastes	1.0 kg	Kilogram
Krupuk*	Kerosene	0.26 liter	Kilogram
	Kerosene	0.39 liter	Kilogram**
	Firewood	2.8 kg	Kilogram
	Firewood	3.1 kg	Kilogram**
	Firewood, rice hulls, agricultural wastes	5.5 kg	Kilogram
Bread	Charcoal	1.2 kg	Kilogram
Pastry (Kuping Cajah)	Kerosene	0.4 liter	Kilogram
Medicine (Jamu)	Kerosene	0.17 liter	Liter
	Firewood	0.8 kg	Liter
Lupis Pisang	Firewood	1.4 kg	Kilogram
Cendol	Firewood	1/3 kg	Liter

* These everyday foods are: Tempe, a soybean cake; Tahu, soybean curd; Krupuk, fried fish or shrimp cake.

** These data from Raintree, 1980, Survey in North Central Java

TABLE III-2

INDUSTRIAL ENERGY USE (Other than Food)

Area and Industry	Raw Material Input	Energy Input	Price of Energy	Product Output	Product Value
Klaten					
Tobacco drying (In Trucuk) -Virginia (air-dried)	3500 kg wet tobacco	650 lit. kerosene	Rp. 35/lit-1979	490 kg dry tobacco	Rp. 700/kg
		3000 kg firewood	Rp. 15/kg-1979 Rp. 11/kg-1978 Rp. 7/kg-1973	490 kg dry tobacco	Rp. 700/kg
-Krosok (smoked)	3500 kg wet tobacco	400 kg firewood plus 2000 kg ricehusk	Rp. 15/kg-1979 (wood) Rp. 7.5/kg-1979 (ricehusk)	540 kg smoked tobacco	
Blacksmithing	16 kg scrap iron at Rp. 110/kg-1979 Rp. 60/kg-1978 Rp. 40/kg-1974 per day	30 kg teak charcoal per day	Rp. 48/kg-1979 Rp. 35/kg-1978 Rp. 12/kg-1974	12 cangkul (#1 grade) or 17 cangkul (#2 grade) or 20 Ganco/day	Rp. 1500 each Rp. 1100 each Rp. 900 each
Chalk (Kapur)		2500 lit Cepucrude or 14000 kg firewood	Rp. 30/lit crude Rp. 5/kg coconut (1979) Rp. 6/kg mango (1979) Rp. 7/kg sono (1979) Rp.10/kg teak (1979) All 20% more than in 1978 ∿Rp. 2.5/kg ∿ (1974)	15m^3 Kapur (m^3 ≈ 750 Kg)	Rp. 7500/ m^3 Kapur

TABLE III-2 (continued)

Area and Industry	Raw Material Input	Energy Input	Price of Energy	Product Output	Product Value
Klaten					
Tiles (In Tatask)	5 grobak clay at Rp. 250/grobak	60 baskets wastes at 14.5 kg/basket	Rp. 60/basket (1979)	2500 Tiles	Rp. 11000/1000 tiles
Lombok					
Tobacco (At P.T. Faroka)		2900 sm firewood (sm ≈ 400 kg) plus 320,000 lit. kerosene	Rp. 2029/sm-1976 Rp. 25/lit.	262,000 kg dry tobacco (total year's product)	
Bricks and Tiles		25 sm firewood	Rp. 2500/sm-1979 Rp. 1800/sm-1978 Rp. 500/sm-1974	10,000 bricks and 15,000 tiles	Rp. 6/brick Rp. 16/tile
Bricks		0.5 sm firewood		666 tiles	
Chalk			by Truck Rp. 2080/sm-1979 1000/sm-1978 624/sm-1974 by horse cart Rp. 2100/sm-1979 Rp. 1500/sm-1978 Rp. 750/sm-1974		Rp. 3750/m^3
Luwu					
Tiles		2 sm	Rp. 1500/sm-1979	1500 tiles	
Bricks		35 sm		20,000 bricks	
Timber		0.3 lit. gasoline/M^3 0.5 lit. oil/M^3		150 M^3/month	

A close examination of the energy production factors of industries in the two groups, i.e. those whose fuel needs are substitutable by electricity and those which are not, reveals a significant difference. Those industries using fuels which are not readily substitutable by electricity are usually energy intensive industries in which the cost of the fuel is a major and growing percent of input expenses and a significant percent of the total product value. From table III-2 two examples are illustrative. In 1979 for blacksmithing the percent of total input cost, exclusive of labor, represented by energy in the form of charcoal is approximately 45%. By contrast, in 1974 it was only 36%. At present the energy cost represents 8% of the final product value. Another example drawn from interviews in Klaten is tile-making. The energy cost for firing a kiln in one village industry accounts for 75% of total input cost exclusive of labor. This energy cost represents 13% of the total product value.

In many such high energy consuming industries rapidly rising fuel prices are increasing the dominance of fuel cost as a determinant of profitability and hence productivity. In Lombok, which of the three survey areas has the most critical scarcity of combustible natural resources, firewood prices have increased five-fold in five years. In Klaten increases in fuel price over the last five years range from two- to four-fold for firewood and four-fold for charcoal. During this same five-year period the average price inflation of consumer goods was only 100% (IMF, 1979). Thus while price inflation was growing at an annual average of 15%, firewood increased at an annual average rate of up to 32% or 38%.

By contrast those industries shown in table III-3 as using fuels to power rotating machinery all have inputs from energy costs of less than 1% of the total cost of the inputs with the possible exception of the textile industry, which has an energy input production factor of approximately 7% for fuels used to power rotating machinery. This cost represents approximately 5% of the value of the product. The only other industry in this category of industries which has significant fuel costs is the paper and paper products industry with an expenditure for fuels of approximately 5% of the inputs or about 3% of the value of the product. However this industry also uses heat energy, and what portion of fuels are used for heat is not determinable from these data. In summary all but one or two industries that are potential candidates for electrification are also those which have relatively smaller needs for energy in proportion to the total inputs, or product value.

Although direct savings from switching to electrical power are likely to be insignificant in most cases, the introduction of powered, or more efficient, rotating machinery could make these industries more productive. The impact on productivity of the use of better machinery is worthy of a detailed study leading to designing a productive uses program. Such a study should look carefully at whether this sort of machinery would be employment-generating or employment-substituting.

In contrast to the prospect of increased productivity in industries using rotating machinery is the situation in industries in which fuel is a major input. These are the industries most likely to be affected by rapidly escalating energy costs. A good example of the impact of such increases was discovered in interviews in a Klaten blacksmithing village,

TABLE III-3

CENTRAL JAVA HOME INDUSTRIES: INPUT/OUTPUT

Industry	Household units	Raw materials (10^6 Rp)	Fuels, etc. materials (10^6 Rp)	Services (10^6 Rp)	Total inputs (10^6 Rp)	Output value (10^6 Rp)
Power for Rotating Machinery						
Coconut	3,400	760	26	2	790	980
Rice Milling	860	1,670	82	78	1,830	2,300
Other grains	800	1,240	40	4	1,280	1,500
Textiles	61,000	2,800	200	40	3,050	4,100
Apparel	1,800	44	66	10	450	620
Wood products, mills	5,000	750	6	42	800	1,250
Furniture (wooden)	8,900	1,110	7	39	1,160	2,020
Paper	1,000	20	1	2	20	66
Metal Products	1,180	250	26	2	280	480
TOTAL	84,000	8,600	450	220	9,700	13,300
Fuel for heat energy						
Sugar	151,000	1,060	2,400	73	3,600	9,100
Tahu and Tempe	29,300	7,900	1,040	33	9,000	11,300
Krupuk, etc.	13,300	2,300	250	11	2,500	3,400
Other foods	20,300	4,200	490	44	4,700	6,300
Pottery	6,500	40	50	3	93	250
Bricks/Tiles	25,000	660	1,030	180	1,870	4,900
Minerals	800	3	0	1	4	27
Agricultural tools	1,150	95	83	2	180	420
Tobacco processing	1,200	634	5	10	650	750
TOTAL	249,000	16,900	5,300	360	22,600	36,400
Handcrafts and others						
basketry, atap,etc.	175,000	2,400	40	13	2,500	5,600
Other	13,500	1,500	50	10	1,560	2,750
GRAND TOTAL	520,000	29,000	5,800	600	36,000	58,000

Like most of the blacksmiths in Central Java, these blacksmiths prefer to use charcoal made from teak wood exclusively. When queried as to whether other charcoals are acceptable, the answer is invariably that they are not, for reasons which are difficult to define, much less quantify. This preference for teak charcoal has been noted in other areas in Central Java (see Raintree, 1980). In part because of increasing fuel prices, but also largely because of a decreasing supply, the price of teak charcoal has risen sharply--approximately four-fold--in the last five years. Two years ago the usual source of charcoal was Salatiga, but as that resource began to dry up, either because regulations governing the manufacture of teak charcoal were enforced or because the resource itself was getting thin, there arose a need to locate another source. The search for a new source provided a local entrepeneur the opportunity to step in and arrange an assured supply of teak charcoal for 90% of the forges, including most of those in the co-operative. One of the entrepeneur's conditions of sale is that she would have first pick of the products of the forges supplied with her charcoal. The leader of the co-operative also apparently buys charcoal from the same source (in Ngawi, East Java) but appears not to be able to supply the needs even of the members of the co-operative. It is interesting to note that this control is brought about not necessarily because charcoal is the most expensive input but because of the increasing difficulty of its supply.

The pressure on industries in rural areas which use relatively large amounts of a dwindling energy resource such as firewood or charcoal is likely to increase. Unfortunately the introduction of a new source of energy will not alleviate this pressure as the great majority of rural industries will not be able to substitute electricity for their energy needs.

III-2 The volume and selection of fuels in rural industries.

This section discusses fuel use and selection in different industries, with particular emphasis on supply problems, and makes a calculation of the amount used of different kinds of fuels and what percentage of these amounts are interchangeable. This section is concerned primarily with the rural electrification project area of Klaten. This area is particularly appropriate as a case study area as it is one of the most highly industrialized in Central Java, and indeed in all of Indonesia. Moreover in addition to data gathered by the surveyors there exists detailed "universe" data from the Indonesian Industrial Census of 1974-1975.

The Industrial Census contains useful data about fuel consumption in both household industries and small-scale industries. However before comparisons can be made between production factors derived from the census and obtained by the surveyors, a word of caution is in order concerning definitions. The surveyors distinguished home industry from small-scale industries by the criterion that all employees are domiciled in the household. This definition differs from that used by the Indonesian Industrial Census of 1974/75 which defined household industries as those engaging less than five workers. By their definition "small-scale" manufacturing establishments are those having five to nineteen employees; "medium" from twenty to ninety-nine; and "large" with one hundred or more.

It is unrealistic to draw sharp conclusions from the results of either survey about differences between household and small industries as any definition is necessarily arbitrary. Even determining which household has a home industry and which does not is difficult since many households at one season or another of the year will produce some articles for sale. Similarly many local industries have seasonal labor fluctuations which would move them from the category of home industry to the category of small-scale industry by the Indonesian Industrial Census definition. Therefore the data which are presented in this section do not emphasize the distinction between household and small-scale industries, except where such a distinction seems important to make.

The first question is how many rural industries there are in a particular study area. Tables III-3, 4, and 5 present data on home industries in the provinces of Central Java, South Sulawesi, and Western Nusa Tenggara. These provincial levels statistics are not broken down by kabupaten, the administrative unit which typically completely contains a project area. However, some inferences can be made by relying on the more finely delimited statistics relating to small-scale industries, which do present kabupaten level data. These statistics, shown in tables III-6, 7, and 8, substantiate the common observation that the Klaten kabupaten is a highly industrialized area with several times its share of the total small-scale industries in Central Java. These statistics show that Klaten is more than three times over-represented in small-scale industries which use fuel for cooking or processing and more than four-times over-represented for industries which use power for machinery.

Although it is unlikely that the home industries in Klaten are as over-represented as its small-scale industries, nonetheless some over-representation in comparison with other areas of Central Java is likely.

