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ENERGY CONSTRAINTS IN PRODUCTION SYSTEMS IN PERI-URBAN AREAS AROUND KUMASI AND HUBLI DHARWAD

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CONTENTS

1. Background

This report presents the findings of a short study carried out between December 1998 and March 1999 to assess energy constraints in peri-urban areas in Hubli-Dharwad, India and Kumasi, Ghana.

This study was commissioned by Natural Resources International Ltd (NRIL) and Hunting Technical Services Ltd (HTS) as sub-contractors on behalf of the UK Government's Department for International Development (DFID). The study is a contribution to the Peri-urban Interface (PUI) system of the Natural Resources Systems Programme (NRSP) of DFID's Renewable Natural Resources Knowledge Strategy (RNRKS). The work was co-ordinated by Intermediate Technology Consultants (ITC) Ltd in the UK, part of the Intermediate Technology Development Group (ITDG). Field research in Ghana was carried out by the Kumasi Institute for Technology (KITE) and the Centre for the Development of People (CEDEP). Field research in India was carried out by EDA Rural Systems Ltd (Delhi) and TIDE Technocrats (Bangalore).

The research builds on baseline studies carried in by NRI in Kumasi (1996) and the Universities of Birmingham, Nottingham and Bangor in Hubli-Dharwad (1998). These two cities have been chosen by the PUI of DFID's RNRKS NRSP as case study cities which may be representative of peri-urban and natural resource issues in sub-Saharan Africa and Asia. The research programme has three purposes:

1. Management of peri-urban resources optimised through improved productivity and energy efficiency;
2. Crop production intensified on a sustainable basis;
3. Productive potential increased by greater use of "waste" materials and recycling of resources.

As such this study is only one of a number of commissioned studies in these areas, further details of which can be obtained from the PUI programme manager at HTS.

This project aimed to review energy resource availability and use by households and small scale productive enterprises in peri-urban regions, illustrated by case studies from the peri-urban areas in Kumasi and Hubli-Dharwad. A short review of literature and previous work was conducted in the UK and in-country. This was followed up by two weeks of field work in each area by a three person inter-disciplinary team from the partner institutions. Due to the limited resources available UK team members were involved in design and monitoring of field work but not in implementation.

The proposed *activities* of the project were to:

- Identify the most significant productive sub-sectors in the study areas under consideration.
- Identify the energy service requirements of households and the small scale productive enterprises identified in 1 above.
- Identify the constraints to production and income generation which arise due to access (or lack of access) to energy services in the study areas.
- Analyse the energy resource streams currently and potentially available in the peri-urban areas under study (whether utilised or otherwise).
- Identify competing uses for energy resource streams, including ranking of uses by priority by users themselves.
- Identify opportunities for access to improved energy services, including access which will provide or support income generation and livelihood opportunities.

The proposed *outputs* of the project were:

- Recommendations for energy-enterprise development and promotion activities in the two areas in the period up to 2001.
- A framework for the development of energy efficiency measures in households and small scale enterprises in the two case study areas.

- Recommendations for research into strategies for increasing security of energy service supply by diversifying the energy resource base in the two regions.
- A booklet synthesising the lessons learnt and the key recommendations, constraints and prospects for the two regions. The booklet will be cross-cutting, synthesising the lessons learned in terms of Natural Resources and Energy, and contributing to the growing debate on urbanisation.

This report details the findings from this work and divided into five main sections:

1. **Background** to this research study is given in this section
2. **Review of Issues and Existing Data** at the peri-urban interface in developing countries and affecting the contribution energy services make to sustainable livelihoods. This section explores literature and work available to the project before field work was conducted.
3. **Approach & Methodology** details the key research questions identified by the review, and the methodology developed to tackle these with the resources available.
4. **Findings & Analysis for India** presents the data which resulted from the work, together with analysis of this, in light of previous studies.
5. **Findings & Analysis for Ghana** presents the data which resulted from the work, together with analysis of this, in light of previous studies.
6. **Recommendations** distils the analysis into a summary of the project team's opinions of what represent the key energy constraints to and opportunities for improved livelihoods in Hubi-Dharwad and Kumasi and what role DFID and other partners might play in improving energy services in peri-urban areas in general.
7. **References & Sources** including literature, reports, contact details and web resources.
8. **Appendices** of questionnaires used to gather general village information, household information and industrial information.

2. Review of Issues and Existing Data

2.1 Defining the Peri-Urban Interface

DFID RNRKS defines the peri-urban interface as "characterised by strong urban influences, easy access to markets, services and other inputs, ready supplies of labour, but relative shortages of land and risks from pollution and urban growth". This describes an essentially rural area with both the advantages and disadvantages of urban influence; and an urban-rural trade-off of improved services and infrastructure but over utilised natural resources an environment.

In defining "peri-urbaness" we should be careful to avoid purely spatial or physical descriptions. Leeming and Soussan (1979) discuss the differences between the concepts of 'urban fringe' - a zone of direct impact of the physically expanding city on the surrounding rural areas - and 'hinterland' - encompassing a more market-oriented view, where the people use the city for the provision of services, trade, employment and transportation. Sumberg (1996), based on a study of peri-urban livestock in Tanzania, argues that a food systems approach (economic/agroecological) is more appropriate than the peri-urban concept based on demographic systems (urban/peri-urban/rural). In addition, baseline studies in Kumasi (NRI and UST 1997) recommend a more inclusive systems approach in order to adequately understand the influence and interaction of urban economic and social processes on the agricultural and economic production systems and livelihood activities of surrounding areas. Hence the peri-urban system is not a fixed geographical area, nor a single production system, but does, according to both studies in Kumasi (NRI and UST 1997) and Hubli-Dhawad (Birmingham et al 1998) have the following characteristics compared to more traditionally rural areas:

- **Dynamic in space and time:** the peri-urban zone is in transition from rural to urban
- **Areas within the zone are heterogeneous:** the rate of urbanisation is variable, as well as the impact and degree of urbanisation, reflecting, not least, the underlying economic, social and cultural values of the inhabitants
- **Competition for land between agricultural and non-agricultural uses:** key issues in the ownership of and access to land include the structure and conduct of land markets, and differences between regulation, tradition and tenure of agricultural and non-agricultural land
- **Competition for jobs between agricultural and non-agricultural work:** whilst the DfID definition stresses the '...ready supplies of labour..' in PU areas, and there may be more opportunities for non-agricultural employment both in the PU area and in the city, resource constraints (capital and training/education) may limit access to the non-farm labour market
- **Changing social and economic balance between indigenous and immigrant inhabitants:** the PU area is characterised by rapid population growth driven by both in-migration from rural areas and out-migration from urban areas, resulting in increased and changed demands on the natural resource base, and in changes to the community structure
- **Increasing dependence on the urban centre:** peri-urban villages show a range of increased dependence on the urban centre through employment, increased dependence on the market, and decreased self-reliance in food production and other traditional agricultural products
- **Increased provision of facilities that may speed up development:** service provision (such as electricity, piped water, schools, health care) may depend upon the ability, willingness and cohesiveness of local communities to lobby for and organise the installation of facilities. High-income outsiders may demand higher levels of services, whose provision may then drive higher rates of in-migration
- **Increased pollution and waste disposal problems:** increased populations and decreased access to land for land-intensive waste disposal methods may result in real and perceived problems of land and water contamination and

With the exception of the issue of labour availability, these characteristics generally match those of the DfID definition and were generally iterated by the Hubli-Dharwad study (Birmingham et al 1998) which further added related issues:

- **Reduced efficiency of production systems** in the PUI, where rapid change and growth may lead to the inefficient production systems, e.g. use of resources such as land, labour, capital and markets. Other effects might include the degradation of the natural resource base and pollution impacts; and,
- **Economic intensification** is focused on the PUI, which attracts a large share of capital investment and innovative economic development;

Clearly degree of active government management and regulation will have significant impacts in such a fact paced and chaotic environment. In Hubli-Dharwad where this is clearly weak further peri-urban characteristics included (Birmingham et al. 1998):

- **Planned zoning and development is weak:** planning of industry, commerce and habitation is challenged in the PUI, where land-use change is rapid and controls are weak;
- **Scarcity of information and public investment**: there is a lack of information on the status of the natural resource base, and on the production/use/waste cycle in the PUI, as well as a lack of investment in public infrastructure resulting in part from the historical trend of centralised public resources in India.
- **The degree of 'rurality' is highly variable**: the Hubli-Dharwad city-region exhibits highly rural characteristics, with large number of people involved in 'rural' activities such as farming and herding. The process of urbanisation is taking place, but within a framework of key constraints that include electricity and water services, a weakness of municipal authority and planning, and a lack of other institutions once the peri-urban village moves into the urban sphere of influence. A particular feature of India is that large companies and factories are required by government regulations to locate in rural areas remote from cities, and so their urbanising impact in the PUI are lessened.

In Kumasi the NRI and UST researchers (NRI and UST 1997) tested three approaches to defining the PUI production system in a Village Characterisation Survey carried out across 66 villages less than 44km from Kumasi city centre:

(i) Change in Agricultural Production System; they investigated significant differences in agricultural production in urban, peri-urban and rural farming systems in relation to Kumasi;
(ii) Influence of Markets, Communication and Transport systems and their impact on the surrounding areas;
(iii) Geographical Distribution around Kumasi

i) *Change in Agricultural Production System*

As the ease of access to the city increased (which may be taken to be indicative of the degree of urbanisation),

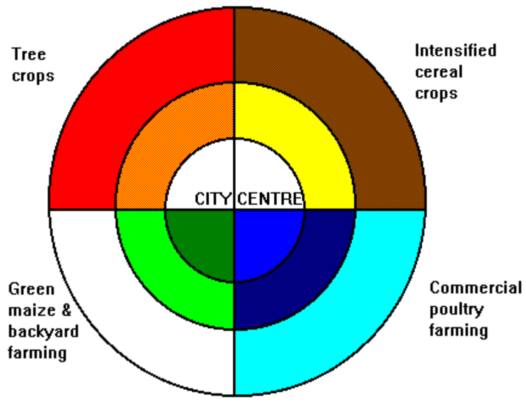
- fallow period and soil fertility decreases, perhaps resulting from an increased pressure on land resources and land access;
- overall dependency on agricultural production decreased;
- Short-term food crops (maize and other backyard farming) increased, perhaps forced by land insecurity.

In villages further from the city core an increase in 'weedicide' was reported on maize and rice crops. Whilst this seems contradictory, it may be indicative of an attempt by those farmers in the PUI with the most access to land to maintain competitive in markets by increasing production.

Whilst increase in poultry farming was greatest in those areas with intermediate access, increased use of poultry manure was seen in all villages.

Figure 2.11: Diagram representing some farming systems for which the occurrence in the peri-urban area appears to be related to distance from the city centre.

Darker shading indicates important or increasingly important, lighter or lack of shading indicates unimportant or declining in importance. Circles at approx. 10, 20 and 30 km radius from city centres.



Source: From Village Characterisation Survey, NRi and UST, 1998

Zone 1: Agricultural production was essentially 'urban farming', characterised by two main groups of in-migrants:
1) poorer households who produce for sale to supplement income, and
2) relatively wealthier households growing within house compounds both for household consumption and for sale.

Both groups grew maize or other 'snack food' crops, suggesting some level of household productive enterprise.

Zone 2 is closest to the concept of the peri-urban interface and in which competition for land access and change of land use from rural to urban is most rapid. Long term crops (oil palm and cocoa) are decreasing, whilst intensive vegetable production and commercial poultry farming are increasing. The two key farming groups are
1) rural in-migrants, typically with small plots of less than 0.5 Ha, and
2) larger households, remnants of the previous rural population, the 'rural-stayers', whose traditional bush fallow system is in decline due to land pressures, decreasing fallow periods (and presumably decreasing holding size due to sub-division).

Zone 3, the rural fringe, retains to a greater extent the traditional farm holdings of the village structure; holdings are generally of 2-3 Ha, with exception of tree crop plantations of cocoa (in decline) and oil palm (increasing). Bush-fallow continues to predominate on a cycle of 6-8 years, with some intensification, particularly cereal production, on a larger scale.

ii) *Influence of Markets, Communication and Transport systems*

A definition of the Greater Kumasi city region was attempted, based on criteria of:

- frequency of public transport from the village to the city,
- frequency of trader visits to the village/supplier, and
- supply areas of markets for particular goods and products.

Based on this survey, the researchers defined a physical outer zone around the city within which villages are served by a minimum of 5 tro-tros (eighteen-seater minibuses) making 5 trips per day, and an inner zone serviced by 10-12 tro-tros per day. In effect, the outer zone represents those villages dependent upon the city's central markets for both buying and selling perishable goods on a daily basis, and the inner zone is the commuter zone. These areas were portrayed on a map as the 'urban footprint' or 'city region' of Kumasi.