TABLE III-4

SOUTH SULAWESI HOME INDUSTRIES: INPUT/OUTPUT

Industry	Household units	Raw materials (10^6 Rp)	Fuels, etc. materials (10^6 Rp)	Services (10^6 Rp)	Total inputs (10^6 Rp)	Output value (10^6 Rp)
Power for Rotating Machinery						
Coconut Oil	650	27	2.9	0.82	31	46
Rice Milling	1,500	400	74	21.4	500	1,290
Other Grains	1,210	230	5.0	2.1	240	330
Yarn and Thread	1,210	24	1.1	0.4	26	140
Woven Textiles	22,400	935	7.5	9.6	950	1,560
Cordage and Twine	570	6.8	0.2	-	7.0	15.7
Other Textiles	1,300	93	1.3	0.3	97	170
Apparel	570	110	0.7	1.2	112	170
Wood Products, Mills	2,170	89	13.1	0.68	94	260
Furniture (wooden)	1,370	250	0.7	11.2	265	630
TOTAL	32,150	2,160	106	48	2,300	4,600
Fuel for heat energy						
Sugar	9,000	200	61	2.7	260	670
Other foods	2,300	320	12	0.4	330	810
Pottery	950	5.4	8.2	-	13.6	72
TOTAL	12,250	530	81	3.1	600	1,600
Handcrafts and others						
Bamboo, atap, etc.	18,800	320	0.4	2.7	332	940
Other	3,300	500	72	4.7	580	1,370
GRAND TOTAL	66,500	3,500	260	58	3,800	8,500

TABLE III-5

WEST NUSA TENGGARA HOME INDUSTRIES: INPUT/OUTPUT

Industry	Household units	Raw materials (10^6 Rp)	Fuels, etc. materials (10^6 Rp)	Services (10^6 Rp)	Total Input (10^6 Rp)	Output Value (10^6 Rp)
Power for Rotating Machinery						
Coconut Oil	1,130	111	4.6	0.11	120	143
Woven Textiles	1,200	28	0.5	0.30	29	63
Cordage and twine	1,600	15	1.2	-	17	63
Other Textiles	1,100	410	6.3	-	420	540
Wood products, sawmills	760	76	-	0.70	76	180
Furniture (wooden)	1,240	103	2.9	7.6	113	190
TOTAL	7,030	744	15.5	8.7	770	1,180
Fuel for heat energy						
Other foods	1,920	460	29	0.67	490	670
Sugar	780	21	8.1	-	29	51
Pottery	2,340	6.0	8.0	-	14	52
Brick and tiles	880	28	36	0.30	64	159
TOTAL	5,900	520	81	0.97	597	932
Handcrafts and others						
Basketry, atap, etc.	15,700	98	1.6	0.29	100	270
Other	1,420	104	15	4.0	123	350
GRAND TOTAL	30,050	1,460	113	14	1,590	2,700

TABLE III-6

EMPLOYMENT IN SMALL INDUSTRIES IN KLATEN AND CENTRAL JAVA

1974/1975 Census

Industries Grouped by Major Type of Energy Needed	Number of Small Industries Central Java	Percent of Central Java Total	Number of Small Industries in Klaten	Number of Workers in Klaten
Power for Machinery				
Textile	2,445	26%	620	6,430
Plastic wares	42	7%	3	18
Manufacture: vehicles, machinery, appliances, cement	260	15%	39	330
Rope manufacture	5	20%	1	51
Sawmills, furniture, wood products	630	11%	68	470
Printing	120	3%	4	40
Dairy Products: oils, fats	230	9%	21	140
TOTAL	3,700	20%	760	7,500
Heat Energy from Fuel Combustion				
Food products	3,040	10%	307	2,500
Tobacco drying	270	4%	11	60
Fired: Ceramic	2	%	1	6
Lime	180	12%	22	210
Bricks	170	13%	22	150
Blacksmiths	230	52%	119	800
TOTAL	3,900	12%	480	3,700
GRAND TOTAL	7,600	16%	1,200	11,000
Population 1975:	23,100,000 (Central Java)	4.5%	1,040,000 (Klaten)	

TABLE III-7

EMPLOYMENT IN SMALL INDUSTRIES IN LUWU AND SOUTH SULAWESI

1974/1975 census

Industries Grouped by Major Type of Energy Needed	Number of Small Industries South Sulawesi	Percent of South Sulawesi Total	Number of Small Industries Luwu	Number of Workers in Luwu
Power for Machinery				
Manufacture	190	1%	2	13
Sawmills, furniture, wood products	376	14%	51	379
Paper & Chemicals	35	9%	3	22
Textiles and Apparel	158	0	0	0
TOTAL	759	7%	56	414
Heat Energy from Fuel Combustion				
Food products	1,297	1%	14	87
Fired: Lime, Bricks, etc.	391	5%	20	118
Tobacco	81	0	0	0
TOTAL	1,769	2%	34	205
GRAND TOTAL	2,528	4%	90	619
Population 1971	5,180,000	6%	330,000	

TABLE III-8

SMALL INDUSTRIES IN EAST LOMBOK AND WEST NUSA TENGGARA

1974/1975 Census

Energy Needs	Number in East Lombok	Percent of West Nusa Tenggara Total	Number in West Nusa Tenggara
Rotating Machinery (Shaft Power)			
Sawmills; furniture, wood products	10	21%	47
Printing	2	29%	7
Total	12	22%	54
Heat Energy (Fuel Combustion)			
Food Products	17	17%	102
Fired: Lime	17	19%	58
Bricks	1	1%	69
Tiles	16	28%	58
Blacksmiths	18	95%	19
Total	63	21%	306
Grand Total	75	21%	360
Population 1971	596,000	27%	2,200,000

For example, the household survey discussed in section II of this report found that 13% of the survey of households in Klaten had a home food industry. The IPB survey of 1978 found 8% of the households in Klaten with a home food industry. The over-all average for Central Java from the Industrial Census as shown in table III-3 is 5%. The Census is more likely to have overlooked more home food industries than other types of home industries thereby resulting in an overall underestimation for Central Java. A compromise of these three surveys is that 10% of Klaten households have a home food industry. This figure is used in the following calculations.

Since 12% of the households in Central Java have some sort of home industry according to the Industrial Census, it is likely that in Klaten the percentage is as high as 20%. This difference is because Klaten has relatively more industries and because the Industrial Census probably under-estimated many kinds of industries. Since this 20% of project households is a large fraction of the households likely to be making a hook-up to PLN electrification lines at the outset of the project, the study of the energy consumption of these home industries is important.

The data contained in the Indonesia Industrial Census of 1974/1975 are used to estimated the number of industries in the Klaten kabupaten with the following assumptions: the data for the Province of Central Java from table III-3 are used to estimate the number of household industries in Klaten, with the assumption that Klaten, even though it has only 5% of the population of Central Java, has more than 10% of the household industries. This assumption means that approximately 20% of households in Klaten have a home industry. No correction is made for the different kinds of home industries which are found more or less frequently in Klaten than in the Central Java statistics. For example 10% of the total number of sawmills in Central Java are probably not in Klaten. On the other hand, probably more than 10% of the textile and food industries are in Klaten. The assumption of 10% is probably conservative as Klaten has 16% of the total of small scale industries of Central Java (see table III-6).

The fuel consumption of Klaten home industries is estimated in the following manner. Average prices for fuels in 1975 are assumed to be Rp. 4 per kilogram for stemwood-grade firewood, Rp. 20 per liter for kerosene, Rp. 12 per kilogram for charcoal, Rp. 1.5 per kilogram for agricultural waste. The category of other petroleum fuels is mostly gasoline and solar fuel which is used for diesel engines. In 1975 solar sold for approximately Rp. 25 per liter and gasoline for approximately Rp. 55 per liter.

Assumptions about the fuel use of different industries are as follows: All of the rotating machinery industries are assumed to burn either solar or gasoline in a 9:1 ratio. Food industries such as Tahu, Tempe, Krupuk, etc. are all assumed to spend 25% of their budget for stemwood and 75% for kerosene. The sugar industry is assumed to use 75% agricultural wastes and 25% stemwood. Brick and tile manufacturers are assumed to be spending 70% of their fuel budgets for wood and 30% for agricultural wastes. Lime manufacturers are assumed to burn 75% stemwood and 25% crude oil. These percentage splits are derived from data on the choice of fuels in household industries interviewed in this survey. The percentages split for brick and tile manufacturers is also borne out by the data of Raintree (1980).

Estimates of the volume of fuel consumption in Klaten are shown in table III-9 for households, household industries, and small scale industries. The estimates for small-scale industries are derived from data in table III-6 about the fuel budgets of different categories of small-scale industries in Klaten. Note that the broad manufacturing category in table III-6 is assumed to use solar fuel as larger industries are more likely to be using diesel-generators rather than gasoline powered generators. One very large category of household industries has been left out of all of these figures, that is the handicraft industries making handwoven mats and atap, products which require little or no fuel. The estimates of table III-9 for household industry fuel consumption for Klaten are calculated on the basis of two hundred thousand households in Kabupaten Klaten and the consumption figures for houses with home industries given in the household section of this report. The rural electrification project area contains 98 villages, or roughly one quarter of the kabupaten total, and hence about 50,000 households.

A startling observation from the data of table III-9, which is shown graphically in figure III-1, is that almost as much stemwood-grade firewood is consumed in industries as is burned in households. This fact is not strange in light of the observation that most of the household cooking fuels, except in households with home food industries, are agricultural or home garden waste rather than stemwood. With such a large consumption, it is reasonable to suppose that the industrial market for firewood sets the price for the entire firewood fuel sector in Klaten. This observation is even more likely to be true in Lombok although a detailed analysis has not as yet been made for Lombok.

In contrast to the balance between home and industrial consumption of stemwood firewood is the observation that the overwhelming majority of consumption of kerosene in Klaten is in the home for domestic use as opposed to a productive use. This is not to say that the kerosene consumption of home industries is not significant as the 15 million liter figure shown in table III-9 represents more energy than all the firewood, agricultural wastes, and charcoal consumed by home industries.

In contrast to the relatively even-split between wood consumption in industries and in households for domestic purposes, is the split between fuels which are substitutable by electricity between domestic and industrial consumption. The 50 million liter consumption of kerosene for household lighting can be substituted completely by thirty million kilowatt hours of electricity. In contrast the only industrial fuels that can be substituted are petroleum fuels other than kerosene (perhaps a very small percentage of the kerosene consumption can be substituted but almost all is used for cooking). If all of these fuels are substituted it would require approximately ten million kilowatt hours of electricity. Thus as current energy consumption patterns stand at the moment, the market for electricity in productive uses in home industries and small-scale industries in Kabupaten Klaten is approximately one third of the market in households for household lighting only. The markets for the Klaten project area by itself are proportionally smaller -- 25% of these figures.

Table III-9

Estimated Fuel Consumption in Klaten Kabupaten 1975

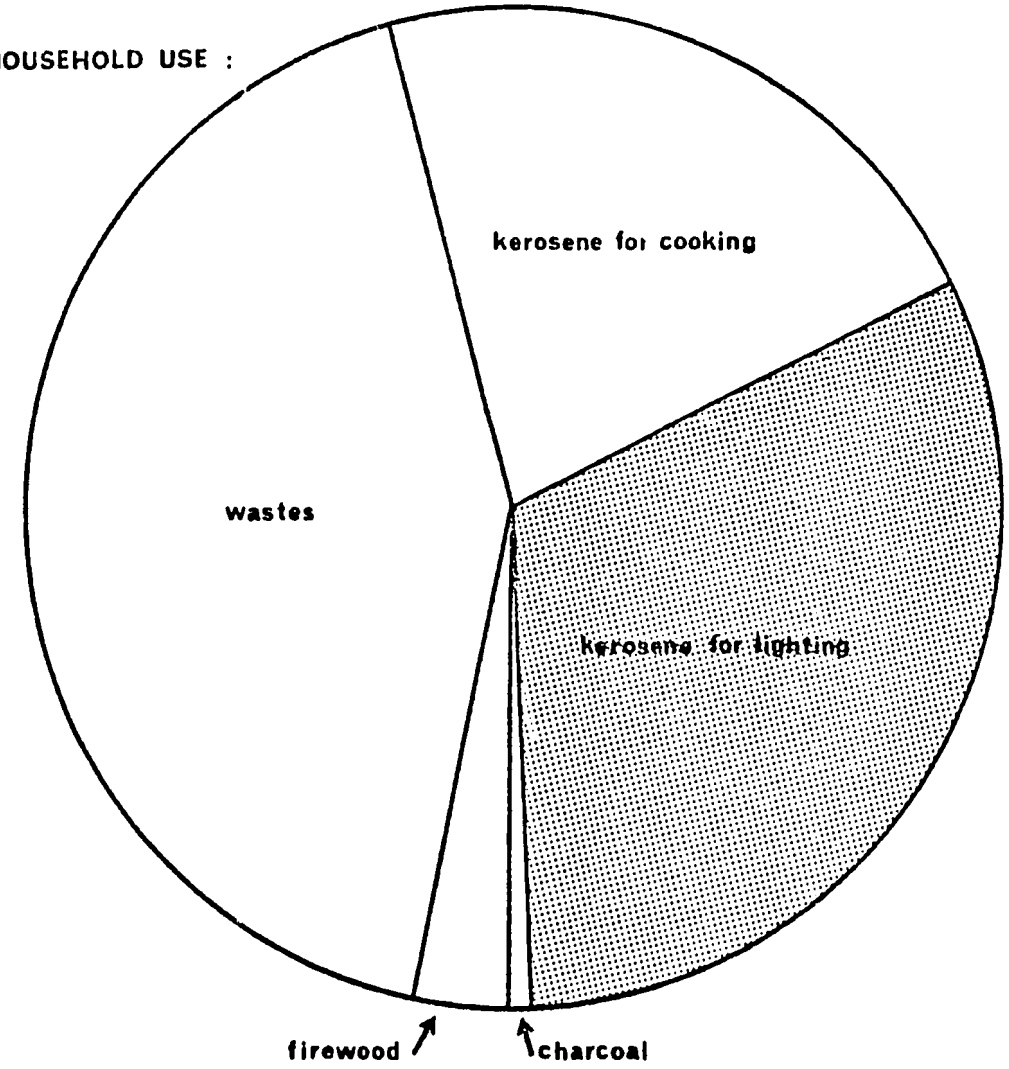
	households	home industry	small scale industry
Stemwood (tons)	85,000	45,000*	22,000
Agricultural and garden wastes (tons)	280,000	20,000	22,000
Charcoal (tons)	∿ 1,000	700	4,000
Kerosene (000 ℓ)			
- Cooking	35,000	15,000**	1,000
- Lighting	50,000		
Other petroleum (000 ℓ)	(?)	2,000	1,500
Electricity (000 kwh)	∿ 0	∿ 0	∿ 100

* 25,000 is for home food industries

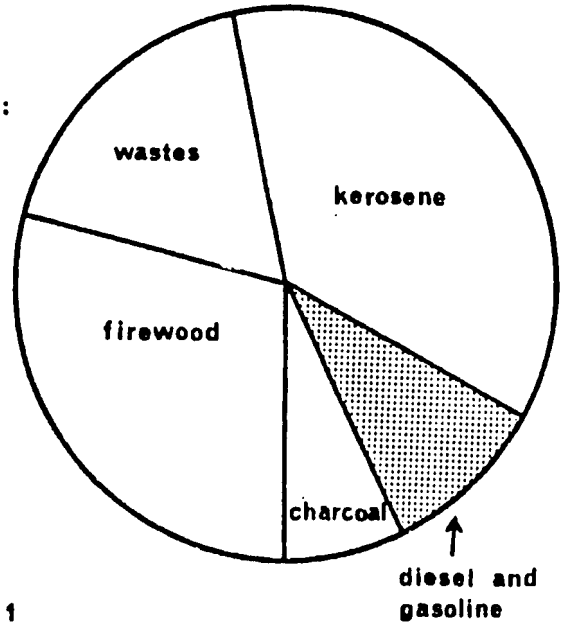
** Nearly all 15,000 is for home food industries

CURRENT FUEL USE IN KLATEN

HOUSEHOLD USE :



INDUSTRY (HOME AND SMALL SCALE) USE :



FUELS SUBSTITUTABLE BY ELECTRICITY

Figure III - 1

Fuel selection for small-scale and household industries is more constrained to higher quality fuels than is fuel selection for households. In food industries the choices are kerosene, stemwood, and certain higher quality agricultural wastes. In this respect, fuel use in food industries is almost as flexible as in household use except that many agricultural wastes of very low quality such as cornstalks, coconut leaves, and so forth, are not suitable for home food industries as problems in fire-tending make use of such fuels difficult if not impossible. The tobacco industry can substitute kerosene for firewood for drying tobacco but kerosene cannot be substituted for the wood and waste used to smoke tobacco, the chalk/lime industry still uses great quantities of firewood, but in recent years there has been a shift toward using a low grade of crude oil, either supplied by Pertamina or from private oil companies, such as Cepu. The brick and tile industries are constrained by the unavailability of a kerosene using process for firing tiles that is economicallly feasible. In general higher quality bricks and tiles require a higher grade of firewood whereas those of lower quality are often fired almost exclusively with waste.