Trends in production of agricultural goods were identified as indicative of peri-urban pressures, reflecting a variety of impacts including changes in land values, access and security, access to markets and market demand.

The spatial distribution of commuting areas (and the associated transport links) are also indicative of changes in the status of natural resources in the peri-urban areas, as a measure of in-migration (both urban to peri-urban and rural to peri-urban) and a related move from a local economy centred on agriculture to a more diversified one.

iii) Geographical Distribution

A cluster analysis of economic development and population densities was carried out in order to measure the ‘urban footprint’. However, the degree of ‘urbaness’ was found not to relate directly to either:

- Communication links and roads (ribbon development) or to
- Radial distance from Kejetia market (the central market in Kumasi), except in close proximity to the city.

As an example of spatially / geographically uneven peri-urban development, Rakodi (1998) cites the example of Bangkok which underwent a process of rapid physical expansion between 1975 and 1984 whilst leaving large pockets of undeveloped land in the suburban zones due to the lack of infrastructure and services between the main transport arteries. While studies in Hubli-Dharwad (Birmingham et al 1998) draw attention to the influence of rural factors; the PUI exhibits different characteristics in areas with different soil types, as reflected in the type of agriculture practised, the value of land and the extent of urbanisation.

Clearly the PUI is determined and hence defined by many factors. Depending on the needs of our particular study we must choose our variables carefully if we are to study its affects.

2.2. Energy Needs and Options in Peri-Urban areas

In most countries, the energy needs of *urban* populations are usually met from dual systems, in which conventional (centrally planned and administered) electricity supply sources are complemented by fuel supplies which are burned for heat (Reddy, BR, 1997). In the UK, for instance, electricity use is, in the main, complemented by natural gas and in Sri Lanka, urban electricity use is complemented by the use of LPG or wood-burning stoves. Privatisation of energy supply systems worldwide has changed the ownership of conventional supply streams but, so far, the models of supply remain the same.

In contrast to this, *rural* energy needs in non-industrialised and industrialising countries are generally locally planned and administered and not subject to external models. However, such needs are also widely documented, as are the energy resources and energy management systems available to rural communities (e.g. World Bank, 1996, DFID 1999).

Peri-urban communities span both of these categories. Peri-urban energy resources are based around both rural and urban systems, and resource use is determined by access to conversion technologies (stoves, appliances etc) and energy service stream (LPG, charcoal etc).

Rural resources are often available to peri-urban producers directly, but these resources also form part of the supply chain to the commercial cash cultures of urban society. Meanwhile urban, commercial services reach out to fill the needs of a mixed population of rural and increasingly urban livelihoods and production activities. The total picture is complex and poorly documented.

Domestic Energy Demand in Peri-Urban Areas

In peri-urban areas, household energy use generally reflects that in nearby rural and urban areas. Energy services are primarily required for cooking (which demands by far the most amount of energy), water heating and lighting, with some households also using electricity (often delivered via batteries) for radio/ TV, sometimes lighting, and (rarely) refrigeration. See, for instance, ETSU and ETC (1996), Sathaye, J and Tyler, S, (1991).

The use of wood stoves for *cooking* is widespread, and this represents a steady market for fuelwood vendors, many of whom are women, supplying either urban markets or wealthier peri-urban markets. The use of stoves themselves, however, also represents a health risk, especially to women and children who work close to them on a daily basis (e.g. Scwela, D 1997, ITDG 1998). Other non-processed biomass fuel streams are also used in stoves such as crop residues, wood industry residue as well processed biomass such as dried dung cakes and charcoal.

Kerosene lamps are commonly used to meet *lighting* requirements in poor households worldwide, although use of alternative resources such as low cost solar lanterns or electricity from low cost grid connection is likely to occur in higher income households. LPG use, for cooking, is also usually restricted to higher income households. LPG stoves and bottles (the adoption cost) is prohibitive to lower income households, though if as traditional fuels become scarce and LPG infrastructure improves, the cost of the fuel itself can become competitive.

Productive Energy Demand in Peri-Urban Areas

In peri-urban areas, where many houses are diversifying their activities away from traditional rural activities (e.g. Ellis F 1999) the distinction between household income generating activities and small scale enterprises is not always clear. In general, though, we can make a distinction between household, domestic or 'reproductive' activities (as above) and productive activities. The following types of energy are required for the latter

1. Process heat, usually generated from the combustion of biomass in various forms, although LPG and kerosene may also be used. Used for food processing, kilns, and many other semi-industrial processes.
2. Motive power, generally produced by people, animals, water, wind, diesel or electric motors.
3. Electricity, more motive power as above, lighting, and a range of other appliances such as sewing machines, icemakers, etc. Supplied by batteries, generators or grid connections.

Energy sources and appliances can act as a major constraint to productivity through:

- high cost of energy source,
- poor availability or security of energy supply
- inefficiency or inappropriateness of conversion technology or process

Improving access to decentralised energy service provision is emerging as a way in which energy constraints to small scale production can be reduced. This frequently (but not always) involves energy supply systems based on renewable, locally-available energy sources. Meeting these energy service requirements can be a business opportunity in itself.

Energy Resources and Technologies in Peri-Urban Areas

Traditional Fuels

Biomass can be used in its

- natural form, such as wood, or crop residues;
- semi-processed form, such as charcoal, dung cakes, or in
- fully processed state, subject to anaerobic digestion to form biogas.

Consumption of traditional biomass fuels in marginalised peri- urban communities is growing rapidly and as a result biomass resources are being depleted, often at unsustainable rates. The time taken for their collection has increased considerably over the last three decades, and prices for these fuel streams have also increased (e.g. Mercer and Soussan 1991; Soussan, O'Keefe, Munslow 1990; RWEDP 1996). However, the use of crop and timber residues is a useful fuel stream which can, in some cases, substitute for traditional resources (Barnard and Kristoferson 1985).

Biomass wastes and by-products (such sawdust, sugar cane bagasse, cocoa pods, rice or coconut husk, etc) are already widely used as a fuel for process heat. However, competing non-energy uses must be balanced against this, particularly their use as soil improvers in high population areas which are already likely to be suffering land use pressures (BASIN 1994, Allison et al 1998). Often these fuels are last choice in a domestic situation due to high ash residue after combustion, disintegration under wet conditions, though in productive or industrial situations their use may be more acceptable.

Where combustion of traditional biomass resources is used to provide heat for cooking, improved cookstoves can achieve marked improvements in combustion efficiency, resulting in lower levels of biomass use, and improved kitchen environment. (Sarin 1991, Ravindranath 1997)

Biomass (particularly wet crop residue or animal residue) can also be converted into energy via the production of biogas (Gabra and Pitea 1996). Biogas production can, however, impact negatively on soil fertility in areas where such residues are incorporated into agricultural land as fertiliser. In some cases it can have a net positive effect, as biogas slurry can also be used as a fertiliser.

Box 2.21: Charcoal as a Modern and Traditional Fuel
Charcoal is important as a fuel which competes with both modern and traditional fuels. Its price is interrelated with fuelwood as both fuels depend on the availability of wood in the surrounding area. If it is competitively priced compared to fuelwood then people may switch back and forth depending on price. As a transitional fuel its properties compare well with kerosene, both in energy efficiency and convenience. As a modern fuel it is still used alongside LPG and electricity, either for specialised cooking and grilling or as a second cook source for boiling rice an LPG or electric ring. (Sathaye and Tyler 1991)

Commercial Fuels

Kerosene, diesel and LPG are widely available in urban areas in Ghana and India. However, these fuel sources are expensive, and the poorer sections of peri-urban communities have limited access to them. Subsidy structures have been used in several countries to promote their use, with varying success.

Electricity

Though low level use of grid electricity for lighting is affordable by even low income households, access to electricity is restricted by organisational factors (e.g. requirements for legally registered addresses, building standards, weakness of grid supply systems) and by conventional cost recovery techniques (such as high connection charges and metering practices).

Box 2.22: Electricity Access and its Affect on Fuel Choice in the PUI
Access to electricity is affected - more than other fuels - by government policy. How does access to electricity affect the choice of other fuels? Electric light provides a much higher quality of lighting for less money than kerosene. The primary cause of low penetration of electricity is limited access to service either by not extending the service or by charging high initial fees to discourage connection. As

suggested above, if access is available then even the lowest income households will choose to use it, although often at low levels which are limited by income. Strangely, but importantly, ESMAP studies have shown that availability of electricity is correlated with modern fuel switching. This is possibly because it encourages modernity or acts as a proxy for modern fuel market development. (Barnes et al 1998)

Security and availability of fuel supplies may be of greater importance than their cost in PUI areas due to the poor development of market systems for traded fuels. Traditional biomass fuel distribution systems - whether commercial or non-commercial - tend to be more stable, effective and highly integrated than those for modern commercial energies (ETSU and ETC 1996). This, combined with the increasing incomes of some households, is likely to lead to multiple fuel use; through choice in the case of the richer, and as a risk minimisation strategy in the case of the poorest.

2.3 Energy Development and the Peri-urban Interface

Levels of income, economic development and degradation of the natural resource base vary greatly in the PUI which is in essence a patchwork of rural settlements at varying stages of urbanisation. These variations have significant implications on both access to energy markets, and choice of energy supply (ETSU and ETC 1996). Urban and peri-urban areas exhibit a range of energy use patterns in which traditional fuel use is mixed with a range of energy sources higher up the energy ladder. As cities grow, or as households come under more urban influence, traditional biomass fuels are substituted by a succession of more modern fuels, such as kerosene, LPG and electricity. Barnes *et al* (1988) describe this as the urban energy transition and propose, for domestic energy consumption at least, a three stage model:

Stage One, typified by underdeveloped markets and preponderant use of ***wood*** as the energy of sources. Wood is abundantly available nearby and / or low in price; modern fuels are scarce and / or expensive and incomes are low. Often agricultural intensification and initial clearing of bush can meet the rising demand for wood by the influx of migrants bringing with them mainly wood-based rural cooking habits. For a while, at least, wood prices remain low and there is little incentive to switch to alternative fuels. Even at this stage though, higher-income households will switch to more convenient, less smoky fuels such as kerosene, charcoal or LPG, if they are available.

Stage Two, marked by local deforestation, decreasing availability of wood and the emergence of modern fuel markets for ***charcoal and kerosene***. The combination of decreasing supplies of wood fuels and increasing demand will cause the price of woodfuels to rise dramatically and lead to the ascendancy of substitute fuels such as charcoal and kerosene. Charcoal is a likely substitute as it is light and transport costs of hauling it into a city are lower than for wood. Kerosene will become a fuel of choice because it can be distributed commercially, in small quantities, without much government investment in a distribution system and without substantive investment by households in new cooking equipment. Stage Two can be further sub-divided:

> High Charcoal Use Either with charcoal prices that are below their economics costs, or near their economic costs and accompanies by taxes on kerosene and LPG
> High Coal and Kerosene Use Prices for these fuels are highly subsidised and have virtually eliminated wood or charcoal use
> Multiple Fuel Use Generally market oriented pricing policies with only modest fuel subsidies or taxes.

Stage Three, characterised by developed markets, increasing incomes and large scale switching to ***LPG or electricity***. Wood energy prices are competitive with the price of alternative modern fuels. Governments and households are able to make investment necessary for distribution systems and appliances, respectively. Stage Three fuels are the cleanest, safest, most efficient and convenient fuels. They also reduce pressure on the local, if not more distant, environment. Hence the combination of advantages on environment, production, health and well-being makes these the fuels of choice for economic, social and environmental development - in most cases.

Understanding the basis for urban energy transition is fundamental to understanding patterns of energy use in peri-urban areas, themselves in various stages of transition and urbanisation. Barnes et al (1998) describe several socio-economic factors which affect the degree of energy urbanisation:

- **Income** is one of the strongest influences on urban household energy use in developing countries though discerning ‘cut points’ at which people will switch fuels is notoriously inaccurate. Rising but inequitably distributed income will lead to some classes making a rapid transition while the majority remain dependent on stage one or two fuels. Stagnating incomes slow the transition and force people to use wood or charcoal, perhaps beyond the point at which the environment around can sustain supply. It is important to note that although income is strongly related to the type of energy chosen, and to expenditure on fuels, it is not related to total quantity of energy used.
- **Exposure to and availability modern / commercial fuels**, particularly influential in stage one when even high income households can afford but do not have access to modern fuels. Political decisions – such as foreign exchange based decisions or subsidy - are likely to influence the availability of fuels such as LPG, kerosene and electricity more than market factors. In Malawi, for instance, poor areas would not receive connection because the electricity company insists on up-front connection costs. In India the limited kerosene import is restricted to ration shops and ration card holders which effectively limits its use to lighting but not cooking.
- **Rural migration and population growth** in urban centres are around will quickly lead to increase in total peri-urban demand for fuelwood and speed the transition to stage two fuels. Unless the government in prepared to facilitate this transition demand will quickly outstrip capacity of local oil and power companies and broad scale shortages will result.
- **Availability of biomass** will depend on patterns of land use, rainfall and many other factors. It is important to examine the volume of biomass stock, the rate of regrowth and the costs of harvesting. According to econometric studies carried out by the ESMAP of the World Bank (see Barnes et al 1998 for review) if wood is relatively abundant around cities it will be used by people in all incomes classes, simply because it is familiar and available (see also ETSU and ETC 1996). Thus wood and charcoal will be used extensively, until the very highest stages of the transition, simply because the wood is available but because it is available in places and quantities which fit into the lives of the PU poor. In these cases of biomass availability charcoal often remains a transition fuel for longer and competes well with kerosene.