In Lombok local authorities are concerned about the state of combustible natural resources. In Eastern Lombok there is a definite shortage of commercial firewood. Further, Lombok has few home gardens as are found in Central Java so the resources of garden wastes are also limited. In Lombok there is a push to get local industries to switch from burning firewood to kerosene. For the last four years, the tobacco drying industry has been required to use kerosene for drying operations. There is also a move to encourage other industries, such as brick and tile makers, to switch to kerosene fired stoves. Unfortunately there is concern amongst the brick, tile, and chalk manufacturers as to the quality of their product being adversely affected while the cost of the fuel increases.

III-3 Employment in rural industries

Tables III-6, 7, and 8 show estimates of employment in rural small-scale industries and tables III-10, 11, and 12 show estimates of employment in rural household industries. Household industries have a much greater employment than small-scale industries in Central Java and presumably Klaten as well. If Klaten is assumed to have 10% of the home industries of Central Java, then there are approximately one hundred and sixty thousand domiciled workers each engaged 97 days per year, or 1/3 time on the average. In addition, home industries hire non-domiciled workers also, adding approximately 7 to 8 % to the total of man-days worked by household industry workers. By these estimates the labor force of home industries in Klaten is more than 10 times the labor force of small-scale industries, which employ approximately eleven thousand workers (see table III-6).

There are significant differences in the number of workers employed in industries which can be electrified and those which cannot. These differences can be seen in figure III-2. Overall those industries which use a fuel which is substitutable by electricity employ more workers per unit of fuel than those that use nonsubstitutable fuels this difference is due in part to the relative labor intensity of these industries and in part to the pattern of employment. Workers employed in home industries which may benefit from electrification work approximately 1/3 time, whereas those workers in other industries work approximately 1/2 time. For both types of industry an average of 3.1 workers are employed per home industry. The industries which may benefit from electrification hire outside workers more frequently.

The pattern of part-time employment is indicative of the seasonal nature of many home industries. Table III-13 shows data about the work force wages and hours worked per week in industries interviewed in this survey. Since the work-hours per week shown in table III-13 are in excess of 40 to 50 hours per week, that is full-time while the industry is active, it is likely that many industries have a strong seasonal pattern of activity. Because of this seasonality investments in machinery are more difficult to pay back. Investments in training workers are similarly limited. Consequently it is not surprising to note that in the industries surveyed in Table III-13, unskilled and semi-skilled workers predominate.

Seasonality also makes connection to electric lines less attractive than maintaining a generator for supplying the power needs of those industries which are already mechanized. PLN charges both an energy charge and power or wattage charge. Even though there may be periods of several months during the year when energy charges are minimal, the potential customer has to pay the power charge. This extra expense may serve as a considerable deterrent to a decision to hook-up to PLN rather than continue using a generator.

Table III-14 gives estimates of profitability per employee of various industries While the range of profitability is great, industries which consume a large proportion of their inputs as energy such as roof tiles have a lower profitability per employee than those which do not. It is these industries which are most likely to be affected by rising costs of energy.

TABLE III-10

CENTRAL JAVA HOME INDUSTRIES: EMPLOYMENT

Industry	Household units	Domiciled workers	Man-days worked (000)	Households hiring workers	Hired Man-days (000)	Equivalent jobs (Mandays 300 days/year
Power for Rotating Machinery						
Coconut Oil	3,400	10,800	1,400	220	40	4,800
Rice Milling	860	2,400	180	820	580	2,500
Other grains	800	2,400	200	260	150	1,200
Textiles	61,000	190,000	16,400	2,500	1,400	60,000
Apparel	1,800	6,100	600	220	90	2,300
Wood Products, Mills	5,000	14,200	1,240	2,400	610	6,200
Furniture (wooden)	8,900	24,000	2,300	2,200	900	10,700
Paper	1,000	3,100	290	10	10	1,000
Metal Products	1,180	3,340	340	405	434	2,600
TOTAL	84,000	260,000	23,000	9,035	4,200	91,000
Fuel for heat energy						
Sugar	151,100	456,000	73,500	1,470	380	246,000
Tahu and Tempe	29,300	92,000	12,100	2,570	1,310	44,700
Krupuk, etc.	13,300	44,000	4,800	1,100	470	17,600
Other foods	20,200	63,000	6,400	2,350	1,086	25,000
Pottery	6,500	19,000	2,300	180	90	8,000
Bricks/Tiles	25,000	73,000	9,500	3,700	1,600	40,000
Minerals	800	2,300	180	30	10	630
Agricultural tools	1,150	3,250	280	830	310	2,000
Tobacco processing	1,200	5,000	700	250	90	2,600
TOTAL	249,000	757,000	109,800	12,480	5,346	400,000
Handcrafts and others						
Bamboo, atap, etc.	175,000	540,000	52,600	380	130	175,800
Other	13,550	41,600	4,500	1,800	825	17,700
GRAND TOTAL	521,000	1,156,000	190,000	24,000	10,371	700,000

TABLE III-11

SOUTH SULAWESI HOME INDUSTRIES. EMPLOYMENT

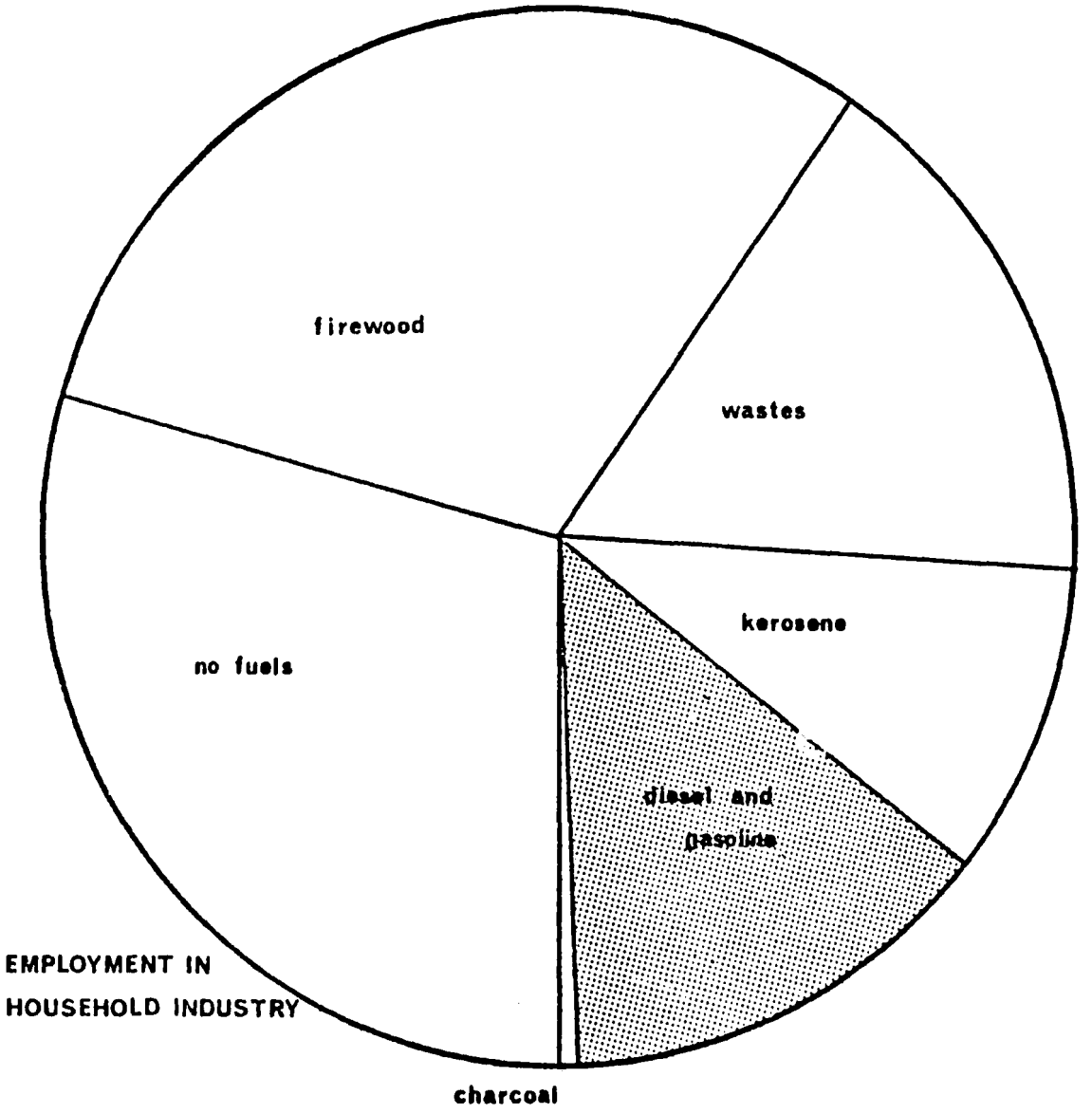
Industry	Household units	Domiciled workers	Man-days worked (000)	Households hiring workers	Hired Man-days (000)	Equivalent jobs (Mandays ÷ 300 days/year
Power for Rotating Machinery						
Coconut Oil	650	2,000	110	-	-	400
Rice Milling	1,500	4,200	210	1,000	374	2,000
Other grains	1,210	4,050	160	600	53	710
Yarn and Thread	1,210	4,500	460	44	10	1,600
Woven Textiles	22,400	70,000	5,400	220	74	18,000
Cordage and Twine	570	1,700	130	-	-	400
Other Textiles	1,300	3,700	200	15	6	700
Apparel	570	1,400	90	50	15	350
Wood Products, Mills	1,370	4,000	270	100	70	1,100
Furniture (wooden)	1,370	3,530	260	370	200	1,500
TOTAL	32,150	99,080	7,300	2,400	800	27,000
Fuel for heat energy						
Sugar	9,000	26,200	3,100	220	75	10,600
Other foods	2,300	5,140	290	805	475	2,500
Pottery	950	3,100	450	13	5	1,500
TOTAL	12,250	34,400	3,800	1,040	550	14,500
Handcrafts and others						
Bamboo, atap, etc.	18,800	56,000	4,500	750	240	16,000
Other	3,300	8,400	600	1,700	550	4,000
GRAND TOTAL	66,500	197,900	16,200	6,000	2,100	61,000

TABLE III-12

WEST NUSA TENGGARA HOME INDUSTRIES: EMPLOYMENT

Industry	Household units	Domiciled workers	Man-days worked (000)	Households hiring workers	Hired Man-days (000)	Equivalent jobs (Mandays ÷ 300 days/year
Power for Rotating Machinery						
Coconut Oil	1,130	3,200	210	61	35	820
Woven Textiles	1,200	3,500	200	-	-	660
Cordage and Twine	1,600	4,700	650	-	-	2,200
Other Textiles	1,050	2,900	150	85	15	550
Saw Mills	570	1,400	102	410	140	810
Furniture (wooden)	1,240	3,000	250	130	52	1,010
TOTAL	6,800	19,000	1,600	690	240	6,100
Fuel for Heat Energy						
Other foods	1,900	5,300	510	73	38	1,800
Sugar	780	2,220	240	1	-	800
Pottery	2,300	5,200	410	12	5	1,400
Bricks and tiles	880	2,220	150	480	210	1,200
TOTAL	5,900	15,000	1,300	570	250	5,200
Handcrafts and other						
Basketry, atap, etc.	16,000	39,000	2,600	49	18	8,700
Other	1,600	4,300	280	310	110	1,300
GRAND TOTAL	45,000	77,000	5,800	1,600	620	21,400