While income remains a crucial factor in fuel choice, availability may outweigh it in the following cases:

	More Rural	**More Urban**
Biomass / Woodfuel	Cheap or abundantly / freely available	Scarce due to depletion in a large radius around city
Modern / Commercial fuels	Unavailable or expensive if not close enough to main line of communications to attract suppliers	Available through well established distribution networks

Both the degree of deforestation and the availability of modern fuel options can be influenced strongly by government policy and legislation, which will in turn guide the energy transition in urban and peri-urban areas (Barnes et al 1998).

Influencing Fuelwood Supply and Demand - Policy Approaches

The so-called 'fuelwood crisis' of the last three decades (e.g. Eckholm et al 1984, Lamba, D, 1990) has been approached by donors and governments as an energy supply and demand problem. Two key policy approaches have been taken. To

1. improve supply, foresters have tried to increase fuelwood supplies with peri-urban plantations and community woodlots and to protect public forests and woodlands from encroachment while
2. reduce demand, ministers have tried to promote fuel-efficient stoves and charcoal kilns and substitution of modern fuels to reduce fuelwood demand.

Most of these efforts have failed and the subsequent rethinking now sees fuelwood problems as manifestations of more fundamental problems in rural land, labour, capital markets and urban energy markets, and the failure of governments to establish the fundamental conditions that would allow efficient and sustainable allocation of land and resources between forest and cropland - wood and energy (Mercer and Soussan 1991, Mearns and Leach 1989).

Improving the efficiency of charcoal production, for instance, may actually increase rather decrease the deforestation rates by expanding the areas accessible to urban markets. As such, considerable care is needed in designing appropriate policy interventions.

Influencing Fuelwood Substitution - Policy Approaches

The transition from traditional fuels to modern fuels is influenced by many factors but seems to be driven by three, each of which has implications for policy (Barnes et al 1998)

- Income Level
- Fuel Prices
- Access

Income levels have been discussed briefly above and are important to consider in designing policies.

Energy prices and pricing policies (though taxation and subsidy) in developing countries are a crucial influence on the fuels that urban and peri-urban consumers will use. If kerosene is taxed then transition away from wood will be delayed with widespread deforestation. Those with higher incomes may switch to electricity and kerosene more quickly than otherwise. If kerosene is subsidised then transition will occur, but only fully once the environmental externalities and increased transport costs of unsustainable wood harvesting make wood uncompetitive. The low price is likely to act as a cap to woodfuel prices, though rarely as a base.

Access to a fuel is determined fundamentally by two related factors: the basic supply of a fuel in a local market (i.e. the cost of consumption) and the up-front costs of adopting the fuel. While LPG is a fairly cheap fuel to consumers, the cost of adoption (bottle, stove) act as a barrier. Electricity, on the other hand, may be cheap to adopt if connection and meter are provided for free, but consumption beyond basic lighting requirements will be constrained by the cost of appliances (AC, fridges) and their higher running costs. Up-front capital costs for some modern fuels represents a crucial factor in the pace of the energy transition.

2.4 Energy Issues in the Hubli-Dharwad PUI

The Hubli-Dharwad Municipal Corporation (HDMC) includes the twin cities of Dharwad (administrative centre) and Hubli (trade and commerce centre). It is held to be representative of medium-sized cities in South-Asia whose growth is severely constrained by power and water shortages (Birmingham et al 1998). Hubli-Dharwad is the third largest urban agglomeration in Karnataka state and the 26th largest in the country. HDMC has a population of 648,298 (1991 census) and the population density is currently around 3395.3 people/sq.km. The Hubli-Dharwad city region (covering all the villages connected to

Hubli and Dharwad by city bus services) includes five talukas (sub-districts) - Dharwad, Hubli, Navalgund, Kalghatgi and Kundgol. The total population of the city region is 1,428,174.

Initial natural resources survey work was carried out by Birmingham et al (1998a) in 25 villages with sector studies of farming, energy, waste, socio-economic institutional and land use change. Observations included:

- significant landlessness, rapidly changing labour markets with implications for agriculture,
- poorly functioning product markets for peri-urban farmers
- interactions and synergies between systems and issues e.g. the availability of waste materials and their utilisation for either energy production or soil fertility augmentation.
- production of high-value perishable agro-products such as vegetables, milk and fruit, with concurrent marketing and labour cost implications
- water and electricity shortages have constrained industrial and urban development

Household Energy

A few studies have been undertaken to estimate the energy consumption and future energy demand in Hubli-Dharwad city region. The majority of these studies focus on the domestic sector in which energy is primarily consumed for cooking, water heating and lighting purposes. Table 2.41 presents the per capita energy consumption in Dharwad district based on a survey conducted in 50 villages of Dharwad District by Karnataka State Council for Science and Technology (KSCST and IIS 1994).

Table 2.41: Annual Per Capita Fuel Consumption in Hubli-Dharwad (in 1991)

Fuel type	Units	Cooking	Water heating	Lighting
Firewood	Kgs	370.2	25.2	-
Crop residue	Kgs	186.6	21.6	-
Dung cakes	Kgs	76.5	11.5	-
Kerosene	Ltrs	0.57	0.07	6.2
Electricity	KWh			32.0

As shown in the above table, mainly biomass based fuels are used for cooking and water heating with crops residues a significant fuel. Interestingly total charcoal consumption in the domestic sector was almost insignificant. For lighting, the two main energy sources are kerosene and electricity. These finding are supported by baseline research for the DFID PUI Production System Programme (Birmingham et al 1998) and work in other parts of India (e.g. Turare, C, 1998).

Surveys of monthly per capita energy expenditure were carried out by the Government of Karnataka between 1993 and 1999 (TEDDY, 1998-99) examined household energy consumption across the state of Karnataka. We see a clear progression up the energy ladder in urban areas compared to rural areas (Table 2.42):

Table 2.42: Monthly Per Capita Fuel Consumption in Households (1993-94) in Karnataka

Fuel	Units	Rural	Urban
Firewood & chips	Kg	23.62	9.51
Kerosene	Litre	0.70	1.79
LPG	Kg	0.04	0.68
Electricity	KWh	2.62	10.54

Ramachandra and Shastri (1996) estimate that 70-80% of the biomass sources cater for the domestic cooking and water heating needs of the rural population. As such several studies have been carried out into the efficiency of the various improved stoves on the market (e.g. Ravindrath 1997).

Small Scale Enterprises Sector

There is limited published information available on energy consumption for the medium and small scale enterprises sector. In Karnataka as a whole the following table estimates industry (all sizes) and urban domestic usage of firewood (Subramanian and Ramachandra 1996). It is interesting to note the substantial consumption for cremation. Also, note that total urban domestic consumption is 3.6 times higher than total state industrial consumption (Table 2.43):

Table 2.43: Industrial vs Urban firewood consumption in Karnataka State

Industry	**Estimate firewood consumption (000s tonnes/year)**
Tobacco curing	124
Tile manufacture	100
Manganese and iron ore	20
Tea curing	9
Polyfibres	66
Sandal oil factory	5
Rubber	1
Paper Mills	69
Cremation	500
Urban domestic needs	3352

Subramanian and Ramachandra (1996) go on to make recommendations for energy savings in:

- wood burning stoves
- construction of buildings
- tobacco curing
- water lifting
- sugar industry
- jaggery making

Industries using motive power from electricity include mainly flour mills running off 10HP motors and some rice mills, cotton gins and oil mills (KSCST and IIS 1994). Flour mills, oil mills and brick kilns and mentioned by Suresh et al (1994).

Analysis of 1992 census data by the Indo-Dutch Project Management Society (Vyasulu 1997) into the economy of Dharwad notes that more ‘small industry’ is located in rural areas than the state average (49% compared to 38%). Food products and food processing, followed by metals, contribute most employment.

Lighting and Electricity

In 1981 electricity was available to almost 90% of villages with a population of over 500 in the Dharwad district (Suresh et al 1994) though no data of percentage of connected households within each village was given. Table 2.42 shows that rural domestic electricity consumption was four time that of urban areas while data shown by Subramanian and Ramachandra (1996) shows a factor of six difference.

Electricity consumption in Karnataka dates back to 1900 when the first hydroelectric plant was built in Shivasamudram (Subramanian D K & Ramachandra T V, 1996). In 1992, the total installed capacity in Karnataka was 2,969 MW, which is 4.5% of the total installed capacity of India. The total electricity generated in 1992 was 12,500 GWh/year providing a load factor of approx. 50%. In Karnataka, industrial sector is the largest consumer of energy (with nearly 70% of energy being consumed by them) followed by All Electrical Homes (% of such homes not available).

Hubli-Dharwad is a net consumer of electricity with no generation capacity in the District. The electricity requirement is met through imports from Maharashtra and some neighbouring districts. The region faces electricity shortage especially in the rural areas with average load shedding being 6-10 hours per day.

Forests and Natural Resource Base

A shown above the majority of the energy consumption needs for cooking and water heating are met by biomass based fuels that are derived from natural resources. Karnataka State has a geographical area of 19,000,000 ha, of which approximately 20% is under the control of Forest Department and only about 11% is well wooded. The remaining area is at different stages of degradation (Karnataka Forest Department, 1998). The demand for forest products, such as, fuelwood, fodder, timber, minor forest produces, etc. has increased considerably over the years leading to increased pressure on limited forest resources. In Hubli-Dharwad significant forest land is observed in south and west regions of Hubli-Dharwad, which are greener and are part of the hilly terrain. Forest land shows marginal increase in some villages (Birmingham et al 1998), perhaps due to government replanting schemes.

The Annual Plan of the Government of Karnataka (for the year 1997-98) focuses on development programmes to meet the requirements of forest produce both in the rural and urban areas through development of degraded forest areas, wastelands and conservation and protection of existing forest resources. Schemes which affect Hubli-Dharwad include:

1. Fuel and Fodder Scheme, to promote plantations of fuel and fodder trees in forest areas
2. Development of Degraded Forests
3. Greening of Urban Areas, through tree planting
4. Roadside Plantation Scheme, to provide shade for travellers and fuel and fodder for locals
5. Raising of Seedlings for Public Distribution, mainly species for construction purposes
6. Soil Conservation in Dharwad and Raichur districts through afforestation
7. Employment based scheme for village plantations
8. Drought Prone Area Programme, though afforestation and fodder production
9. Integrated Development of Western Ghats Forest belt.

Energy Policy - future plans

Beyond the biomass policies above the state government plans to promote decentralised sources of energy to improve the overall energy situation in the state. Some of the steps proposed in the Integrated Rural Energy Plan for Dharwad, which focuses keenly on renewable energies, include (Suresh et al 1994):

- National project on biogas development: installation of 14,500 (200 in Dharwad) plants in 1998-99 (Source: State Govt. Order - 577/97 and see TIDE, 1998)
- National Programme on improved chulha for 1998-99: distribute chulhas to 40,000 (1,200 in Dharwad) families through Gram Panchayat;
- Solar cookers
- Solar photovoltaic street lights
- Windmills

Other studies on neighbouring state energy policy (Alam et al 1998) have concluded that the key policy intervention to date – fuel subsidies – remain inequitable where poor do not have as good access to subsidies as the rich. In addition the:

- Public Distribution System of kerosene through ration cards targets mainly the wealthy, middle class families.

- Electricity supply is under increasing strain
- Accessibility of LPG and kerosene should be enhanced
- Price of electricity should be raised so that its supply becomes financially viable
- Fuelwood trade is based on market principles and should not be changed
- LPG is the fuel of choice for cooking and steps should be taken to reduce cost of adoption.

2.5 Energy Issues in the Kumasi PUI

Kumasi is in the Ashanti Region of Ghana and is rich in natural resources. However, inappropriate and uncontrolled exploitation of these resources have lead to depletion of water and forest resources, land and soil degradation, increased runoffs and erosion and pollution of downstream water sources. Other environmental problems include poor waste management due to improper disposal of household refuse, industrial effluence etc. and air and noise pollution especially in district capitals.

The population of Kumasi was 260,286 in 1970 and 376,246 in 1984 [Ghana Population Census Reports]. Its population today (1999 estimate) is a little over 1,000,000. Kumasi has a large population of immigrants due to its strategic location and economic activities. The rapid urbanisation in this city caused by migration, population growths and developments has tended to convert much agricultural land into settlement areas (Nsiah-Gyabaah 1998, Kasanga 1998). Lands in many peri-urban areas have been approved for planning scheme/layout marks.

Baseline work in Kumasi (NRI, 1995) highlighted the following characterises the Kumasi PU area.

- Vegetable production primarily takes place on small sites, typically less than I Ha, with little or no mechanisation.
- Land constraints limit fallow periods and crop rotation.
- Three types of cultivation: home or compound gardening, market gardening and truck gardening (the trucking-in of agricultural produce from PU areas.
- Farms located in and around urban centres are normally near waterways or river valleys.
- Poultry are the most important livestock sector, and is significant in the PU areas.
- Manure handling is a problem, as cropping sites may not be near the poultry farms; alternative uses (biogas production and odourless drying to produce fertiliser) need further research.

The following tables summarises other peri-urban characteristics for the area (after NRI an UST 1997):

Table 2.51: Comparison of Rural, Peri-Urban and Urban Characteristics of Kumasi Districts

Factor	***Urban***	***Peri-Urban***	***Rural***
Land Usage	Mainly residential		Mainly farming
Factories	Most	Some	Few
Sand-winning	Few	Many	Some
Land Ownership	Mainly non-stool owned.	Mainly stool-owned	Mainly stool-owned
Schools (Primary and Secondary)	Adequate	Fairly adequate	Inadequate
Electricity	Almost all houses	Many	Very few
Piped water	Many houses	Few	Very few
Refuse and night soil collection	Few	Very few	Very few
Farming	Youth mainly non-farmers	Many are full time or part time	Most are farmers
Corn mill	Common	Common	Uncommon
Fallow period	None	Normally 2-3 yrs.	Normally 4-5 yrs.
Price of plot	Very high	High	Low

Expensive room rents in Kumasi is forcing both migrants and ex-indigenous people into peri-urban areas thereby increasing the population in these areas. Adult women are more involved in farming than men or the youth. For most of the young people with no capital or training to start their own businesses the only option is casual work in some of the firms, masonry, and other minor employment around and in nearby Kumasi (Kasanga, 1999).

Energy Consumption

Statistics on energy consumption in Ghana show that woodfuels provide about 70% of the nation's energy needs from crude end-use devices (Energy Information Centre – Ministry of Mines and Energy, 1995). Wood fuel is used mainly for cooking which is the most energy intensive activity. The domestic fuel sources in typical sub-urban and rural communities differ significantly as shown in Table 2.52 below (Nsiah-Gyabaah and Sarfo-Mensah, 1994) though woodfuels still constitute a major fuel source even in urban communities:

Table 2.52: Domestic fuel Sources in Urban and Rural areas of Ghana:

Source	Urban %	Rural %
Firewood	22	51
Charcoal	33	13
Agriculture Residue	4	9
Electricity	16	0
Gas	0.2	0
Kerosene	25	27

Table 2.53 below shows a general description of energy forms and uses in typical rural and sub-urban areas (Nsiah-Gyabaah and Sarfo-Mensah, 1994). Currently, the promotion of cottage industries has led to the diffusion of quite a number of low-tech activities in some peri-urban to rural areas. These cottage industries normally require motive power.

Table 2.53: Energy Resource Streams in Rural and Sub-Urban Areas

Source	Resource Base	Production/ Extraction Process	End Use Rural	Sub-Urban
Firewood	Local	Cutting & transporting	Cooking, brewing	Cooking etc.
Charcoal	Local	Conversion & transporting	Cooking, heating, industry (blacksmith)	Cooking, heating, etc.
Electricity	National Grid			Lighting, local industry, cooking, ironing, refrigeration, etc.
Batteries	Urban Industries	Transportation	Lighting, entertainment	Lighting
Fossil Fuels (Kerosene, diesel, etc)	Local/ Urban	Importation/refining and transportation	Transportation, agriculture, entertainment, industry, lighting	Transportation, agriculture, industrial, commercial
Solar energy	Local		Crop drying	Crop drying
Wind	Local		Winnowing	Winnowing

Table 2.54: Utilisation of Common Domestic Appliances

Appliance	Urban %	Rural %
Open fire (mud stove)	23	38
Electric Stove	1	0
Iron (Electric and wood-fired)	15	10
Refrigerator	5	1
Radio	15	6
TV	3	1
Kerosene lantern	23	33
Coal pot (Charcoal)	14	11
Water heater (1000W)	1.9	0

End-use devices commonly used in rural and urban areas are shown in Table 2.54. Improvements or even replacements of crude or inefficient devices such as mud stoves or kerosene lanterns could go a long way towards providing high quality services from available resources.

Biomass Supply

Surveys by Nketiah et al (1988) found that charcoal was used by more than 90% of Kumasi households while firewood was sued by just over 10% and other fuels (electricity, gas, kerosene) by less than 2%. Comparing these figures to results in Table 2.53 we should note that this data is for urban households.

Charcoal supply is generally satisfactory with well established supply networks coming mainly from transition savannah areas such as Kintmpo and Nkoranza and dominated by the Sissala people. Farmers in the transition zone complain they have little control over charcoal burners entering their farms and cutting trees (NRI and UST 1997). Although there is a system of permits issues by chiefs and district assemblies these are seen more as a means of raising revenue than managing natural resources. There is second grade of softer charcoal produced from sawmill off-cuts, used by poorer people and traders producing prepared food. This level of charcoal production is also dominated by the Sissala. However, the government is trying to encourage reduced and more efficient timber consumption by the sawmill industry which may affect the availability of off-cuts.

Firewood tends to be used most by larger households, situated at the edge of urban areas and have access to more woody areas, and possibly because larger households may be poorer and unable to afford charcoal. More recent research (Amanor 1995) suggested that firewood is becoming scare in villages close to Kumasi and that villagers are travelling to neighbouring villages to purchase. Notes by NRI and UST (1997) quote that 9%-37% of farmers felt they were unable to meet all fuelwood requirements from their own farms. 11-58% claimed they spent more time looking for wood than in the past, between 1 and 21% purchased fuelwood and that there was an active market in fuelwood run mainly by children and a few women.

Biogas Energy and Energy from Waste

Studies of waste available in Kumasi have been carried out by UST Faculty of Agriculture and are summarised in Table 4.56 below (Famiyeh 1997). Large quantities of nightsoil, household and other organic refuse are available with good potential for biogas generation. There has been some experimental work though biogas has not taken off and may not while initial costs are high and there are competing uses of these waste products (i.e. for animal feed, soil improvers).

Table 4.56: Measures of Wastes Generated in Kumasi

Soil improvement resources	Quantities available in the Kumasi Peri-urban area		Present use
		Annually	

Municipal waste	400t-670t/day	124,800t-209,040t	Rubber slippers, bottles and scrap metal are retrieved
• Domestic waste	425t-590t/day	132,600t-184,080t	
• Market waste	50t-80t/day	15,600t-24,960t	
Nightsoil and sewage sludge	250-350m^3/day	78,000-109,200 m^3	
Livestock manure			
• Poultry manure		34,114 tonnes	67% used for farming, mainly on vegetables. Small amount used for fishing
• Other livestock manure (1996)	6,500 cattle 73,942 sheep 55,482 goats 5,706 pigs	9,445t DM manure 41,592t DM manure 12,483t DM manure 11,683t DM manure	Applied to home gardens
Sawdust (1997)		2,781t-9,270t or 14,016 m^3-46,718 m^3	Estimated that 14% used by sawmills to fuel kilns and 10,000t * used per year by charcoal burners
Agroindustrial wastes			
• Slaughterhouse	On average 200 cattle, 300 sheep and goats and 4 pigs slaughtered per day	Quantities of waste unknown	Manure and blood disposed of through sewage system. Offal sold for consumption. Hooves and horns sold to glue makers
• Brewery waste		5,850t spent grain 29t spent yeast Unknown quantity of sludge	67% used as livestock feed 3% given to farmers Disposed of in drainage systems
• Oil palm waste			Palm kernel, fibre and bunches – fuel Oil and bunches ash - soap Sludge – livestock feed, fuel or soap
• Cassava peel		89,361t – 178,722t	Livestock feed
• Cocoa waste			Most cocoa goes to Takoradi and Tema for export – so the assumption is that substandard beans are largely available outside the region

The abundance of timber in the Ashanti Region has attracted lots of timber processing firms in and around Kumasi. There is a recommended annual allowable cut (AAC) of timber from Ghanaian forests for both export and domestic consumption, which is about 1.0 x 10^6 m^3. This figure does not includes the vast amount of wood left in the forest as branches, stump, defective log and fallen parts of standing trees. Forest Products Inspection Bureau, FPIB permit in 1993 shows that out of 805,665m^3 of log equivalent processed, 517,845m^3 went to waste representing some 51.8% of the annual allowable cut. In 1988, an estimated 342,000 tonnes of residue was released from the concentration of wood - processing firms in Ghana (Odame 1991). Over a million (1,000,000) tonnes of residue was left to rot in the forest. The residue produced from wood processing activities is capable of producing about 85MW of electricity (Odame 1991).

Electricity Supply

The Volta River Authority (VRA) is responsible for generation and high-voltage transmission throughout the country; one of VRA's subsidiaries - the Northern Electricity Department (NED) - is responsible for distribution in northern regions of Ghana. The VRA is also in charge of the country's main power stations including two hydropower stations on the Volta River at Akosombo and Kpong with total capacity of 1072MW which supply over 90% of the nation's electricity (Brew-Hammond 1996). The Electricity Corporation of Ghana (ECG) was responsible for distribution throughout the country until the establishment of NED in 1987; ECG is now in charge of distribution in the southern part of Ghana where the bulk of the population lives. VRA used to be the leading electricity exporter in the West African sub-region until recently. At present, VRA imports electricity from Côte d'Ivoire. In 1998, the electric power sub-sector of the Ghanaian economy suffered severe shortages, mainly due to over-dependence on hydropower and a drop of the Volta River below minimum dam operating conditions. Currently, diversification of the sources for electricity generation in Ghana is being addressed through thermal complementation using petroleum-based fuels. In 1997, the VRA commissioned a 220 MW combined cycle plant that uses light crude oil at Aboadze, near Takoradi. This power plant is to be expanded in phases, first to 330 MW by 1999 then ultimately to the planned 660 MW. In addition, the Ministry of Mines and Energy is deploying mobile Thermal Power Generation units in various parts of the country to meet growing demands. The Ministry has power purchasing agreements with Agrecko, a British Power Generating Company for the provision of 30 MW capacity, with Farore Atlantic, another British Company based in Aberdeenshire, Scotland, for the provision of 70 MW capacity and with Africore Resources of Arlington, USA to provide generating capacity for 100 MW of power. Furthermore, it is also expected that by the year 2000, GNPC's Western Power Plant of 130 MW capacity and KMR of USA's 200 MW plants would be in place, all to be fuelled either by imported liquid petroleum fuels or by natural gas (both locally produced and imported).

Electricity Cost and Availability

The Government is determined to extend grid services to every district capital by the year 2000 and total national connectivity by 2020. At the moment 5% is consumed by rural areas. At a demand growth of 13%, electricity requirements will be 2382MW by the year 2011. This means that an additional 1400MW will be needed. Generation, transmission and distribution problems give rise to power outages, which can persist for days. On the average, outages are about 12 hours per week.