DISTRIB'JTION OF INDUSTRIAL EMPLOYMENT IN KLATEN BY FUEL TYPE



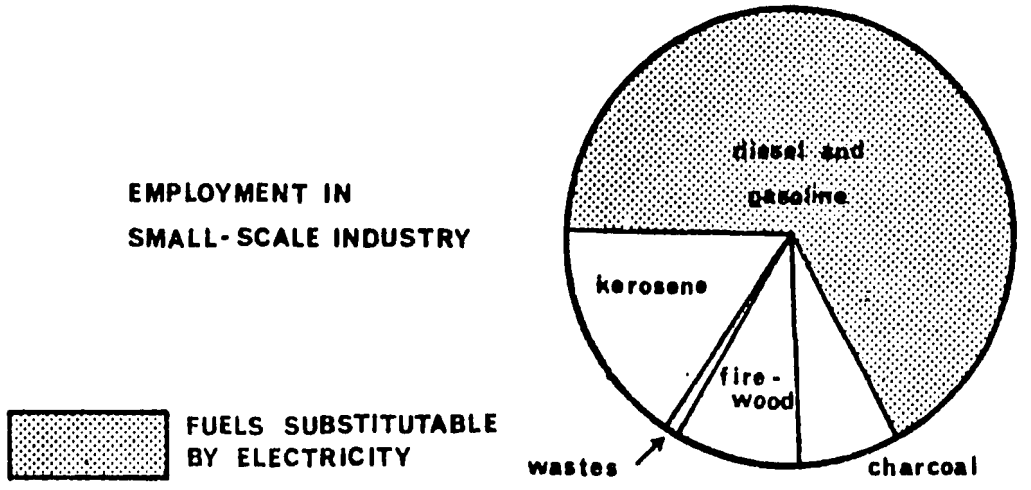


Figure III-2

TABLE III-13
LABOR REQUIREMENTS

Industry Type	Area	Labor Skilled	Semi-Skilled	Unskilled	Work Hours Per Week	Daily Wage
Construction Material						
Brick Making	Klaten	-	1	2		
	Lombok	-	5	-	42	200-300
	Lombok	-	2	-	91(119)1	750
	Luwu	-	1	10	Casual	5002
Roof Tiles	Lombok	-	4	-	91	675
	Luwu	-	1	4	60	3002
Timber	Luwu	-	20		Casual	2000-4000/m^3
				100	Casual	25000/m^3
Furniture	Klaten	17	-	10		
	Lombok	12	7	2	45	400-1000
	Luwu	12	-		55-65	3250-6000/m^2
		-	-	8	35-40	1500
	Luwu	2	-	-	60	3000/pc
Food Processing						
Tahu & Tempe	Klaten	-	1	3		
	Klaten		1	2		
	Lombok	-	5	-	91	400
Flour Chips (Krupuk)	Klaten	1	-	3		
Palm Sugar	Lombok	-	1	-	34	300
Eggs	Luwu	1	-	-	n/a	n/a
Rice Mills	Klaten	1	1	2		
	Klaten	1	2	3		
	Lombok	1	-	4	60	150-300
	Lombok	1	-	7	67	400
	Luwu	-	1	1	14	20% of Income
	Luwu		1		60	750
				7	Casual	320/ton
Ice	Luwu		1	2	60-70	3752
Other						
Tobacco Shredding	Lombok	12			21	650
				11	56	250
	Lombok		15		35-42	
				15	56	400
Drying Tobacco	Klaten	1	-	4		
	Klaten	1	1	6		
Blacksmith	Klaten	1	4	-		
	Klaten	1	3	-		
Cinema	Luwu		2	2	35	280

1 Maximum assumed to be 7-13 hour day per week although some survey data was assumed to be higher as indicated in parenthesis.

2 Meals also provided.

3 Skilled: carpenters, mechanics, chicken breeders, blacksmith supervisors
Semi-skilled: carpenter assistants, machine operators, craftsmen assistants
Unskilled: wood cutters, day laborers

TABLE III-14

EARNINGS, TRANSPORT, AND MARKETING OF KLATEN HOME INDUSTRIES

Product	Estimated Net Income (000's)Rp/Yr	Net Income Per Employee (000's)Rp/Yr	Transport Used	Marketing Outlet
Tahu	650	325	Bicycle	Market
	218	109	Bicycle	Market
	460	230	Bicycle	Agent
Fried Tahu	295	295	Manual	Personal Sales
Tempe	1274	255	Bicycle	Market
	2073	296	Bicycle	Market
Roof Tiles	485	242	Bicycle	Ex House
	330	165	Bicycle	Ex House
	158	53	Ox Cart	Agent
	28	28	Cart	Orders
Jamu (Medicine)	175	175	Manual	Market
	420	140	Bicycle	Ex House
Krupuk	3652	736	Bicycle	Store
Bread	89	45	Bicycle	Order
Apparel	960	240	Small Truck	Market
Furniture	1400	350	Cart Truck	Order
Kuping Gajah	4	4	Bicycle	Order
Chicken Eggs	195	195	Truck	Order
Tobacco Drying	1448	289	Small Truck	Ex Factory

III-4 Impact of rural electrification on rural industries

The question examined in this section is what are the changes in the pattern of energy use in rural areas that result from the provision of electrical power. As a change over to electrical energy use will necessarily affect employment, the relationship between employment and energy is also examined. But, before these questions are discussed, the current condition and prospects for growth of rural industries are summarized below. Again, particular emphasis is placed on the Central Java kabupaten of Klaten.

Virtually all of the industries found in the rural electrification project areas are traditional and stable. There is little evidence of any significant change in the pattern of industrialization over the last twenty-five years. Traditionally most industries are small in scale and associated with households. The most common product of rural industries are food items, construction materials, furniture, and simple manufactured goods. The supply and markets for these industries are both predominantly local. The supply of energy as an industrial input is roughly half from fuels such as firewood and agricultural wastes of local origin and half from fuels such as firewood, kerosene, and other petroleum products, imported from outside the region. Labor is predominantly un-skilled and employment is typically seasonal. Most of the methods used in manufacture are labor-intensive.

The markets of most industries are local (see Table III-15). An industry's market size is determined primarily by the local population. Traditionally industry owners have perceived little benefit in attempts to expand their firm's market size as the higher transport cost involved to reach these new markets will make their product uncompetitive with similar products made by firms in neighboring districts. Thus the growth rate of local industries follows the growth of the local population.

The Klaten area is an exception as it has many industries with markets beyond the local populace and with sources of raw materials from outside the immediate region. An example of such an industry is tobacco processing. Much of the tobacco that is dried and graded in Klaten is bought directly from farmers up to one hundred kilometers away. The markets for most of the tobacco that is processed in Klaten are cigarette and othe tobacco product manufacturers outside the region and overseas. Industries such as tobacco drying and chalk (lime) manufacturing import firewood and raw materials from great distances as is described in section IV of this report. The relative aggressiveness of Klaten industries in seeking new markets has led at least some competitors in other areas of Central Java to refer to Klaten as "the Japan of Central Java."

Capital and credit are hard to obtain for most industries. A major long term study of rural industries in Northern Central Java (Soetoro, 1979) has concluded that lack of availabe credit is an important limit to industrial growth in rural areas of Central Java. Table III-16 shows the answers of respondents in surveyed areas to questions on financial resources available to them. Loans are available from banks at rates up to 2% per month plus initial extra fees of up to 20%. However, the use of

TABLE III-15

TRANSPORT FOR INDUSTRY

Product	Input Transport	Output Transport	Distance (km) Input	Output
Klaten				
Tahu Cooking	Becak	Bicycle	2½-3	3
Tempe Cooking	Bicycle	Bicycle	2	2
Bricks	Picul, Bicycle	Cart	1	3
Blacksmith	Bicycle	Bicycle	2½	-
Drying Tobacco	Truck	Truck	2-3	25
Furniture*	Trucks, Colt	-	-	-
Rice Mill*	Colt	Bicycle, Colt	11	-
Rice Mill*	Colt	Picul, Bicycle, Colt	20	-
Lombok				
Soybean Cake	Colt	-	11-22	-
Bricks	Truck, Picul	Truck, Cart	½-5	1½-3
Bricks	Picul	Picul	3	2½
Roof Tiles	Picul	Picul	3	2½
Furniture*	Truck, Colt, Picul	Picul, Truck, Colt	4-54	18-54
Shredding Tobacco*	Picul	Colt	1-6	71
Rice Mill*	Truck, Colt, Cart, Picul	Truck, Colt, Cart, Picul	1½-6	1½
Rice Mill*	Cart	-	1	1
Luwu				
Roof Tiles	Picul	Picul	1	½
		Cart, Bicycle		1-5
Bricks	Cart, Bicycle, Picul	Small Truck	½	1-8
Ice*	Bicycle	Bicycle	1-3	1-10
Construction Timber*	Truck,	Truck,	10-25	10-25
	Cart,	Cart,	5-10	5-10
	Picul	Picul	1-2	1-2
Furniture*	Small Truck	Picul	30	1-2
Furniture*	Cart	Picul	1-3	1-3
Eggs*	Oplet, Bus	Bicycle, Motorcycle		1-22
		Oplet, Ferry	600	1-50
Huller, Polisher*	Truck	Truck	1-27	1-85
Huller*	Picul, Bicycle, Cart	Picul, Bicycle, Cart	1-2	1-2

* Industries which can make use of electricity.

NOTE: Picul is a shoulder load.

TABLE III-16

INDUSTRY CREDIT SOURCES

Product	Previous	Future
Klaten		
Tahu Cooking	Family	Profit
Tempe Cooking	Family	Profit
Bricks	Family	Profit
Blacksmith	Family and Trader	Bank Loan
Drying Tobacco	Tobacco Factory	Tobacco Factory
Furniture*	Family	Bank Loan, Profit
Rice Mill*	Savings	Savings
Rice Mill*	Savings	Bank Loans
Lombok		
Soybean Cakes	Profit, Farm	Farm Profit
Palm Sugar	Savings	Savings
Bricks I	Profit, Farm	Bank Loan
Bricks II	n/a	n/a
Roof Tiles	n/a	n/a
Furniture*	Savings	Bank Loan
Shredding Tobacco I*	Profit, Farm	Farm Profit
Shredding Tobacco II*	Loan from Friends	Bank Loan
Rice Mill I	Profit, Farm	Farm Profit
Rice Mill II	Bank Loan	Production
Luwu		
Bricks	Savings	Bank, Money Lender
Roof Tiles	Savings	Bank
Timber	Creditors, Co-op	Bank
Furniture*	Savings	Bank
Furniture*	Bank	Profits
Eggs*	Savings	Bank
Rice Mill*	Creditor	Savings
Rice Mill, Drying & Polishing*	Government	Government

* Industries which can make use of electricity

this credit source is limited by a requirement for collateral for loans. This requirement often forces the use of alternative sources of credit at much higher interest rates. Even though many respondents indicated that they would use the bank as a source of expansion capitol, very few have already done so.

A shortage of entreprenuership may be a factor that limits industrial growth in many rural areas. However, the survey encountered many local entrepenuers who have broken out of traditional patterns of industrialization in a risk-averse agricultural society. The tobacco dryers of Klaten and furniture makers in other areas are examples of entrepenuers who were able to build up profitable commercial and industrial activitieseither by improving marketing systems, by making improved products whose greater value could absorb increased transport costs, or by reducing the costs of production relative to product value. This last path to greater productivity is the concern of this section.

In the general case, an industry operator who wishes to reduce his cost of production relative to the value of his product has three alternatives. The first alternative is to substitute cheaper fuel or cheaper labor. The second alternative is to use fuel more efficiently. The third alternative is to reduce the number of labor. These three alternatives are not equally feasible for each industry, or in each project area; however, for the purposes of discussion here, other factors such as the supply of alternative fuels or capital financing for the purchase of more efficient machines or fuel burning devices are assumed not to be constraints. The emphasis of this discussion is on the theoretical range of options open to industries. In this context rural electrification assumes importance first because it provides a possibly more efficient alternative to current fuels and second because electric machines can reduce labor costs.

Fuel consumption and employment levels can be obtained from the Indonesian Industrial Census of 1974/75 which presents data concerning rural industries at the kabupaten level for Java and a few other populous areas and at the provincial level for the rest of Indonesia. These data, which include statistics on expenditures for fuel use, allow the calculation of the volume of fuel consumption by particular industries if local fuel prices in 1974/75 are known. Table III-17 gives examples of the detail of data available from the industrial census for small industries in Klaten and Luwu. From these statistics ratios of the number of employees per fuel input for all these industries can be calculated. Examples of these ratios are shown in table III-18.

The ratio of employees to fuel use is a measure of the relative labor intensity versus energy intensity of an industry. This statistic, which is independent of fluctuations in market price of the industrial product, is a function of the choice of industrial methodology. This ratio reflects the strategy of that industry as regards the second and third alternatives in the above list. For example, an industry which uses a process designed to emphasize alternative two (i.e. more efficient use of fuel), would exhibit a relatively higher ratio of labor per fuel use. By contrast an industry emphasizing alternative three would exhibit a lower ratio of labor to fuel use. Often these differences are dramatic as can be seen in the contrast

TABLE III-17

SMALL INDUSTRIES: EMPLOYMENT, FUELS, AND PRODUCT VALUE

	Number of units	Number of workers	Fuel purchased (000 Rp)	Electricity purchased (000 Rp)	Product value (000 Rp)
Klaten Industries					
Ice cream, ices	19	130	560	1,670	26,000
Rice Mills	88	740	23,000	0	220,000
Noodles	100	640	12,000	140	330,000
Bakery	13	86	3,400	76	5,000
Tapioca (Cassava)	49	630	610	0	44,000
Tahu/Tempe	11	67	1,930	0	61,000
Krupuk	41	298	2,900	0	74,000
Other foods	3	20	1,500	0	8,400
Drying tobacco	9	36	120	0	1,700
Textile (weaving)	570	5,770	8,800	0	1,100,000
Batik	33	400	4,200	0	26,000
Other textile	19	220	390	0	49,000
Apparel	4	38	37	0	8,100
Wood furniture	64	420	20	0	81,000
Printing	64	40	65	93	13,000
Cement goods	4	43	1	0	21,000
Lime	22	210	104,000	0	190,000
Bricks	23	150	5,800	0	25,000
Agricultural tools	85	550	31,000	0	16,000
Metal Goods	34	250	24,000	106	120,000
Machinery Manufacture	20	170	28,000	402	170,000
Other Manufactures	5	32	13	0	16,000
TOTAL	1,300	11,000	250,000	2,500	2,600,000
Luwu Industries					
Abattoir	11	61	0	0	26,000
Saw Mills	37	301	820	-	67,000
Wood furniture	11	63	4	0	27,000
Bricks	18	110	3,900	0	17,000
TOTAL	77	53	4,700	0	137,000

TABLE III-18

DEPENDENCY OF EMPLOYMENT ON FUEL USE IN KLATEN INDUSTRIES

Type of industry	Fuel	Full time jobs per million liters kerosene equivalent: home industry	small scale	large scale
Coconut oil	firewood, kerosene	3,700		22*
Rope Spinning	electricity			800*
Rice Mill	diesel, gasoline	770		
Other grains	diesel, gasoline	730		
Textiles	diesel, gasoline	7,400	12,000	
Apparel	diesel, gasoline	900		
Wood products, sawmills	diesel, gasoline	38,000		
Furniture	diesel, gasoline	38,000		
Paper	diesel, gasoline	25,000		
Metal products	diesel, gasoline	1,800	300	
Tobacco	firewood, kerosene, agricultural wastes		10,000	
Sugar	firewood, agricultural wastes	2,000		
Tahu and Tempe	firewood, kerosene	870	----Average: 1,100	
Krupuk	firewood, kerosene	1,400		
Other Foods	firewood, kerosene	14,000		
Lime	firewood, crude oil		40	
Pottery	firewood, agricultural wastes	4,000		
Bricks, tiles	firewood, agricultural wastes	720	540	
Agricultural tools	firewood, agricultural wastes	500	300	
Basketry, atap	little significant fuel use	91,000		

* These data are from Albay Rural Electric Cooperative in the Philippines. As the Central Java PLN grid supplies approximately 2 kwh of consumed electrical energy per one liter of petroleum fuel burned in its thermal power stations (see section II-6), the kwh used in these industries is converted to liter-equivalent of kerosene in the ratio of 2 kwh/liter.

between the manufacture of coconut oil by Klaten households and by the highly mechanized factory in the Philippines. However, from these data alone it is difficult to determine whether the difference is due to alternative three, i.e., use of fuel to substitute for labor, or alternative two, more efficient use of fuel, or perhaps a combination of the two.

A clearer picture of the two strategies inherent in these alternatives can be obtained if the data from table III-17 are displayed on a graph which shows each industry plotted according to the number of employees per million Rupiah product value and the amount of fuel used per million Rupiah product value. Such a graph is shown in figure III-3 for industries in Klaten and Central Java. On this graph are also plotted two industries from a Philippines rural electrification service area which has been operational for six years.

A plot of industries such as figure III-3 is useful in several ways. For example compare the positions occupied by industries in figure III-3 and the ratio of jobs per million liters kerosene equivalent shown in table III-18. From the ratios of table III-18 the sugar industry with two thousand jobs per million liters kerosene equivalent does not appear to be significantly different from the metal goods industry which has eighteen hundred jobs. However, the sugar industry is in a position relatively more precarious should labor or fuel costs increase suddenly.

The ease with which the relative vulnerability of industries to such increases can be seen in figure III-3 is one value of this kind of plot. Drawn on figure III-3 is a curve which indicates combined input expenses of labor, at Rp. 400/man-day, and fuel, at Rp. 60/liter-equivalent, equal to one million rupiah (note a price for electricity of Rp. 30/kwh is approximately the same as Rp. 60/liter of solar). The distance between this line and the location of a particular industry is in essence a margin which, when diminished by the cost of raw materials, represents the potential profit of that industry, given a particular labor and fuel cost. An optimum strategy for an industry given both rising fuel and labor costs is to reduce either labor or fuel costs in such a way as to maximize the distance from this line of zero profit.

{Technical note: The industrial data shown in figure III-3 are plotted on a logarithmic scale. Use of the log-log plot shows the true relative profitability of each industry in comparison with other industries and with fuel and labor costs. General overall price inflation can be easily adjusted for by sliding both coordinate scales a distance proportional to the factor of change. Since the data shown are for 1974/75 prices, an approximation for 1979 prices can be made by adjusting each axis by the log of the factor corresponding to the price inflation of 100% from 1974/75 to 1979. Or equivalently, the log of 2, which is 0.3, can be added to each number shown on the coordinate scales. By similar logic the curve of constant combined fuel and labor cost can be translated to any position determined by an assumed minimum wage and unit fuel cost. Another convenience of this plot is the ease of calculating the percent of product value represented by labor or fuel costs. This percent is the inverse of the antilog of the distance from the industry's location to the value of the average (or minimum) wage or unit fuel cost.}

INDUSTRIAL EMPLOYMENT AND FUEL USE IN CENTRAL JAVA

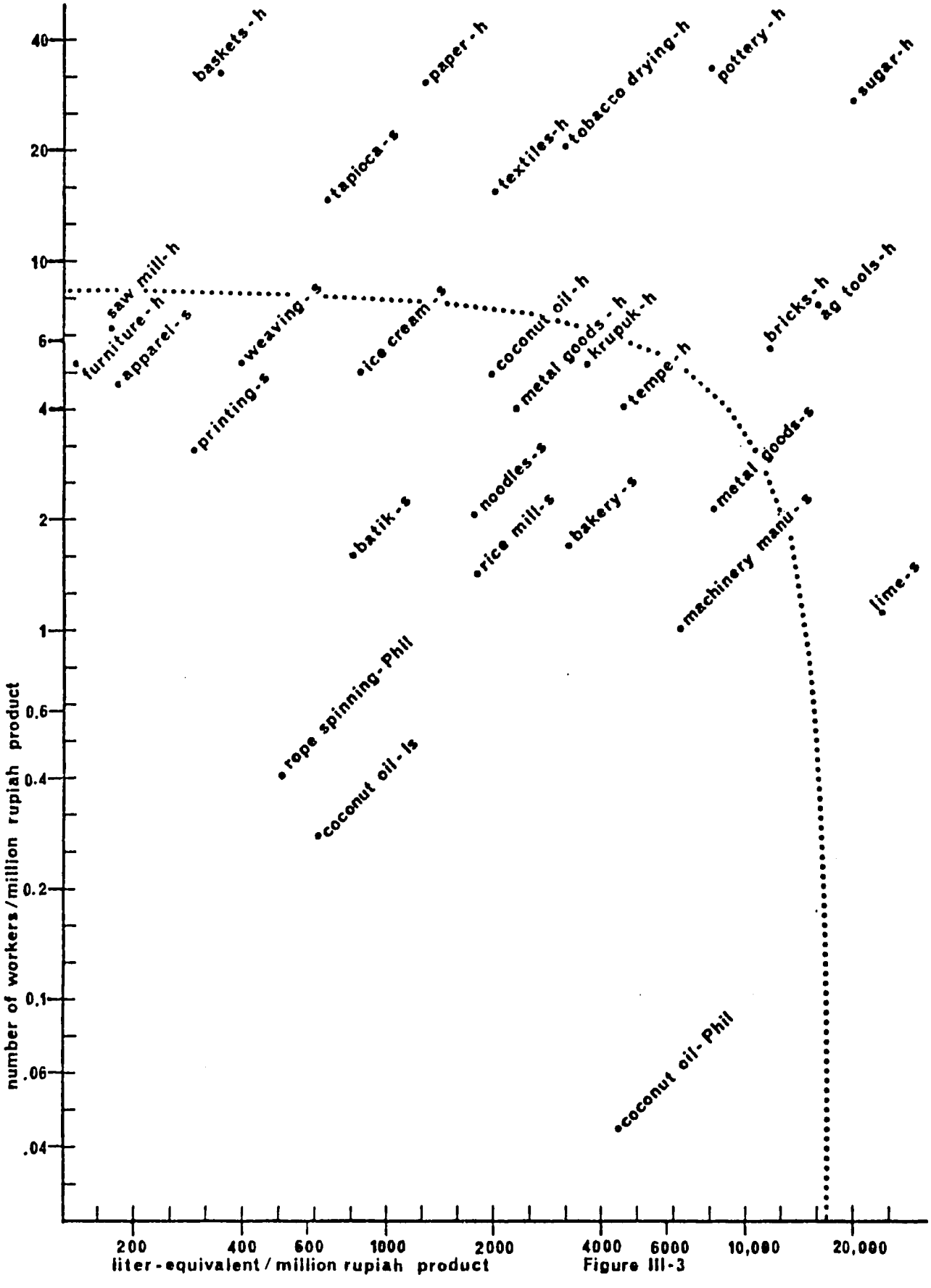


Figure III-3

The position of industries relative to the curve of figure III-3 defines which of the three cost reduction strategies are feasible. For example, the producers of sugar, bricks, agricultural tools, and lime must look to fuels cheaper than diesel, gasoline, or kerosene, i.e. alternative one or look to more efficient fuel use, i.e. alternative two. The makers of baskets, tapioca, paper, tobacco, etc. may look for cheaper fuels, but that strategy alone is not sufficient. They must also look for ways to reduce the labor input through adoption of more automated processes, i.e. alternative three. As electricity is a relatively expensive fuel, it cannot substitute profitably for other fuels. However, the use of additional energy in the form of electricity can buy substantial reductions in labor costs, over and above the reduction in labor costs possible through efficiencies of scale.

The magnitude of labor reduction which can be effected through increased energy input to power highly mechanized industrial processes is best illustrated by the case of coconut oil manufacture. In central Java 25% of the estimated 1974 total Central Java production of 24,000,000 liters of coconut oil was produced in home industries. Approximately 3,400 households produced coconut oil for sale thereby giving the equivalent of full-time employment to 4,800 workers. The remaining 75% of production was by large scale industries, 10 in number, which employed 500 laborers. Both of these points are shown on figure III-3; the house industry is indicated by "H," and the large scale industry by "LS." Note that both labor and fuel costs have been much reduced. By contrast, the coconut oil factory in the Philippines which employs only ninety persons as full-time workers, produces approximately 10,000,000 liters/year of coconut oil. However, the increase in productivity per employee has been bought only by a greater energy intensity in the manufacturing process.

Although in theory a more efficient use of fuel could reduce production costs (aternative two) there are no available case examples. This kind of change would be feasible only in the most highly energy intensive industries such as brick-making and lime production. It has been proposed (Raintree, 1979) that more efficient kilns in these industries could reduce the energy input and hence increase the profitability of these industries. However, it usually happens that more efficient kilns require higher quality fuels which are more expensive. Thus the operators of kilns more likely will substitute cheaper fuels such as agricultural wastes unless more efficient kilns burning firewood are provably cheaper.

There are other industries which are both less energy intensive and less flexible in the kinds of fuel which can be substituted. Many industries such as printing and manufacturing have a choice between direct drive motors and electric motors driven by auto-generation or by power from PLN electric lines. While one or another of these choices can be made cheaper to the industry operator through manipulation of subsidies on fuels and electricity, the cost to society is not greatly different as the majority of electricity comes from petroleum fuels. If significant quantitites of electricity could be generated from non-petroleum sources, then electricity would be a truly cheaper fuel.

The attraction of relatively cheap electricity for new industry has been demonstrated in the Moresco co-operative in the Philippines where all of the electricity is generated by hydropower and is sold at a rate approximately one third of the cost of electricity generated by combustion of petroleum fuels. The availability of this cheap energy has lead to relatively rapid industrialization in that area of the Philippines. By contrast most of the industries in areas with relatively expensive power are there because of factors other than the availability of electricity. The coconut oil factory in the Philippines predates rural electrification by five years.

In summary, rural electrification will have little impact on the current pattern of fuel use in existing rural industries. Most existing industries, as can be seen in figure III-2, are not capable of substituting electrical power. In the industries which can use electricity, there may be a trend toward labor substitution. The main hope for productive uses leading to employment generation lies in development of new markets for existing industries or the introduction of altogether new industries.

There are other possible productive uses of electricity in rural areas which if planned carefully can have positive, but indirect impacts on industries. The use of electric power to process low grade agricultural wastes so that they can be burned more efficiently by a greater number of industries is one such alternative that merits further study. Revelle (1980) in a review of Asian energy problems suggests that pump irrigation is another productive use to create more energy. The investment of energy for pumping of water can produce a larger return in energy in the form of food and agricultural wastes. Both of these uses of electrical power would increase the productive base upon which the majority of industries in an area such as Klaten depend by indirectly increasing fuel supply.

Whatever the role of rural electrification in rural productivity, it is likely that the future will see an ever greater percent of agricultural wastes being removed from fields and burned in industries. The impact of this trend on soil structure and fertility will become a more serious concern. This concern is discussed in the next section.

IV. NATURAL RESOURCES AND THE SUPPLY OF ENERGY

IV-1 Forests, Gardens, and Fields: Energy Involution

The central concern of this environmental assessment is the relationship between energy development and the condition of the natural resource systems which are the major source for rural energy needs and the basis of rural productivity. In other countries this relationship has received much attention because agricultural systems are believed to be increasingly threatened by the need for fuel. For example, in Nepal the need for firewood for cooking fires has lead to denudation of steep mountain slopes with a consequent increase in erosion and siltation and a decrease in agriculture productivity. In parts of the Indian subcontinent increasing reliance on animal dung for cooking fuel is perceived as a threat to soil fertility as fields are robbed of the nutritive content of animal manure (NCAER, 1978). However, energy-related problems in Indonesia, in particular Java, are different.

The most important distinguishing characteristic of Java is that it is green. Unlike most of the Indian subcontinent, there is rainfall throughout the year in amounts adequate to assure that the fertile soils of Java achieve a near maximum year-round productivity of biomass. The term "productivity" when used in conjunction with biomass should be understood in its ecological meaning, that is fixation of carbon dioxide in organic form in plant materials. Productivity in this sense is the net change in the total amount of plant material per unit area per unit time.