Electricity rates are regulated at bulk supply and retail levels. The bulk supply tariff is the price at which VRA sells power to ECG, NED and large consumers (such as the mines and a few large manufacturing concerns). The utilities submit their tariff adjustment requests for governmental approval as and when necessary, usually on an annual basis. Tariff studies are conducted by international consultants from time to time to provide guidance to both the Government and the donor agencies, particularly the World Bank. Price regulation is also cost-based with an 8 % rate of return on net fixed assets required of ECG (by the Ghana Government) and 7.3 % on average equity employed for VRA (by the World Bank)

Energy Planning and Policy

Energy service is amongst the top agenda in Kumasi Management Assembly's (KMA) 1996-2000 development plan (Development Plan for Kumasi Metropolitan Area, 1996). "Its supply and use should also be in a manner that does not compromise environmental quality or future supplies. Thus its supply must be on a sustainable basis. Efficiency of supply is also important to ensure that costs are minimal. This will make for its affordability" (KMA, 1996). Improvement and extension of electricity service is prominent in KMA's agenda though the KMA plan does not address demand-side management of resources. It proposes the installation of co-generation plants in sawmills to generate electricity from wood residue to augment electricity supply. Financial and technical constraints are likely to retard satisfactory realisation of this. Plans for woodfuel supply and utilisation include the establishment of woodlots (fuelwood plantations) in peri-urban and suburban areas and manufacture, promotion of sawdust stoves and installation of briquette manufacturing plant at large sawmills with log-input capacity of more than 40,000m^3. Expansion of LPG utilisation is also a key element in KMA's vision,

Policies on petroleum products are made on national levels. There is concern over the significant foreign exchange spent on petroleum. World Bank sponsored energy plans for Ghana have recommended (see Technology Transfer Centre 1992):

- Improved cook stoves
- Improving industry and transport sector efficiencies
- Electricity system rehabilitation
- Rehabilitation of the petroleum sub-sector
- Enhancing productive potential of the forestry sub-sector
- More economic pricing policies

3. Approach and Methodology

3.1 Sampling and Informants

Six villages were chosen from those sampled in the baseline work by the DFID NRSP. These were purposefully selected against the following factors, in order to give a range of peri-urban type.

- Accessibility (distance from market, urban centre, road, grid etc)
- Economic development (i.e. number of industries, general socio-economic status) AND / OR Intensity of cropping system
- Availability of existing natural resource base (i.e. forest, scrub resources for firewood)

The following was also ensures:

- Geographic spread and spread in distance from urban centre.
- That at least one key small industry (identified in pilot survey) is included so that this can be studied at the same time.

Details of the villages are given in the results sections (India 4 and Ghana 5).

In each village the following discussions / interview were attempted:

General:
1x General Village level group discussion
1x Focus group with women

Domestic:
10x Household interviews

Industry:
2-3x key informant interviews with 1-2 key small industries.

5-6 Key small industries, identified in the pilot survey, surveyed during the course of the village studies.

Supply Side / Market System:
4x Interviews with supply side (vendors / industries / agriculture)

Key informant interviews with energy producing industries (agro / industrial waste), or energy vendors (fuelwood sellers) AND / OR non-biomass energies which offered good potential to substitute biomass use (e.g. LPG) were also attempted.

3.2 Key Questions and Questionnaires

From the literature review a checklist of key research areas and questions was assembled as below. From this questionnaires were assembled, as attached in appendix A.

Table 3.2: Key questions

1.	**Definition of Peri-Urban Areas: key characterisations**
2.	**Poverty and Gender Issues**
2.1	Definitions, in relation to PU areas; grades of poverty
2.2	Gender impacts of resource options
2.3	Livelihood strategies; impacts on marginalised groups

3 Energy Resources in PU Production Systems

3.1 Biomass

Sources: Wood; Crop residues; Sawmill residues (offcuts, sawdust); Animal waste/dung; Charcoal; Human wastes; Organic materials i.e. food wastes

Technologies: Briquetting; Chipping etc.; Improved conversion technologies e.g. cook stoves

3.2 Biogas

Sources: Crop residues; Charcoal; Animal wastes; Human wastes

Technology: Access; Knowledge; Appropriateness

3.3 Conventional Fuels: Kerosene; Diesel; LPG substitution

3.4 Electricity

Grid: Price constraints; Access; Low-cost grid connection options

Renewable: PV

4.5 Other renewables: Solar heating (direct, water, thermal storage)

4 Demand and Utilisation: Energy Use in PU Production Systems

4.1 Household Energy Use in PU Areas: Household-based enterprises
- Lighting
- Efficiency
- Stove design/choice
- Fuel choice/access/availability
- Conversion methods

4.2 Energy Use by PU SMEs: Key productive enterprises
- Energy Requirements: process heat, motive power, electrical
- Indicators of constrained productive capacity

4.3 Available Energy Provision: Resources
- Services: sustainability in PU production systems
- Formal Sector - Institutional issues - State vs. private provision
- Informal sector - small scale energy production/sale - fuelwood collection and sale

4.4 Fuel Transport Issues

4.5 Energy Used in Transport

5 Competitive Uses

5.1 Alternative use/valuation

5.2 Socio-economic impacts of biomass diversion

5.3 NR productive impacts of biomass diversion

5.4 Risk/Choice options; key constraints

5.5 Technology choice and options

3.2.1. Energy Needs Assessment

It is important to point out at this stage that it is extremely difficult to estimate energy service requirements in terms of absolute numbers of Joules of heat or Candelas of light required. Short of rigorous testing of every *chulla* and lamp, every piece of firewood or litre of kerosene, this is not achievable. The surveys, therefore, use an assessment of fuel inputs required to give an indication of energy service requirements.

3.2 Timing and Workplan

Stage One: Baseline Exploration (carried out with initial literature review, 5 days in total, December 1998).

- **Exploration of Production Systems and Energy Streams**
- **Identification of Target Populations**.

Proposed survey methods and focus were re-evaluated, with input from all team members in the three countries, in light of experience from the baseline exploration. This was be followed by:

Stage Two: In-depth analysis (taking around 10- 15 days, January / February 1999)

The analysis was structured by target populations (gender, wealth) sector (production system, energy supply or consumer group) and by locality, using methodologies such as diagramming and discussion - with groups and/or individually. The following were explored:

- **Energy service requirements** with households, artisans and businesses in each of the key localities.
- **Competition and Availability of Current Energy Resource Streams.** (use of priority ranking)
- **Constraints on Production / Income Generation** (use of problem ranking)
- **Analysis of Future Scenarios in Production Systems and Energy Streams:** for improved access or efficiency; including potential dangers and benefits of each.

Stage Three: Review and Synthesis

As well monitoring the key stages between baseline and in-depth surveys, the UK team kept in email and telephone contact with the survey team.

3.3 Constraints to the Survey Process

The field team followed the approach and methodology described above the data they gathered is examined in the following section.

In the course of their work, they identified some limitations to the survey process. In particular:

- <u>Non-availability of villagers</u>: Generally, during the day time villagers were not available (especially since the survey was conducted soon after the harvest) as most villagers were out in agricultural fields or carrying out tasks in town. The villagers discouraged the study team from visiting in the evenings for group discussions. This reduced the survey time considerably, with the result that very little time was available for rapport building and familiarisation with the villagers.

- <u>Overexposure</u>: Most villages in the peri-urban seem to be suffering from ‘survey-fatigue’ and ‘overexposure’. It appears that a number of surveys have been conducted in the past for varied purposes (like promotion of micro-finance activities, agriculture extension work, the baseline study, etc.). Also, villagers were reluctant to participate in the discussions as they did not anticipate any benefits of the survey.

- Small sample size: The findings of the study, apart from village level group discussions and FGD with women, are based on small sample sizes in each village (roughly 5 households per village). This represents a sample of between 1.5 and 2% of villages as a whole and while it gives an indication of the data that might be expected from the village as a whole, it cannot be relied on as being completely representative.

- Opportunity and labour costs: A significant shortcoming of the analysis presented in the report is that it does not provide estimates of opportunity and labour cost of fuel collection time. This is likely to be considerably high in case of small farmers and landless families. In the absence of above, energy expenditure across wealth groups might present a distorted picture and may not adequately reflect the time and effort involved in collection of biomass resources. Therefore, it should be kept in mind throughout the report that fuel cost presented in the report are given only in terms of direct cash expenses.

- Energy constraints in agricultural sector: Even though agriculture is the key productive sector in the sample villages, in accordance with the terms of reference of this study, it was not investigated in detail. This, the team felt, was an important limitation considering the fact that agricultural is not only an energy intensive productive sector but also an energy resource generating activity. This limitation was further accentuated by the fact that during the course of the study, sub-optimal agricultural productivity was identified as one of the most important energy constraints by the villagers.

- Non-quantification of impacts of energy constraints: In the small scale industrial sector, potters and brick kiln owners all indicated that high fuel cost and delayed availability of fuels have affected their activities in the past. However, the loss of income as a result of such affects could not be estimated by the villagers.

4. India Results and Analysis

In this section we examine the data collected by the field workers in Hubli-Dharwad. The data gives some indication of the energy service requirements of both households and small-scale productive enterprises in the study areas, and provides some indication of the constraints to production that relate to energy. We present the data specific to each study area together and in Section 6 an analysis of the constraints and the availability of energy resources and technologies that can be used to overcome them together with a cross comparison between the two areas and draw out the generic issues in order to inform future approaches to this field.

4.1. Summary of Data from Hubli-Dharwad

4.1.1. Study Areas

It was decided that case study villages should be :

- within the H-D Urban Development Authority Area
- within approximately 20 km of H-D - served by city bus services
- within a 20-50 km radius of Hubli-Dharwad.

The team first reduced the 25 villages covered under the Baseline Study to shortlist of 11 based on the criteria set out in the table below:

Criteria	Indicators
Degree of economic development (as an indicator of wealth)	♦ Intensity of farming activities and cropping pattern ♦ Availability of natural resources (for example forest area) ♦ Land pressures ♦ Presence of industries ♦ Energy consumption pattern
Accessibility to urban areas	♦ Frequency of public transport ♦ Distance to main town, road, electricity grid, markets, etc. ♦ Land values (land pressures)
Geographic spread	♦ Distance from H-D ♦ Position around H-D (north-west or south-west)

Table 4.11: Shortlist Criteria for Sample Villages in the Hubli-Dharwad Study

The selection of 6 sample villages from these 11 was then made in consultation with key informants who were previously involved in the Baseline study.
The villages are listed in the table below, together with the key 'Justification Points' identified by the team.

Village	Justification Points
Mugad Dharwad Taluka	× Proximity to forest area × Paddy growing area × Paddy husk used as fuel × Rs 2.50/per trip to H-D × Higher rainfall area (falls in Malnad belt)

	× Agricultural research centre in the village × Biogas
Kotur Dharwad Taluka	× Proximity to industrial area × Around 15 kms from H-D × Well connected - good transportation and communication facilities × High land values × Mango plantations × Increase in area under tabacco × Presence of eucalyptus plantations × Labour shortage for agricultural operations × Close to forest area × Some biogas plants × Brick kilns, lime kilns and pottery
Dastikoppa Kalghatgi Taluka	× Increase in cattle population due to Milk Co-operative × No forest area in the vicinity
Katnur Hubli Taluka	-
Hirenarti Kundgol Taluka	-
Saswihalli Navalgund Taluka	× Cotton and chilli growing area (cotton stocks used as fuel for cooking) × Daily wage labourers × Not well connected with H-D - no direct bus service to H-D × 4-5 kms off the main road × Provides better geographic spread

Table 4.12 : Villages Surveyed by the Hubli-Dharwad Study Team

The key characteristics of the sample villages considered in this study are summarised in *Table 4.13*.

Village / Characteristic	Mugad	Kotur	Katnur	Dastikoppa	Saswihalli	Hirenarti
Distance	10 kms	15 kms	10 kms	21 kms	38 kms	27 kms
Main road	1 km off the main road	1 km off the main road	Yes	Yes	No	Yes
Electricity	Yes	Yes	Yes	Yes	Yes	Yes
Forest resources	Yes	Yes	Yes	No	No	No
Industries†	Pottery, blacksmiths	Pottery, brick kilns, lime kilns, smithy work	smithy work, brick kilns	smithy work	smithy work	smithy work, lime kilns
Energy resources	Paddy husk used as fuel, around 50 biogas plants	8 biogas plants	15 biogas plants	increase in cattle population	cotton stocks as fuel, 1 biogas plant	15 biogas plants
Cropping pattern	Shift to horticulture crops, paddy growing village	Mango plantation Tobacco cultivation	Sericulture, well irrigated, horticulture	Floriculture & vegetable cultivation	More rabi than kharif	Cotton, sorghum, groundnut, chillies & wheat are the main crops
Geographic spread	West	North-west	South	South-west	North-east	South-east

†*only key biomass consuming and/or generating small-scale industries have been considered*

Table 4.13: Key Characteristics of the Sample Villages

4.2. Analysis of Data from Hubli-Dharwad

4.2.1. Domestic Energy

4.2.1.1. Domestic Energy Demand

Within the case study villages, energy use in the home is principally for cooking, heating water and lighting, with a small but increasing demand for electricity for TVs, radios etc. As Table XX below shows, the types of energy consumed still show a high degree of 'rurality' inasmuch as firewood, crop residues and dung cakes are the primary sources of fuel for cooking and water heating in around 94% of households. In fact, there have been no significant changes in energy use observed over the last ten years.

A few (approx. 6%) affluent villagers use either LPG or biogas for cooking. All the case study villages have electricity providing domestic lighting for all but the poorest households, who usually use kerosene lamps as a substitute for electric lighting. Other households will use these lamps as a back -up in times of electricity loadshedding. The next sections examine actual domestic energy consumption of different sectors of the community.

Table 4.21 Sources of energy for domestic use among different categories of villagers[1]

Category	Cooking	Heating water	Lighting
Landless labourers	Firewood, twigs and branches, crop residues, dung cakes,	Firewood, twigs and branches, crop residues, dung cakes	kerosene and electricity
Small Farmers	Firewood, twigs and branches, crop residues, dung cakes,	firewood, twigs and branches, crop residues, dung cakes,	electricity and kerosene
Medium Farmers	Firewood, twigs and branches, crop residues, dung cakes,	firewood, twigs and branches, crop residues, dung cakes,	electricity and kerosene
Large Farmers	LPG, biogas, firewood, twigs and branches, crop residues, dung cakes,	firewood, twigs and branches, crop residues, dung cakes,	electricity and kerosene
Service groups	LPG, firewood, twigs and branches, crop residues, dung cakes,	firewood, twigs and branches, crop residues, dung cakes,	electricity and kerosene

4.2.1.2. Cooking and water heating

The group discussions and subsequent individual interviews in the case study villages reveal that in all households, irrespective of their economic status, food preparation, cooking and water heating consumes at least 90% of total household energy consumption. The range of fuels used is described in Box 1 below.

[1] The researchers used the following classification to differentiate between different groups of people in the case study villages: landless labourers; small farmers with less than 5 ha; medium farmers those with between 5 to 10 ha of land; large farmers over 10 ha; and service groups.

Since cooking and water heating activities are interwoven it is difficult to separate energy consumption for both activities. However, according to villagers, all households only use firewood and crop residues for water heating and this consumes only 2-4% of the total energy used. Cooking, on the other hand, uses multiple fuels and multiple energy-technology combinations to a greater or lesser extent, in most households. Nevertheless, the traditional fuels combination of firewood, crop residues and cow dung, used interchangeably when cooking on the 'chulla' (traditional mud stove) dominates in these villages.

Box 4.2: The Range of fuels available in the case study areas:

There are five basic fuels available for cooking and water heating in the case study villages, all of which have certain properties which make them more or less attractive than others:

- **Firewood** is the most commonly used, still widely available and gives food a taste which people like.
- **Crop residues**: There is increasing use of cotton, chili stalks and maize cobs due to increasing crop production . Cotton stalks are preferred as they have better thermal properties than other crop residues and the fires need less tending. All produce more smoke and soot than firewood.
- **Twigs and weeds**: mainly used by the poor as they are laborious to collect.
- **Cow dung cakes:** used for starting fires, but seldom exclusively for cooking, due to the high amounts of smoke they produce. They are considered to be a poor source of fuel due to the low level of heat generation. Fires made from them need constant tending in order to maintain the flame. The cakes are laborious to make – this is regarded as women's work.
- **Kerosene:** used for starting fires and heating water quickly. In general it is too slow for cooking main meals. Villagers said that the smell of kerosene gives food a bad taste.
- **Biogas** plants produce methane for cooking. At least two baskets of cow dung are needed every day for an average household.
- **LPG** is clean , efficient and instantly available, but involves collecting heavy bottles that need some form of transport. There is a perceived risk of explosion of gas cylinders.

In terms of modern fuels, all families use kerosene for lighting fires. Large and medium farm households who possess kerosene stoves will use them for quick cooking (tea preparation). 4-5% of wealthier households in the sample villages use LPG for cooking. Moreover, due to the absence of LPG distribution networks in the sample villages, a slightly higher percentage of households living in villages closer to LPG distribution agents in Dharwad and Gadag use LPG than those villages further away. Since the early 1990s biogas plants have been promoted by the Government of Karnataka using the incentive of a 70% subsidy for plant installation. As a result of this, all the case study villages have biogas plants. However, only about half the number of biogas plants installed are actually still in use (Table 4.3 below) and 3-4% of households (mainly large farmers) use biogas for cooking . According to villagers a key determinant of continuing biogas use is the availability of cow dung. Informants in Kotur, Saswihalli and Katnur suggest that the cattle population is already low and declining, mainly because cattle fodder availability is decreasing as common land grazing becomes scarce due to privatisation and changes in cropping patterns.

The biogas promotion scheme is regarded as having a low success rate. Experience elsewhere suggests that the biogas programmes would be more successful if promotion schemes supported success in terms of biogas plant output rather than installed capacity.

Table 4.22. Number of biogas plants installed and in use in case study villages

Village	No. of biogas plants installed	No. of biogas plants in use at time of study
Saswihalli	1	0
Hirenarti	no information	15
Katnur	18	15
Dastikop	no information	3
Mugad	50	32
Kotur	8	3

4.2.1.3. Lighting and entertainment

Around 6% of household domestic energy consumption meets the lighting and entertainment requirements of the household. Electricity is available in all the sample villages and around 90% of households have electricity connections. In addition to lighting some electricity is used for TVs (50-60% of households), radios (most households) and irons (most higher income families).

Nevertheless, as loadshedding in the case study villages occurs from 2- 6 hours daily, the majority of households will use a combination of electricity and kerosene for lighting. Even so, the non-electrified households (the poorest) have the highest level of kerosene consumption than other income groups (see Table 4.23)

Table 4.23. Adjusted annual average consumption of kerosene from household survey

	Landless labourer	Small Farmer	Medium Farmer	Large farmer	Service Groups
Kerosene (ltrs)	112	111	87	106	87

4.2.1.4. Annual consumption of traditional fuels for domestic use in case study villages

Poor households in general consume less fuel than richer ones. Table AA below shows a comparison of the average annual consumption of traditional fuels across different wealth ranks.[2] For example, the landless labourer households surveyed consume less traditional fuels than all other wealth groups and approximately 40% less than large farmer households of a similar size. Moreover, the make up of fuel consumption is different. In landless and small farm households, firewood makes up the highest proportion of total energy consumed for domestic purposes. While in medium and large farm households, the proportion of firewood to crop residues consumed is roughly equal, probably due to the fact that these farmers will grow and maize. Landless households use a slightly higher proportion of cow dung cakes than other income groups, possibly because cow dung is free. It is not clear however, whether these landless households are under stress due to insufficient fuel consumption, as the researchers facilitating the exercise did not examine this issue in depth. Nevertheless, a clear message from the focus group discussion was that traditional fuels have not yet become scarce in this area. This is corroborated by the fact that there has been no substantial change in the types of fuels used for cooking and water heating.

Table 4.24. Adjusted[a] average annual traditional fuel consumption according to social group

[2] Caution is needed when interpreting these results as the sample size is small. Nevertheless they do give some indication of the magnitude of different levels of fuel consumption

	Landless labourer		Small farmer		Medium farmer		Large farmer		Service class	
	Total	%of total	Total	% of total	Total	% of total	Total	%of total	Total	% of total
Firewood kg	3149	70	5027	73	2925	56	4141	55	2969	51
Crop residues kg	1017	23	1538	22	2157	41	3184	43	2645	45
Cow dung cakes	278	7	285	5	169	3	173	2	218	4
Total in firewood equivalents b	4444	100	6850	100	5251	100	7498	100	5832	100

a Consumption adjusted for family size of 8
b Calorific values taken as : firewood = 3500k Cal/kg; Crop residues = 3000 k Cal/kg; dung cakes = 3000 k Cal/kg

4.2.1.5. Energy Expenditure in households

The households surveyed were asked to estimate their annual cash expenditure on traditional and modern energy alongside their total household cash expenditure on food, health and education. As other expenditure such as clothes and travel were not included in this exercise, a more exact identification of the proportions spent on energy is difficult and the figures given in Table MMM give guidance for interpretation.

Table 4.25 - No interpretation till we get more figures

	Total annual cash expenditure on energy (Rs)	**% of annual total household cash expenditure**	**Annual Cash expenditure on modern fuels (Rs)**	**% of total annual cash expenditure on modern fuels**
Landless labourer	**357**	**2.1**	**324**	**91**
Small Farmer	**909**	**10.2**	**388**	**43**
Medium Farmer	**739**	**2.9**	**627**	**85**
Large Farmer	**1182**	**3.4**	**622**	**53**
Service class	**985**	**3.5**	**707**	**71**

4.2.1.6. Domestic fuel preferences

Consumption of a type of fuel is not always synonymous with demand, as consumers may not be able to express their energy needs adequately through the market. Therefore villagers in group discussions and women-only focus groups were asked to rank their domestic fuel preferences from the range of fuels available to them.

Table 4.26 shows that the pattern of consumption observed in the previous sections hides a demand for different types of energy for cooking, at present not filled. First, there is a clear preference for modern fuels for cooking in all social categories. However, landless labourers were the only group to rank kerosene above LPG and biogas. Their preference for kerosene, described by many villagers as an inferior fuel may be due to the fact that it is more affordable than other modern fuels and can be purchased in small quantities. Second, all categories ranked traditional fuels as best for water heating. Third, all villagers preferred electricity to kerosene for lighting.

Table 4.26 : Ranked fuel preferences by social category in group discussion meetings

Fuel	Cooking	Water Heating	Lighting
LPG	Rank 1: medium, large farmer, service groups Rank 2: small farmer		

Biogas	Rank 1 small farmer Rank 2: medium, large farmer, service groups		
Kerosene	Rank 1: landless household		
Firewood		Rank 1: all categories	
Electricity			Rank 1: all categories

In the women-only group meetings age appears to be more of a determinant of fuel preference than gender *per se* (however, the women were not disaggregated by social category by the researchers in the focus group discussions). Younger women stated that they would prefer to use modern fuels, while their mothers and grandmothers are still content to cook with traditional fuels. Some of the reasons for this difference are explained Box 4.3.
Older and younger women do have the same preferences of fuel use for water heating and lighting, however. These concur with the preferences of the general group discussions.

Box €€. Reasons for older and younger women's fuel preferences for cooking

Older women
- habitual users of firewood
- smoke doesn't bother them
- food cooked using firewood is tastier
- availability is not much of a problem (and they have to get it anyway)
- LPG is not safe (perceived risk of explosion)

Younger women
- LPG and biogas are faster
- more time for leisure and general housework
- no smoke, better for their and their children's health and clean kitchen
- no soot - clean utensils
- no particular difference in taste - but don't like to use biogas for making *chappati*

The case study villages are rapidly urbanising with scant parallel development in 'urban' energy infrastructure. Thus, although all villagers may prefer to upward shift their energy usage to modern fuels, they have not been able to do so. This is mainly due to constraints in modern fuel supply, availability and initial capital costs of equipment and will be examined in a later section.

4.2.2. Energy in Small-Scale Enterprises[3]

In the communities surveyed, there is a range of agricultural and non-agricultural occupations, consuming mainly biomass fuels and electricity for process heat and motive power. The type and number of non-agricultural occupations are detailed in Table 4.27 below.

[3] The researchers have provided no disaggregated information on the relative size (number of employees, size of turnover) of agricultural and non-agricultural occupations, apart from the fact that they are considered small-scale by the participants in the village focus groups.

Table 4.27. Number and type of non-agricultural occupations in the case study villages

	Saswihalli	Hirenati	Katnur	Dastikop	Mugad	Kotur
Blacksmiths	2	2	3	Some	25	6
Goldsmiths	Some			2	2-3	Some
Flour mills	5	2	2	2	7	
Lime kilns		12				Some
Potters					50-55	
Hotels		2	Some	2	3	Some
Brick kilns			1	3		3

4.2.2.1 Energy demand in agriculture

In the group discussions it was revealed that farmers' main energy demand is electricity for motive power to pump water from borewells and tanks to irrigate land. Given that loadshedding is a constant occurrence in the case study villages, the lack of a continuous supply of electricity came out as a significant production constraint in all the focus group meetings. However, it must be borne in mind that irrigation is only extensive along the Navalgund taluk, where some land is served by the Malaprabha canal. Elsewhere the irrigated areas are very small, usually no more than a few hectares. Even though more villages in the Hubli-Dharwad peri urban region have increased their area under irrigation in the last ten years, it is perhaps significant that it has been neither possible to increase the capacity of tanks, nor sink more borewells in this period. This suggests that irrigation water availability, as well as energy for motive power, may be a significant constraint to increasing agricultural production.

4.2.2.2. Fuel consumption in non-agricultural occupations

The key energy demand of these enterprises is process heat supplied by firewood, coal, charcoal, rice husks and other crop residues and kerosene in the case of hotels. In general, the energy intensive occupations like brick making and lime kilns use fuels with higher energy density such as coal. However, in cases of shortages they switch 'downwards' from commercial fuels back to traditional fuels. The less energy intensive enterprises are more likely to use traditional fuels as shown in Table GGG.