For convenience productivity is commonly expressed in units of kg of dry plant material per hectare per year. Productivity in this sense is always greater than agricultural productivity, which though expressed in the same units excludes the weight of non-edible portions of crop plants as well as weeds and vegetation at margins of fields. Nonetheless whatever definition is used the land of Java, whether planted in forests, in home gardens or in agricultural crops, is among the most productive in the world.

Although Java has severe problems of erosion and loss of agriculture productivity in upland areas, the cause is not the need to burn every available stick of biomass material. Erosion in Java is caused primarily by the land hunger of Java's high population. Prime agricultural lands are being pushed to their maximum productivity, and marginal lands best left in permanent cover are being opened for food crop cultivation.

The population of Java continues to increase, and Java is already one of the most densely populated agricultural areas of the world. Moreover, energy prices are increasing. What are the impacts of these two trends on the natural resource base? If there is an increasing demand on resources of traditional biomass fuels, then how can the resource base sustain additional demands on top of already heavy demands. The response to increasing demand is an involution in the relationship between the human population and its resource base in much the same way that Geertz (1963)

describes the changing relationship between farming communities and their agriculture.

Energy involution is defined as the use of an increasing percentage of the renewable productivity of biomass for fuel. The increased efficiency with which biomass productivity is used comes about in two ways. The first is that an ever increasing percentage of the annual increment of biomass productivity is burned to produce heat for household cooking and for industrial processes. This can happen only if more biomass fuels of lower quality are used. This means that where in one year a family or an industry mostly used stemwood-grade firewood the next year they use coconut husks and bamboo roots. Still later, rice hulls, corn stalks, tobacco stalks, rice stalks, and finally dried leaves are commonly used as cooking fuels. In a completely involuted system, no burnable bit of biomass is immune from inclusion in a cooking fire.

Energy involution opens up a resource of combustible materials from forests, gardens, and fields, which is much greater than the maximum possible annual "harvest" of conventional stemwood. Foresters have measured the proportion of annual tropical wet forest biomass productivity in three categories: "stemwood," or "true firewood" at 21%; other above ground biomass, i.e. leaves, twigs, bark, at 43%; and roots at 36% (Earl, 1975). If, as likely, these proportions hold for home gardens, then involution is utilizing a resource base which is up to four times greater than the yield of stemwood alone.

However, to be able to cook with such low quality fuels requires ever more constant attention to the cooking fire. For example, cooking gudeg (jack fruit) using only corn stalks requires approximately three hours of constant manipulation of the stalks to keep an even, low flame under the center of the cooking pot. However, such tedious labor has its reward. Such a well-tended cooking fire is more efficient at capturing the caloric content of the fuel than a fire made with higher quality firewood which is left unattended for long periods of time. Thus overall a greater percentage of the annual productivity of biomass, measured in calories, is put to useful purpose in an involuted system.

The constrast between the three areas studied in the survey offer evidence supporting the phenomenon of energy involution. One of the most startling results of the survey of household energy use is the answer given to the question "is the distance travelled to obtain cooking fuel the same now as it was five years ago, or greater or smaller?" In Luwu, a frontier area, the answer was as one might expect. Five years ago in Luwu firewood sources were closer to the home. In Klaten, no one said that firewood sources were closer five years ago. The overwhelming majority of people reported that sources were the same distance; however, a small, but significant minority said that five years ago the distances travelled were further! The people of Klaten have thus become more dependent on the resources closer to their house. The increasing exploitation of burnable "wastes" from backyard gardens and nearby agricultural fields implied by this observation is one of the key characteristics of energy involution. A further difference between the three areas is shown in table II-3. The people of Central Java commonly use a much wider variety of lower quality fuels than do the people of Luwu.

Indirect evidence for energy involution comes from an observation in Lombok. The project area in Lombok, unlike most of Java, is not blessed with a high degree of productivity as it has a very long dry season. Further, the kind of home garden that is traditional in Central Java is not common in most parts of Eastern Lombok. Notwithstanding in Eastern Lombok, the lowest income stratum still reports that on the average three quarters of its cooking fuel is gathered by the family. On closer examination, however, it appears that three quarters of this lowest income stratum gathers all of its cooking fuel and one quarter purchases all of its cooking fuel at a cost of approximately 20% of the total family income. The end point of energy involution has been reached in Lombok. The local resource base within a short distance of the villages in Lombok is stretched beyond its capacity to supply the minimal needs of the residents.

Energy involution has major implications for the allocation of family labor resources. In Klaten the amount of time spent in tending a fire made with low quality combustible materials is already much greater than the amount of time spent collecting the combustible materials. The ratio between the time spent preparing and tending a cooking fire and in gathering the combustible materials could be considered an index of the state of involution in a particular community. While no estimates were asked of respondents concerning time spent tending fires, casual observations indicated that an average time is on the order of three hours a day as compared with three hours per week for collecting fuel in Klaten. It should be noted that this is time spent tending the fire over and above that spent actually tending the food being cooked on top of the fire. It has been observed in some households that these are separate activities, often going on simultaneously. It follows then that a great deal of the value of higher quality fuels such as kerosene and high grade stemwood lies in their potential labor savings. This is particularly important for families who place a high value on surplus household labor either for sociological reasons or because the family has a home industry.

One further impact of energy involution is that the family becomes less flexible in allocating its labor resources. Firewood, garden or agricultural wastes can be gathered any time of the day or week, but cooking and fire-tending must be done at the same time every day. Thus in families living in relatively involuted areas the labor necessary for tending cooking fires not only increases, but also it assumes a very high priority in the household labor budget.

Involution may be having long term effects on the productive base of agricultural in many regions. As an ever increasing percentage of agricultural residues are removed from fields for combustion in household cooking or small scale industries, there arises a concern for the long term impact of this removal. How is soil structure affected by the removal of organic matter, and how is soil fertility affected by the removal of the nutrients contained in the agricultural waste? To some extent these effects can be compensated by the use of fertilizer, but fertilizer itself is an energy intensive input and the balance between the two energy needs must be examined in a wide-range of situations before any definite statement can be made. This concern is parallel to the concern that has been raised concerning agriculture productivity in the Indian subcontinent where animal dung is being burned for fuel.

Another impact of involution concerns the home garden resource common throughout most areas of Java. The multiple uses of the home gardens for economic and social purposes have been well documented by Soemorwoto (1979). However, the management decisions made by individual home garden owners as to what plant species are raised in the home garden have not been studied and it is not known how important the home garden is becoming as an energy resource in the eyes of its owner. A major research priority is to study the long-term impact of energy trends on other uses of home gardens.

IV-2 The State of Natural Resources in the Surveyed Areas.

The three areas surveyed were chosen from among the ten project areas of the Rural Electrification I Project because the three represent a range of natural resource conditions. The differences between the three areas are described below.

The 1974 population density is highest in the Klaten kabupaten at 1,450 persons per square kilometer; second highest in the project area portion of East Lombok kabupaten at 1,350 persons/km^2, and lowest in the project area portion of Luwu kabupaten at 80 persons/km^2. Note that the overall population density of the entire kabupaten of Eastern Lombok is 1,100 because of the inclusion of forested area on the slopes of Mount Rinjani. Similarly the overall density of Luwu is 25 because of the inclusion of forested areas to the north of the Luwu coastal plain. The annual population growth rates are 1.5% in Klaten, 0.7% in East Lombok and 5% in Luwu. The high rate in Luwu is the result of the influx of Javanese and Balinese settlers under the transmigration program.

The pattern of land use, which varies greatly from area to area, has important implications for the supply of fuel. Figures IV-1, IV-2, and IV-3, show the pattern of land use in the areas of Klaten, Lombok and Luwu respectively. These maps were derived from many sources: detailed land use and vegetation maps for Luwu from feasiblity studies for the transmigration program; 1:250,000 general topographic and vegetation cover maps for all areas; aerial photographs from 1975 for Luwu; recent Landsat images for all areas; and, limited ground observations for all areas. The ground truth, even though limited, was sufficient to establish correspondence between the definitions used to equate different specific land uses on the basis of their approximate equivalence as energy resources.

The definition of three principal Land use categories shown in the figures are: "forests," any closed stand of trees; "gardens," any relatively open stand of perennial plants, whether associated with settlements; "other," any extensive area of agricultural fields or grasslands. These definitions present some problems of correspondence as Klaten for the most part exhibits a fine grained mosaic of gardens and other areas. Wherever this mosaic occurs in and near Klaten it is included under the garden category as it represents, a greater resource of higher quality firewood than the "other" category.

On the basis of the above categorization Luwu has the most available resources, Klaten the second most, and Lombok the least. In Lombok, which does not have a tradition of home gardens, the resources are limited to commercial stemwood from the mountainous areas to the north of the rural electrification project area, to scattered coconut stands, to streamside vegetation, and to field crop residues.

To estimate the magnitude of local biomass resources requires a calculation of yields based on land use. In Klaten land use is as follows: irrigated rice, 38,000 ha; dry land agriculture, 27,000 ha; settlements and home gardens, 3,000 ha; "kebon" (tree crops) and forests, 60 ha. There are two ways to estimate the amount of residue produced by rice land: by

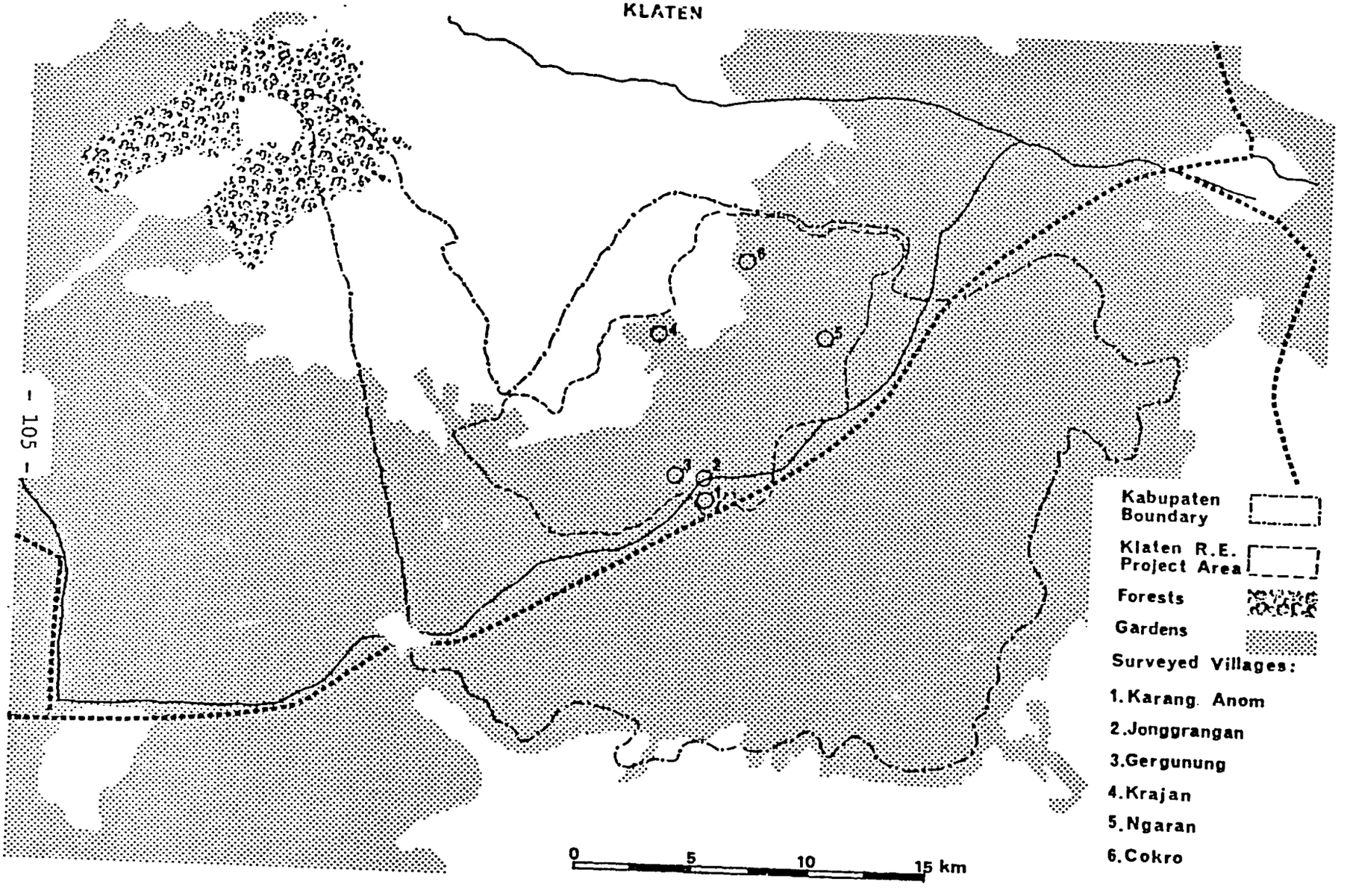

KLATEN
Kabupaten Boundary
Klaten R.E. Project Area
Forests
Gardens
Surveyed Villages:
1. Karang Anom
2. Jonggrangan
3. Gergunung
4. Krajan
5. Ngaran
6. Cokro
0
5
10
15 km