Table 4.28. Type and average fuel consumption of non-agricultural occupations

Enterprise	Main fuel used	Average weekly consumption	Fuel switching	Other comments
Blacksmiths	Charcoal Rice husks	20-25 kg 2-3kg		Pre-harvest peak seasonal demand for blacksmiths For small jobs customer supplies charcoal
Goldsmiths	Charcoal	1.75 kg		Increasing competition from ready-made jewellery, demand for local product in decline
Flour mills				
Lime kilns	Coal and firewood	100 kg 100 kg	Charcoal	
Potters	Firewood + crop residues			Number of potters is declining due to lack of demand for pots and rising costs of firewood
Hotels	Firewood + kerosene	50-60 kg firewood 3-4 litres		
Brick kilns	Coal Rice husk	1600 kg		

Information from the village focus groups suggests that some of these non-agricultural occupations are in decline, mainly due to lack of consumer demand for their products (jewellery and pots). In the case of potters in Mugad, the rising cost of firewood was also given as a reason for a 50% decline in the number of potters over the last 5-10 years. However, no other village reported firewood costs rising significantly

4.2.3. Energy Resources

4.2.3.1 Firewood for domestic cooking and water heating

Firewood makes up the largest share of domestic energy consumption in the case study villages. There are differences between the eastern and western side villages of Hubli-Dharwad in terms of the type of firewood available due to soil, topography and climatic conditions. The western villages (Kotur, Mugad and Dastikop) experience more rainfall and the land is generally hilly, while the east (Saswihalli and Hirenati) is drier and flatter. In the west, firewood is generally obtained from forest plantations, usually in relatively easy reach (3-5km) of the village. Firewood is often lopped from the trees, although Forest Department regulations prohibit this. However, they do permit the collection of fallen wood, twigs and leaves and informally allow harvesting of trees for domestic purposes. The eastern side villages have large-scale tree planting of various varieties of *prosipus* (a fast growing species) on village common lands, roadsides and the boundaries of agricultural fields providing a ready supply of wood in the locality (see Table X below). Nevertheless, according to the group discussions and subsequent individual interviews these differences do not appear to affect availability in the villages east and west of Hubli-Dharwd. Interestingly, although local people did mention that firewood availability has decreased over the years mainly due to the fact that they have to go further to obtain it, they do not perceive firewood as scarce. This is mirrored by the fact that they have not changed their domestic energy consumption patterns.

Table 4.29: Source of firewood in case study villages

	West	Central	East

	Kotur	Mugad	Dastikop	Katnur	Hirenati	Saswihalli
Source	Social forestry, common land, roadsides	Social forestry, common land	Social forestry, common land	Social forestry, fruit tree crops	Common land , edge of fields, government depot Kundgol	Common land, edge of fields , Roadsides
Distance	3 km	8 km	3.4 km	5 km	In the locality	In the locality
Perceived scarcity	None	None	None	None	None	None

However, when discussing methods of firewood collection, in terms of time taken and who does the collection there are some distinct gender and poverty disparities (see table ZZ below). Although the actual way firewood is collected (i.e. lopped from trees) may not have changed much over the years, the methods of transportation have. Now the wealthier households with sufficient storage space take advantage of tractors and trailers and/or bullock carts, either their own or hired, to collect firewood. They have reduced the number of times a year they collect firewood from weekly collection to 4 –6 a year. Therefore, even though the availability of firewood has declined over the years there has been little/or no increase in time taken to collect sufficient firewood in the wealthier households. In the first place, this change in the technology of transportation has, at least in the short to medium-term, overcome any reduction in supply. Second, it has produced a shift in the gender division of labour in these wealthier households, as women have been relieved of the daily burden of collecting sufficient firewood for the family's needs. Third, it has resulted in additional seasonal employment for hired labourers.

The poor, on the other hand, have neither sufficient storage space, nor money to hire carts/trailers, so they continue to collect firewood daily/weekly. This is generally women's work. Discussion with these women reveal that collection time has doubled in the last five years or so, from 2-3 hours per trip to 4-6 hours. However, in common with all the group discussions, they don't perceive a firewood shortage. According to the women it is abundantly available, though the number of times they may have to bribe the forest official is increasing. 'We have to get the firewood by hook or by crook' was a frequently repeated phrase in the group discussions. A further implication may be that cheap and easily accessible substitutes for firewood are not readily available in the area.

Table 4.30: Firewood collection in case study villages among different categories of villagers

	Frequency of gathering fuel	Who collects	Time taken	Seasonality	Market	Changes over last 10 years
Landless labourers	Daily/ weekly headloads, depending on storage space 4-6 times year as seasonal employment	Women and men on daily/ weekly basis. Hired labour: mainly men	4-10 hours / week	Try to store some wood before onset of rainy season	Some firewood vendors operate on very small-scale	Have to walk further, takes 50% longer to collect wood
Small farmers	Daily/ Weekly	Women on daily basis, men for larger quantities	4-10 hours/ week	Store some wood for dry season		Idem
Medium farmers	Twice yearly	Household plus some	4-8 days	Only collect in dry season		Collection now more

		hired labour hire tractors/ Bullock carts				mechanised, some time saved
Large farmers	Yearly	Hired labour, using tractor of bullock carts	4-8 days during dry seaso n	Only collect in dry season	Katnur, Saswihalli 50-60 tractor loads sold annually	Idem
Service groups	Weekly/half yearly	Household plus some hired labour and tractors/ Bullock carts labour		Mainly collect in dry season		Idem

Most of the firewood required by the household is collected and not purchased. However, a commercial trade in firewood in the case study villages does exist, operating on two levels. There are very small-scale firewood vendors who sell wood to some richer households and to potters in Mugad. Also, in Mugad, Sswihalli and Katnur 50-60 trailer loads are sold annually to private contractors and firewood depots. According to villagers this has no impact on firewood availability.

4.2.3.2 Crop Residue

The expansion of cotton cultivation in the case study area has led to an increasing use of cotton residues for cooking and water heating, mainly because of their good thermal properties and low nutritional properties as cattle fodder. Other residues favoured by local people include chili stalk and maize cobs. These residues are collected and stored immediately after harvest in January. One acre of cotton provides sufficient residues for 2 months cooking, for a family consuming an average of 40 kg a month in combination with firewood. Indeed, villagers now believe that the consumption of firewood is reduced between January to June when the majority of households have stocks of crop residues. Given that crop residues are stored outside (due to their bulk) and will rot during the rains, the large farmers are not able to consume all they grow, instead they exchanged it for labour in land clearance and preparation after harvest. This gives the poor the opportunity to acquire an alternative to firewood.

As cotton crop residues appear to a reasonable compliment for firewood in cooking, the increase in cotton cultivation has provided local people with a substantial alternative to firewood in meeting their domestic energy requirements. However, there is scant information on any gender division of labour in collecting crop residues, thus the impact on women of different income groups of a greater dependence on crop residues for fuel is not clear.

4.2.3.3. Dung cake

Making dung cakes is regarded as women's work. However, the evidence on the supply of dung is contradictory. On the one hand, the baseline survey reports a decline of the cattle and buffalo population in the area, due to a reduction in fodder and two major recent droughts. But on the other hand, the villagers report that dung cakes are easily available throughout the year except during the rains when cow dung cannot be dried.

Although dung cakes are not a favoured fuel, they are a free, though time consuming, source of fuel for the poor. Women from non-cattle owning families (often the poorest) will collect dung from the roadside or grazing land when returning from working in the fields and make them into cakes.

4.2.3.4 Biogas

In all the case study villages, biogas plants have been installed under the 70% government subsidy scheme. But many are now in disuse. Although, many villagers in the discussion groups showed interest in shifting over to biogas for cooking, the present technology - 2 cubic meter capacity biogas plants requiring 20-25 kg of cow dung daily - is not capable of providing a sufficient supply for everyone. In the first place, the production of gas it is dependent on cow dung[4], in an area with a declining ruminant population. Second, the high initial investment precludes (even with government subsidy) the majority of the poor. Third, biogas plants take up a lot of space, and space appears to be at a premium, whether it's for storing firewood, crop residues or for the biogas plant.

4.2.3.5. LPG

LPG has been subsidised by the government under the assumption that (relatively) cheap LPG would encourage households to switch to it for cooking and stop using firewood, thus reducing deforestation. However, as the delivery mechanism and the distribution agencies for LPG are all located in urban areas, this is a subsidy to the urban population, as the costs of cylinder delivery to the villages are high. Another factor constraining the use of LPG is the initial investment needed to buy gas appliances. Nevertheless, LPG has found popularity among the more affluent sections of the case study villages, due to ease of cooking and cleanliness.

4.2.3.6. Kerosene

In general, kerosene is the one modern fuel easy to get hold of. It can be purchases at the subsidised rate of Rs 3.5 – 4.0/litre via the Public Distribution Network (PDS) within the village, or from private vendors in urban centres at Rs 8-10/litre. In theory, each ration cardholder (representing a household) can purchase 3-5 litres of subsidised kerosene per month. However, the practice is quite different. First, the quantity of kerosene supplied and distributed each month varies. Second, information from the group discussions indicates that some households have 2-3 ration cards, while a considerable number of landless labourers (for example, approx. 30 in Kotur, 40-50 in Mugad) do not have ration cards at all. A more exact identification of why this is the case is difficult, as the researchers did not probe this area. However, it can be assumed that the people who buy the most kerosene (usually the poorest as they use it for lighting as well as cooking) are having to buy proportionally larger quantities of unsubsidised kerosene than more wealthy families.

4.2.3.7. Electricity

Electricity has been available in the case study villages for some time now. More recently, landless labourers and some small farmers have had access to electricity under the Bhagya Jyothi programme, operated by the Karnataka electricity Board. Under this programme, electricity is free for a certain period, after which the households pay a minimum of Rs 10 per month. Nevertheless, according to the village informants not all households are connected to the grid, ranging from 7–40% of households without connections. Moreover, all villages suffer periodic cuts in supply to households, see Table 4.31.

Table 4.32: Number of households and frequency of electricity supply in case study villages

	Kotur	Mugad	Dastikop	Katnur	Hirenati	Saswihalli
No of households without supply	8%	40%	20%	10%	7%	
Supply	18 hours/ day	20 hours/ day	Summer mandatory loadshedding	20 hours/ day	22 hours/ day	18 hours/ day

[4] Some of the existing biogas plants have been linked to the toilet and are using human excreta

4.2.3.8. Resources for small-scale enterprises

Like domestic energy supply, demand for energy in small-scale enterprises is not perfectly matched with supply. The key areas of energy supply bottlenecks are in transportation of bulky fuels and electricity supply. Coal used in brick and limekilns is easily available and can be procured by ordering in advance from Hyderabad or at the weekly coal auctions in the nearby towns. However, due to a shortage of transport to move the fuel to where it is needed, brick and limekiln operators sometimes have to temporarily discontinue their operations. Charcoal, also used in limekilns and by blacksmiths is generally available throughout the year although availability is reported to be low during the monsoon. The main suppliers are charcoal vendors and illegal producers living near the forests. The shortages of electricity are severe and farmers believe that the current supply of electricity constrains their agricultural productivity. They would very much like to have greater access to electricity for motive power.

4.2.4 Conclusion

Traditional fuels dominate household domestic energy consumption in the case study villages for a number of reasons. They are still easily available and the technology to use them – the chulla - is cheap. These are important determinants in household decisions as considerations of fuel costs include, not only the price (including household labour) of the fuels themselves, but also equipment costs and the ability to purchase these fuels. Of the modern fuels, only kerosene is available in small and affordable quantities for the poor, while LPG is difficult to obtain.

A number of characteristics of domestic energy consumption patterns have been observed in these villages, including differences in the proportions of types of fuel use between households of different income levels and the quantity of fuel they consume. Although there have been no substantial changes in the types of fuel used over the last decade or so, the use of LPG and biogas among the better off families has increased. Nevertheless, firewood, crop residues, particularly cotton stalks and cow dung cakes are still readily available and offer cheap and non-traded (bearing no monetary price, but an opportunity cost in terms of human labour) sources of fuel for cooking and water heating. This is crucial for the poor, as cash is often their scarcest resource. Changes in methods of firewood transportation among the wealthier households have relieved women from these households of the responsibility of being the main firewood provider. This continues to be the case among the poorer households, however. Nevertheless, the time taken to collect these fuels does not appear to present problems yet, as most villagers are still engaged in agriculture.

Cotton is currently a very popular crop to grow, due to the high prices received for it. However, the reliance on cotton stalks for domestic energy particularly in the medium, and large farm households, may be of concern due to the volatility of cotton prices. This could have a significant impact in terms of access to fuel and time spent collecting fuel.