Figure VI-1

EASTERN LOMBOK

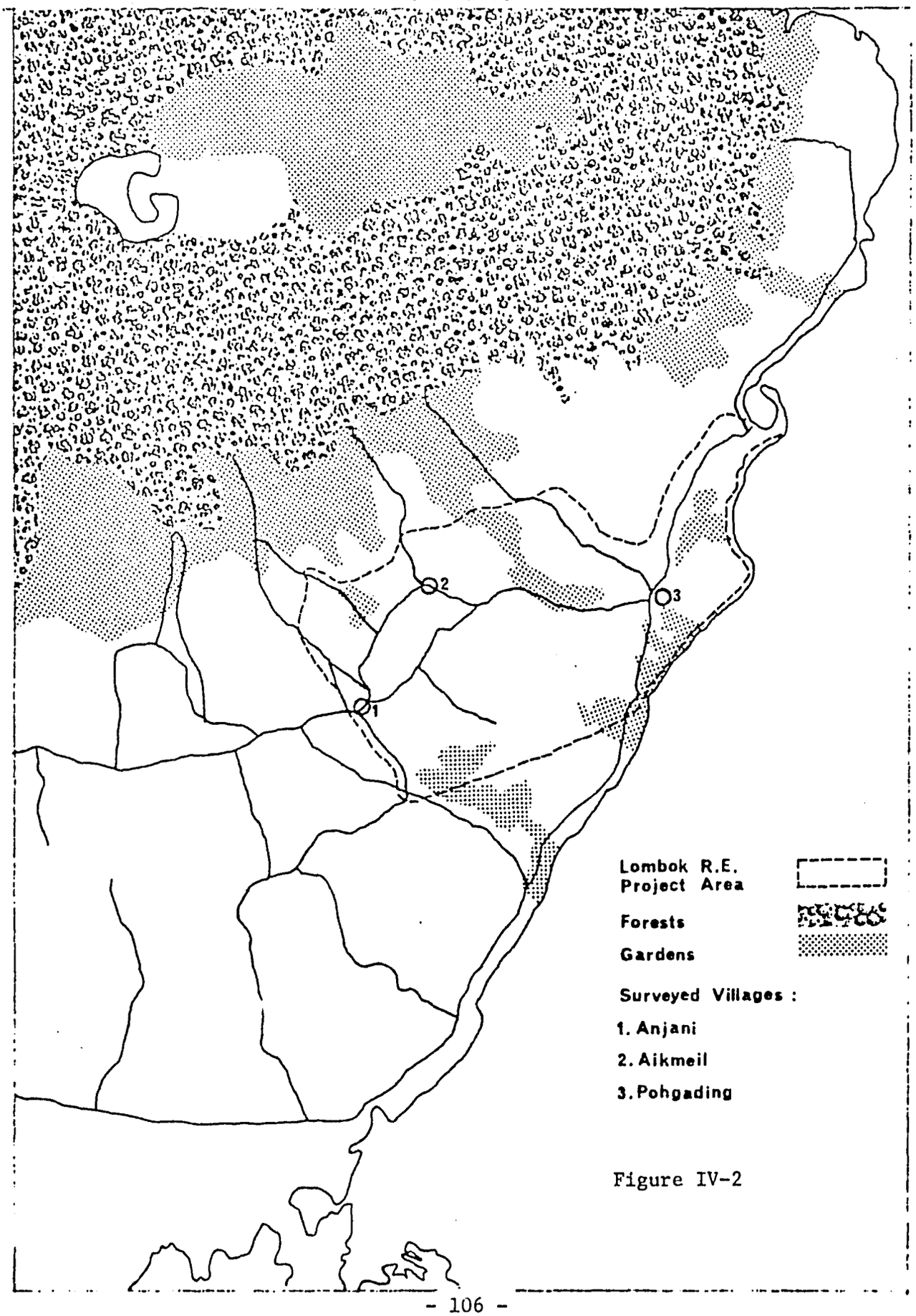


Figure IV-2

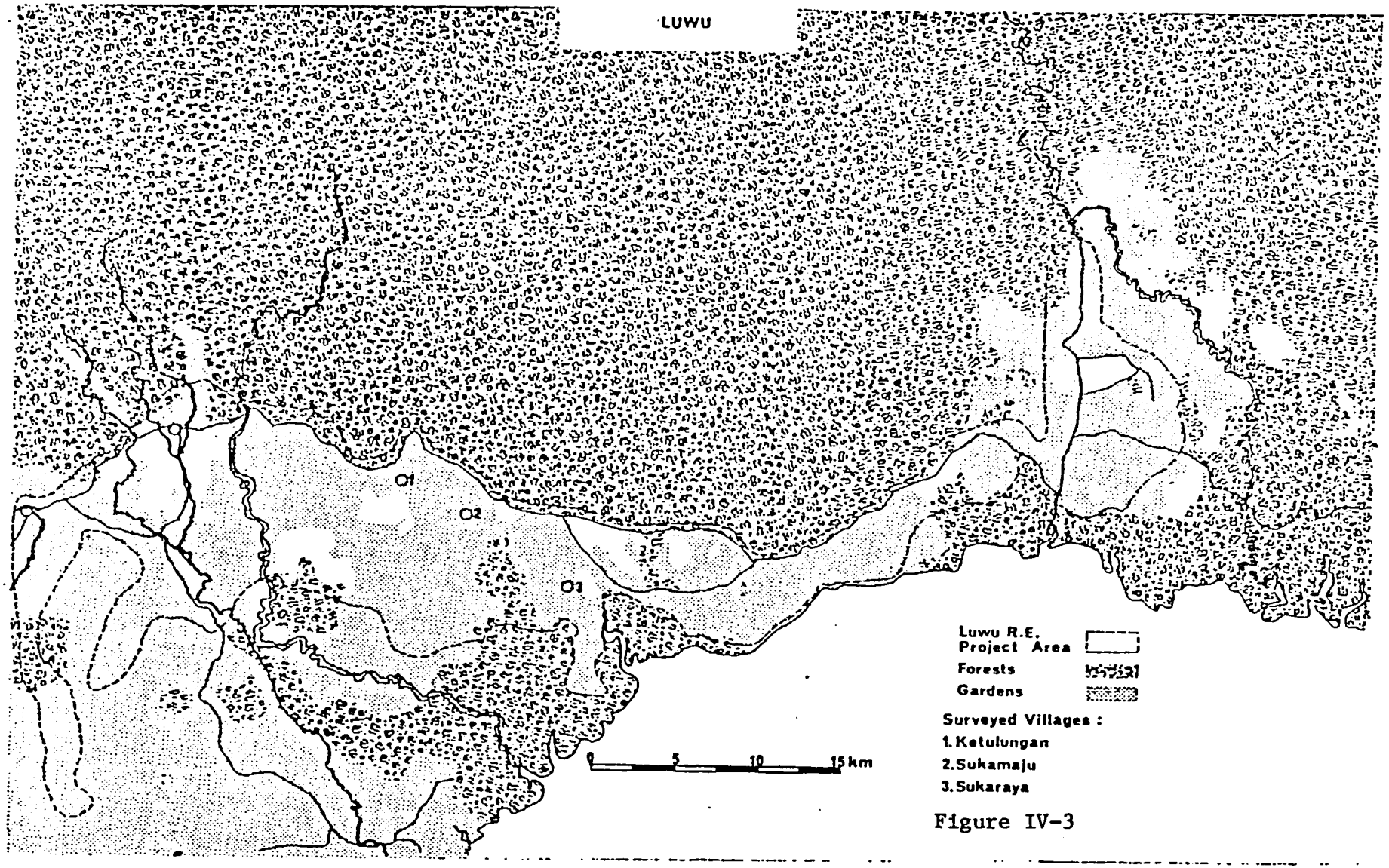

LUWU
O1
O2
O3
0
5
10
15 km
Luwu R.E.
Project Area
Forests
Gardens
Surveyed Villages :
1. Ketulungan
2. Sukamaju
3. Sukaraya

Figure IV-3

acreage planted or by tons harvested. The above ground residue of two crops per year of irrigated rice is estimated to be 10 tons per ha per year (Supomo, 1978), which implies Klaten's residue to be 380,000 tons per year. Or using the harvest factor of 1.5 tons of residue per 1.0 ton of rice (DOE, 1978) times a recent average Klaten rice production of 230,000 tons in 1977 (BPS, 1977), yields an estimate of 345,000 tons of residue. Similarly the dryland residue can be estimated at 4.5 tons per ha per year (PSL-IPB, 1974), which times the acreage of 27,000, is 120,000 tons. Individual dryland crops residue factors are 5.2 tons/ha/crop of corn, 6.1 tons/ha/crop of cassava, 2.0 tons/ha/crop of peanuts (Supomo, 1978). The sum of all the agricultural residues gives a total from 470,000 to 500,000 tons per year in Klaten. However, since many Klaten fields are cropped 3 times a year these figures should be increased 30% to 50%, giving an overall range from 600,000 to 750,000 tons per year.

How important are home garden "wastes" in the total picture in Klaten? The estimates of home garden production of fuel vary from 7.2 (Wiersum, 1975) to 12.5 tons/ha/year (PSL-IPB, 1974). Although these authors do not specify exactly what fuels are included in these estimates, it is likely only stemwood and perhaps some twigs. Since Javanese home gardens are similar to tropical wet forest in their ecology, estimates of the productivity of such forests can serve to place an upper limit. Earl (1975) estimates that managed tropical wet forest can produce up to 40 tons/ha/year of net above ground biomass, of which 13 tons are stemwood and 27 tons are twigs, leaves, and fruit. This figure may be contrasted with yields for test planting of Caliandra spp. of approximately 100 tons/ha/year of stemwood reported by the Indonesian Forest Products Research Institute (LPHH, 1977). This yield is close to the highest observed yields of C-3 plants of 110 tons/ha/year. Plants such as grasses which follow the more efficient C-4 photosynthesis pathway have higher yields measured at 190 tons/ha/year (Bassham, 1977). In view of these relatively high yields it is not unlikely that Klaten home gardens produce 13 tons/ha/year of stemwood and 27 tons/ha/year of other biomass, which times the home garden acreage gives a total of approximately 40,000 tons/year of stemwood and 80,000 tons/year of other biomass, which together with dryland and rice residues of 600,000+ tons/year gives a total of 720,000 tons/year for the Klaten kabupaten. To this estimate could be added another 50,000 or more tons to allow for the relatively higher productivity of grassy strips along canals, dikes, and paddy terrace risers, which along with agricultural residues, supply most of the food for the 190,000 livestock in Klaten, which consists of 50,000 head of cattle; 15,000 buffalo 120,000 sheep and goats; and 4,000 horses (Klaten, 1975). These livestock consume approximately 150,000 tons per year of grasses and agricultural residues estimated on the basis of a consumption of 1.5 % of their body weight in dryweight of feed grasses daily (NRC, 1976). Average body weights are estimated to be 250 kg for cattle, 700 kg for buffalo, 25 kg for goats, and 200 kg for horses.

If the estimates of the last paragraph are compared with the estimated fuel consumption figures shown in table III-9, it is seen that local stemwood sources can only supply 40,000 tons out of an estimated consumption of 150,000 tons per year, or approximately 25%. The remaining demand for stemwood is met by outside sources, which are described in the next section. On the other hand, Klaten households and small industries

burn 47% or 320,000 tons out of a resource of 680,000 tons/year of agricultural and garden wastes. Thus overall approximately 50% of the annual biomass productivity outside of food for man and livestock is used for fuel by local residents. A similar series of estimates gives a higher figure of 60% for Lombok exclusive of the forested slopes of Mount Rinjani. Undoubtedly most of the biomass that is not used for fuel is the lowest quality agricultural residues such as rice straw.

The characterization of the state of local resources by the percent of local renewable biomass resources consumed is only a crude indication of the need for rural energy development programs. More knowledge about local distribution of those resources, their seasonality, their marketing and their quality is needed for each area before attempting to design programs for resource stabilization. Much of this knowledge already exists for the areas surveyed by this study, and it can be applied to help guide future energy programs. For example, since Eastern Lombok has little technical irrigation, the resources from agricultural wastes are more limited than in Klaten. This fact suggests that one use of rural electrification in Lombok is for pump irrigation. The indirect production of more energy resources in the form of agricultural wastes, e.g. corn stalks, rice straw, etc., could have a very positive impact on those most affected by energy involution. On the other hand in areas with a high percentage of land under irrigation as in Klaten, pump irrigation would have only a minor impact in providing significant new sources of wastes for fuel. In Klaten other factors such as the marketing system for biomass fuels, described in the following section, have more influence.

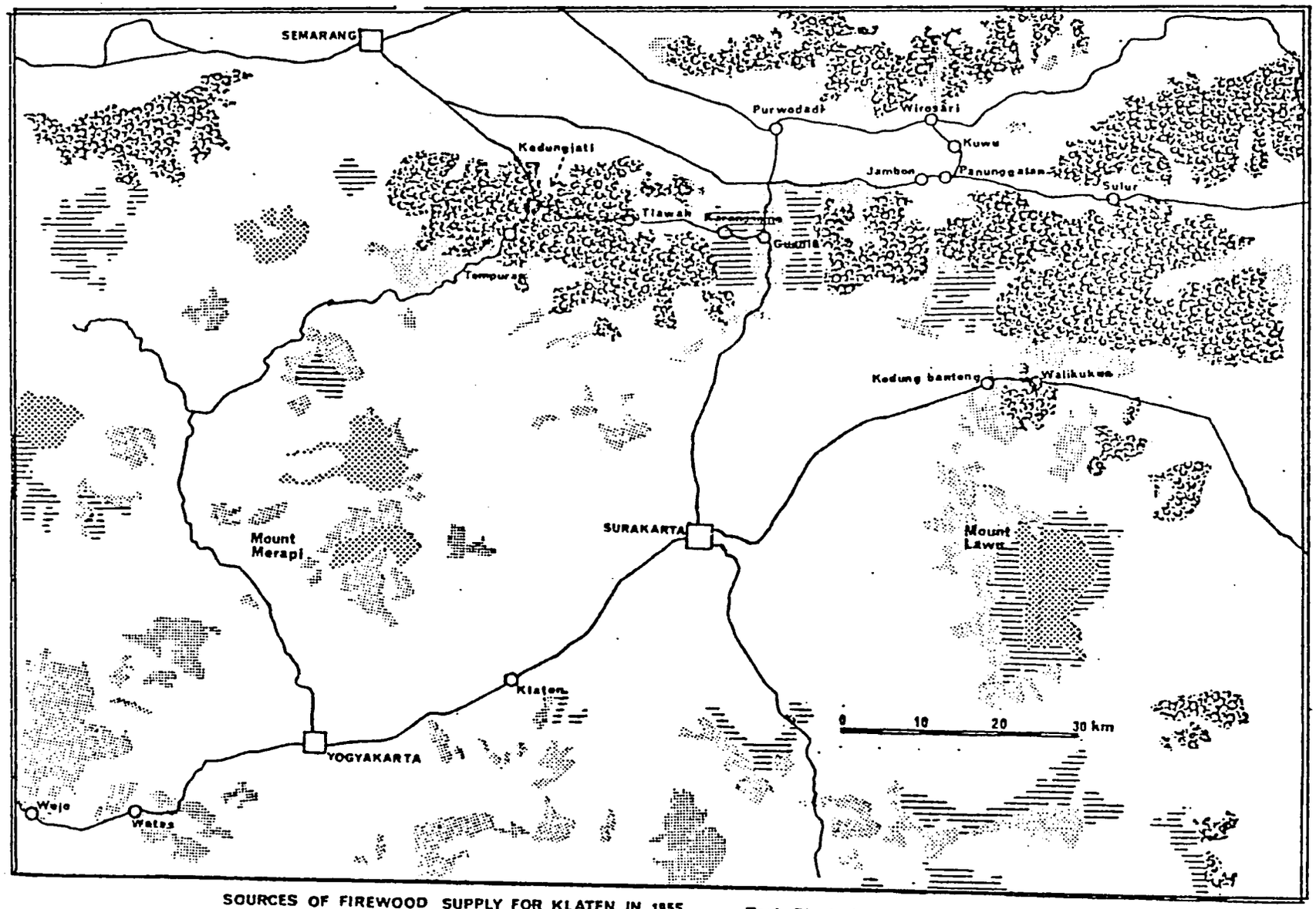
IV-3 Marketing of Traditional Fuels

In a highly involuted region virtually all firewood of the highest quality has a ready market. In an area such as Klaten even very low quality fuels are commonly sold. In Klaten there is a large market for agricultural wastes, such as rice hulls, for the brick and tile industry. Just as different grades of petroleum fuels have their own markets and end uses, which are related to their economics and burning properties, so too do the various grades of combustible biomass. The major difference with petroleum fuels is the distributed nature of the biomass resources and the resulting difficulty of collection and transport. Therefore to characterize the marketing of firewood and other biomass fuels is a difficult task.

The complexity of the supply of stemwood in Central Java is i llustrated by looking at figures IV-4 and IV-5. Figure IV-4 shows the supply area or "fuel shed" for one industry in Klaten in 1955. This industry is a cooperative association of lime kilns which has been in more or less steady production since World War II. Twenty-five years ago all of its fuel was firewood and all of that was brought by railroad train from the rail stations shown in figure IV-4. The current head of the lime kiln co-operative, who was first employed by the co-operative twenty-five years ago as a buyer of firewood, provided the names of the source locations shown in figure IV-4 from his recollection, which turns out to be more accurate than current maps (at one to two hundred fifty thousand scale) of Central Java which do not show five of these locations. These five stations could only be found on a fifteen-year-old route map published by the railway authority. It is interesting to note that three of the rail stations which were stemwood sources then are themselves terminals for narrow-guage forest railroads in teak plantations.

Unlike twenty-five years ago when a significant portion of stemwood consumed in Klaten was entirely transported by rail, the current sources are not necessarily located on rail lines. Among the current stemwood sources shown in figure IV-5 are seven sources which are current supply sources for the lime co-operative. Only two of these are the same locations as twenty-five years ago. These are Gundih and Purwodadi. Two of the current points of supply for this co-operative are further away from Klaten than any of twenty-five years ago; these are Ngawi and Blora. Two are closer: Sragen and Salatiga. One is in a completely new area, Wonogiri. The other points shown in figures IV-5 supply other industries and firewood dealers in Klaten. Although a very small amount of stemwood is still transported by rail into Klaten virtually all of the firewood is now transported by truck. Thus there has been a complete modal shift from the transport pattern of twenty-five years ago. Therefore figure IV-5 shows only main roads.

The markets for lower quality fuels such as agricultural and home garden wastes, by contrast with firewood, are much more limited. Typically agricultural wastes rarely are transported beyond a few kilometers and the lowest quality biomass, such as small dry leaves, etc., are carried by shoulder or back load only within a village. Thus one impact of energy involution is an increasing dependence on <u>local</u> sources of combustible biomass. Although this dependency affects households and industries alike,



SOURCES OF FIREWOOD SUPPLY FOR KLATEN IN 1955

Figure IV - 4

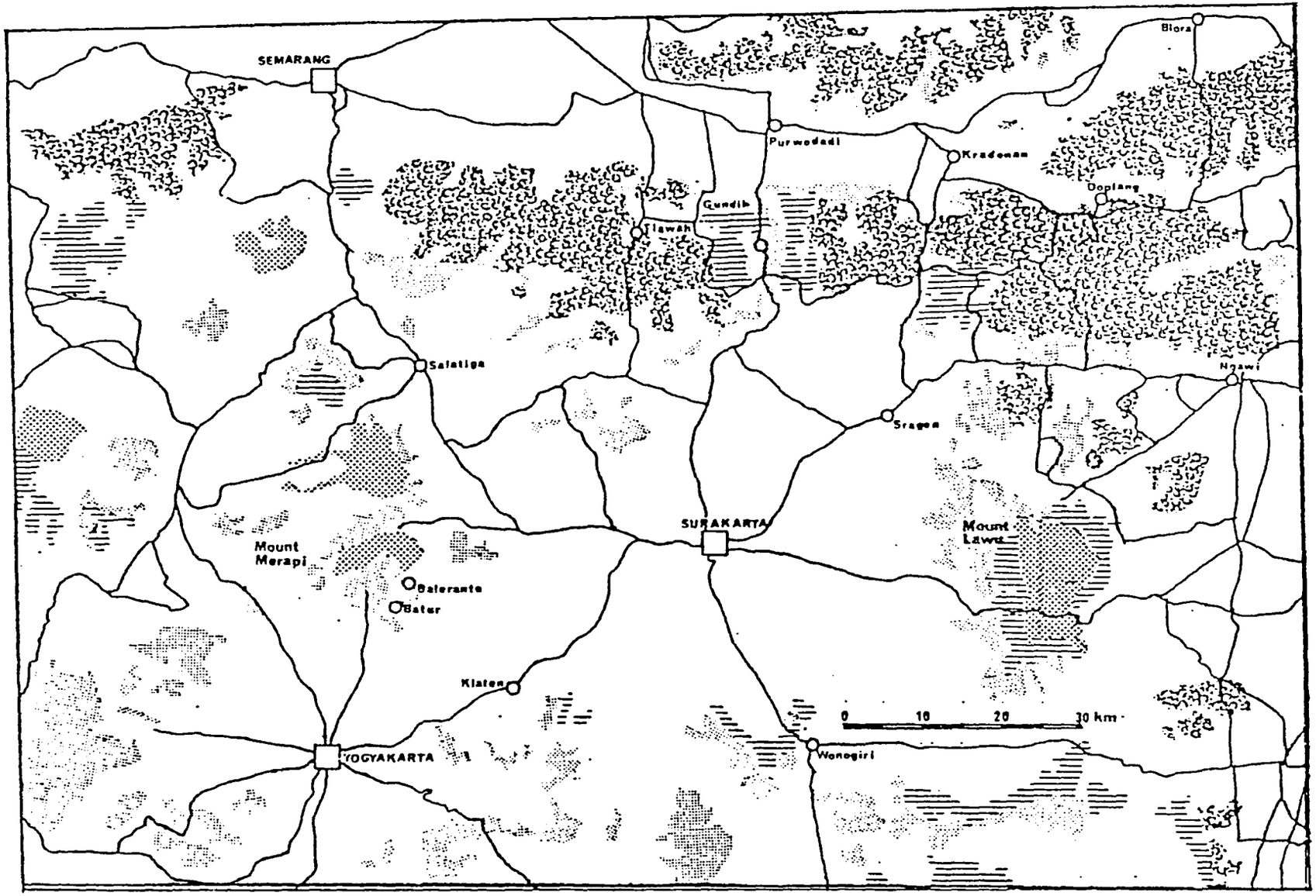


FIGURE III SOURCES OF FIREWOOD SUPPLY FOR KLATEN IN 1979

Teak Plantation
Non Teak Plantation
Protected Forests
Non-Government Forests

Figure IV-5

it is relatively more critical for small industries as local resources may simply be insufficient to supply their needs. In that event, the industry, which was forced by high energy costs (see section III-4) to burn low grade fuel in the first place, will be unable to operate.

In order to obtain a complete picture of the stability of stemwood supplies, it is necessary to survey resources over a wide area as is shown in figure IV-5. Although such a broad survey is outside the scope of this report, there is indirect evidence that the resources are being stressed. One such piece of evidence is the rapid growth in stemwood prices over the last five years. The price increase could be caused by increasing transport costs, dwindling supply, or increasing demand. Transport costs, although increasing, have not increased enough to explain the 4- to 5-fold rise in Klaten. Stemwood supply sources are decreasing, but many sources are the same as twenty-five years ago. Therefore it is likely that demand is growing either through new industries or because of substitution of stemwood for kerosene as kerosene subsidies are removed. If this is true then stemwood prices, at least for the highest grades, will rise by at least as much as kerosene, which is now still heavily subsidized.

If stemwood demand holds strong, then lands now marginal for agriculture will be planted in fast-growing trees for a commercial crop. Such marginal land exists in small amounts even in areas such as Klaten, and in larger amount in areas close to the currently forested areas of figure IV-5. While both locations, i.e. near centers of demand and near supply areas, can be planted in firewood crops, planting the former areas, e.g. "village woodlots," would necessarily remove a source of "free" biomass fuel now open to all as such woodlots will replace other crops and land uses which are sources of wastes and other low quality fuels. This effect would hasten energy involution to the inevitable end-point and force the poorest villages who are usually landless into the commercial fuel market.

In summary, commercial stemwood is marketed over wide areas. One region, even one industry, commonly receives shipments from a "fuel shed" with a radius of 100 km or more. Increasing energy prices are forcing substitution of lower quality fuels by industries and households alike. The process of energy involution is thereby hastened with the ultimate result of the poorest being forced into purchasing rather than being able to gather fuels. Energy involution means that the heaviest demand will be on <u>local</u> sources of poor quality fuels such as agricultural wastes.

IV-4 Rural energy development policy

The primary conclusion of this report is that all rural energy development projects should be designed in accordance with the constraints imposed by the availability of local energy resources. Development planning up to the present has largely ignored the role of traditional fuels and has assumed that energy in all forms, but particularly petroleum, was a cheap and freely available input. Consequently, world energy consumption has grown 1.3 times (oil consumption has grown 2.0 times) as fast as the growth in GNP (Philhower, 1980). But biomass fuels still continue to be important energy sources. Estimates of the percent of total energy consumption which is from biomass fuels are: 52% in India (Argal, 1978); 36% in Zambia (Mabonga, 1978); 25% in Brazil (Muthoo, 1978); and 48% from wood fuel alone in South East Asian countries (Donaldson, 1978). These percentages are unlikely to be much changed in the near future. There is no longer available enough cheap fossil fuel either to substitute for a significant portion of currently used biomass fuels or to increase total energy consumption in these countries to the point where, as in the United States, biomass fuels play an almost trivial role in the national energy picture. The level of energy consumption in the U.S. has gone so far beyond the indigenous renewable resource base that even if all the net primary productivity of biomass in the U.S. were used as fuel it could only supply 25% of current need (Burwell, 1978). Increasingly, development will be constrained by the supply of traditional biomass fuels. The goal of energy development will shift from exploitation to optimization of natural resources.

This environmental assessment has sought to examine the energy needs and resources of three rural areas of Indonesia with the goal of evaluating alternative energy development strategies in terms of their relative contribution toward natural resource and environmental stability. The result of comparing various alternatives, chief among them being rural electrification, is that no single type of project can meet all rural energy needs. This is not a new observation; the same arguement is made by Brown and Howe (1978) and Cecelski et al (1979). However, this study goes beyond this observation in its examination of specific alternatives to conclude that even the simplest energy projects such as village woodlots or enclosed stoves may have serious negative consequences unless planned according to both local needs and local resources.

A success of a project or technology in one location does not assure success in another. For example the Lorena stove, reported as very successful elsewhere (Shaller, 1979), has so far failed to catch on in Indonesia because it has been tried in very firewood-poor areas. The people find it difficult to burn corn stalks and tobacco stalks in an enclosed fire box. In such involuted firewood-poor areas an appropriate energy project activity is to improve the quality of fuels. One such way is to facilitate the use of agricultural wastes by making charcoal from them as recommended by Floor (1978), Hartoyo (1978), Hardjodarsono (1978), and others.

Whatever energy project activity is chosen, it must be developed in such a way that the full spectrum of local energy needs are recognized, evaluated, and if need be, addressed. Rural electrification, although traditionally designed primarily for domestic household lights, small

electronic appliances, and rotating machinery, can be made to serve broader energy needs, for example by increasing the production of agricultural wastes through pump irrigation, or by improving the burning quality of agricultural wastes by powering machinery to manufacture charcoal briquets. However, before such a project idea is adopted, consideration must be given to the state of energy resources in each proposed project area to be sure that the process or technology serves both to optimize and to stabilize the local base of productivity.

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