At present there are trade offs occurring within the natural resource base, as farmers choose to use cotton and other crop residues for fuel, rather than composting them or using them a soil ameliorant through re-incorporation into the soil. However, farmer's decisions not to make compost may be pragmatic and practical, as it seems that cattle manure traditionally used for compost making could be in short supply. It appears that using crop residues as a substitute for firewood has, to some extent, reduced the rate of deforestation, at least in the short-term. Interestingly, in the baseline survey (1998 p61) it was reported that in various PRA exercises farmers did not reckon that soil fertility was a major production constraint, although the scientists did see it as a problem. This needs to be examined in more detail.

There are many more constraints to the supply of modern fuels including electricity, both for the household and biomass fuels for small-scale enterprises in this area. A key problem is the lack of development of modern energy markets and effective distribution systems. The results are shortages and a tendency for these fuels not to reach the peripheral areas where the poor often live. Commercial fuel market supply systems are poorly understood but crucial for peri-urban energy development.

5. Ghana Results and Analysis

In this section we examine the data collected by the field workers in Kumasi. The data gives some indication of the energy service requirements of both households and small-scale productive enterprises in the study areas.

5.1. Summary of Data from Kumasi

5.1.1. Study Areas

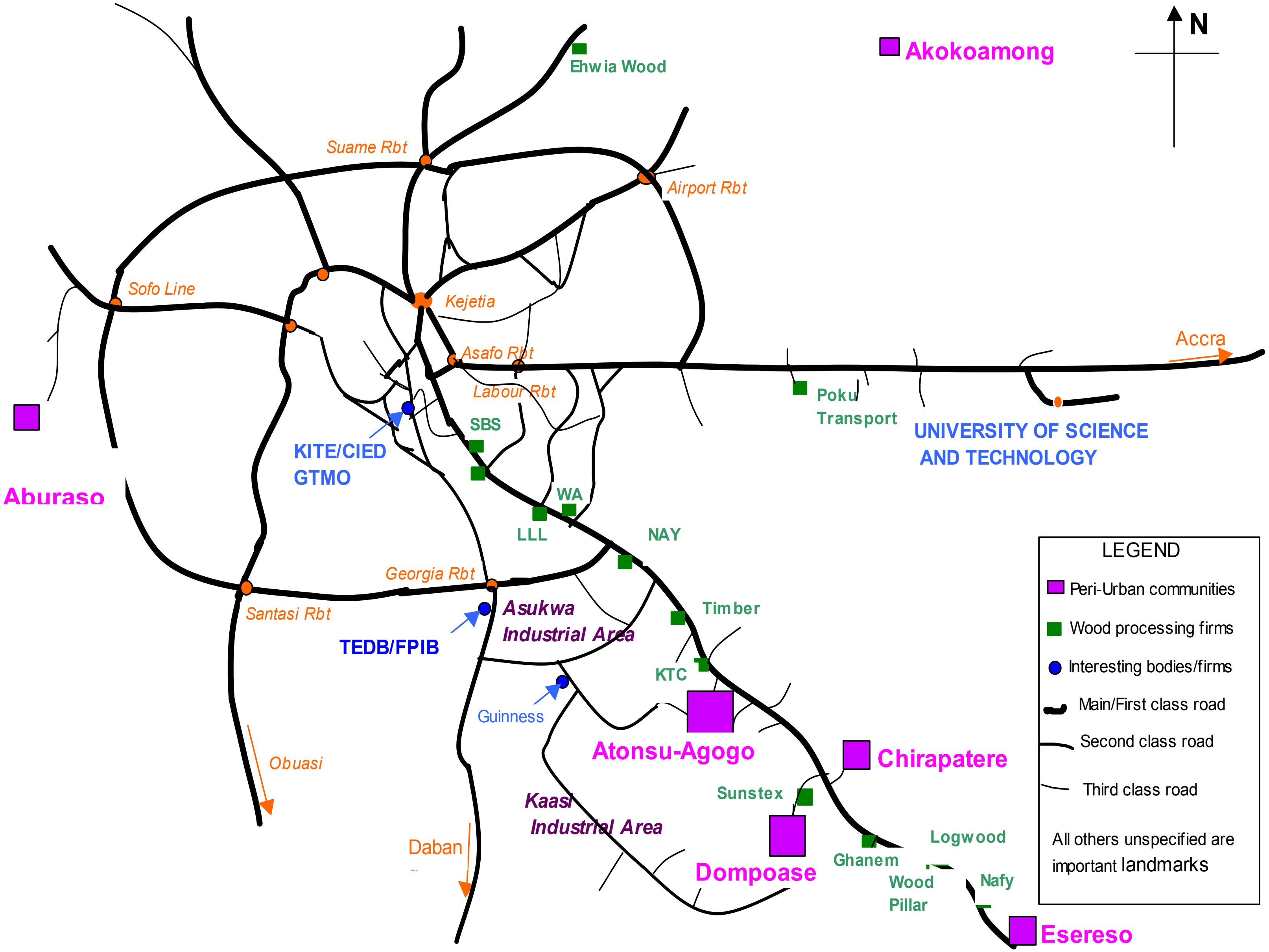
The criteria for selection of communities for this phase was to work more extensively on the areas already covered in the baseline study (phase 1) and choose other areas worked on in the broader peri-urban study. The selection was such as to give a wide geographical spread (both in distance and position around urban Kumasi) and ascertain energy issues in areas that are in sharp contrast with the ones already explored in phase 1.

The four peri-urban areas covered in phase 1 are located in the southern part of Kumasi, namely Atonsu-Agogo, Dompoase, Chirapatere and Esereso. They were chosen for this study mainly because of their proximity to lumber industries and hence, access to biomass resources. Two further villages were chosen for the second phase, to provide a contrast, namely Aburaso and Akokoamong. Most of these peri-urban communities have a large percentage of unemployment, which is an indication of poverty and dependence on indigenous energy services. Altogether, the communities cover about 5km^2 which is about 2% of the total area of Kumasi. The characteristics of the villages are shown in the table below:

Table 5.1 Study communities' characteristics

Community	*Domp-oase*	*Aburaso*	*Akokoamong*	*Atonsu-Agogo*	*Chirapatere*	*Esereso*
Criteria						
Distance	7km	9km	13km	6km	7km	10km
Main road	No	No	No	Yes	No	Yes
KMA	Yes	No	No	Yes	Yes	No
Electricity	Yes	Yes	No	Yes	Yes	Yes
New buildings	Yes	Yes	Few	Yes	Yes	Yes
Forest resource	Yes	Yes	Yes	No	Some	Yes
Sawmill activity	Yes	No	No	Yes	Yes	2 km away

A map of Kumasi showing the location of the six communities is presented in the next page.



N
Akokoamong
Ehwia Wood
Suame Rbt
Airport Rbt
Sofo Line
Kejetia
Asafo Rbt
Labour Rbt
Accra
Poku Transport
UNIVERSITY OF SCIENCE AND TECHNOLOGY
SBS
KITE/CIED
GTMO
Aburaso
WA
LLL
NAY
Georgia Rbt
Santasi Rbt
Asukwa Industrial Area
TEDB/FPIB
Timber
KTC
Guinness
Atonsu-Agogo
Chirapatere
Obuasi
Sunstex
Kaasi Industrial Area
Daban
Logwood
Ghanem
Dompoase
Wood Pillar
Nafy
Esereso
LEGEND
Peri-Urban communities
Wood processing firms
Interesting bodies/firms
Main/First class road
Second class road
Third class road
All others unspecified are important landmarks

5.1.2. Survey Process

The methods adopted in this research involved the use of semi-structured individual interviews, focus group discussions, as well as key informant interviews to elicit unbiased information from the residents of the communities. The PLA tool assisted in ranking, prioritising and analysing the collected raw data.

The main problems encountered in the study included the amount of time used up in protocol activities, the initial reluctance of residents who have complained that there have been a lot of interruptions by researchers with no positive sign of improvement in their livelihoods and the substantial deficiencies in natural resource information in the country.

5.2. Analysis of data for Kumasi

5.2.1. Domestic Energy

[*EXCHANGE RATE : US$ 1.00 = ¢2,300.00*]

5.2.1.1. Domestic Energy Demand

Within the case study villages, energy use in the home is principally for cooking, lighting, domestic appliances and entertainment. The fuels and devices used vary across the income groups as shown in Table 5.2 below. In general there has been a switch away from using firewood in all income groups to charcoal. The wealthy are more able to shift their energy use upwards from charcoal to modern fuels, which comprise a higher proportion of their total energy use.

Table 5.2 Sources of energy for domestic use among different categories of villager

Group	Cooking Fuel/ type of appliance	Lighting	Other Domestic Appliance Fuel/ type of appliance
Rich	LPG, charcoal Stove, coal pot	Electricity	Electricity Fridge, freezer, colour TV, radio
Medium	Charcoal, kerosene Coal pot, stove	Electricity	Fridge, black and white TV, radio
Poor	Charcoal, firewood, crop residues Coal pot, mud stove	Electricity, kerosene, candles	Lantern

5.2.1.2. Cooking and water heating

Table 5.3 below shows that there are some differences in the types of domestic energy-technology combinations used in cooking and water heating across the case study villages. In general, the villages further away from Kumasi, with more rural livelihoods and local economies consume a more ‘rural’ mix of fuel sources, with a greater dependence on firewood and crop residues.

Charcoal is the most widely used fuel for domestic cooking in all the villages and all income groups. On the one hand, this has been encouraged by landlord preferences, increasing demand for accommodation and house design, and by declining availability of firewood, on the other. For example, most landlords are wary of the potential fire hazards of cooking with firewood and have banned its use for cooking. Many have also banned LPG for the same reason. As Atonsu-Agogo rapidly develops into a residential area there is increasing demand for accommodation. To fulfil this demand, former kitchens are being converted into sleeping rooms and residents now have to cook on verandas or balconies. There is neither sufficient space to cook with firewood, nor to store it. In the older sections of

Chirapatere town however, it is common to see residents cooking with firewood outside their house as there is sufficient space and the house design makes this possible.

Table 5.3 Comparison of household energy use for cooking and lighting in the case study villages

	Dompoase	Atonsu-Agogo	Chirapatere	Esereso	Aburaso	Akokoamong
Soft/hard charcoal (%households)	88	88	60	80	70	69
Firewood (%households)	7	7	30	15	28	30
Crop residues (%households)		1	2		10	10
LPG (%households)	2	2	6	3		
Kerosene (%households)	1	2	2	2	2	1

Households consume varying quantities and combinations of soft and hard charcoal for cooking, depending on its availability. Soft charcoal produced locally from sawmill offcuts, edgings and slabs, is low grade and burns quickly. In the case study villages average consumption varies between ½ to 1 sack per week at a cost of 7,000- 9,000 cedis/sack, but it can also be bought in smaller quantities, which means that it is more accessible to poorer people.

Villages close to sawmills (Dompoase, Atonsu-Agogo, Chirapatere and Esereso) consume more soft charcoal than the ones further away, indeed there is no soft charcoal available in Aburaso. Hard charcoal comes from the forests in the north of Ghana. As it burns more slowly, needs less tending and produces less ash, average consumption of hard charcoal is 1/5 –1/3 sack/week costing between 6,500-10,000 cedis/sack.

Firewood is the second most used fuel in the case study villages and the percentage of households using firewood varies between 7% and 30%. It is no accident that in the villages where a greater number of households use firewood, they also consume more firewood per household, up to 3 adult headloads per week. One adult headload weighs about 40kg. The price of a headload varies from about 2500-4000 cedis, increasing with the proximity to the urban centre. These households are likely to be the poorest, with firewood making up the greatest proportion of their energy needs. Apart from Chirapatere with its special house design in the old town, the villages which consume more firewood are also further away from the conurbation of Kumasi.

Household use of crop residues, mainly maize cobs for fuel follows, to some extent, the same pattern as firewood consumption. The people of the furthest away villages of Aburaso and Akokoamong are still more dependent on agriculture for their livelihoods and have greater access to crop residues as a source of fuel.

In terms of modern fuels for cooking, LPG is not widely used and only between 2 and 6% of households in the more urban villages use LPG. It is a fuel used mainly by wealthy owner-occupiers who are not subject to bans on its use by their landlords.
The use of kerosene for cooking is more prevalent in the urban villages, in fact the researchers record that it is mainly by single young men for cooking. In the remoter villages kerosene is seldom used by villagers for cooking as it is reported to be expensive and there are a wider variety of local alternatives for process heat for cooking.

5.2.1.3. Lighting and entertainment

Within the study villages, electricity is generally used for lighting and domestic appliances for household use and entertainment. It is now rarely used for cooking due to the new high tariffs resulting from the restructuring of the Government's electricity pricing policy.
As Table 5.4 below shows, kerosene is used as the alternative to electricity for lighting in poor households and in all households in Akokamong. On average, the households use 1 gallon of kerosene a month.

Table 5.4 Comparison of household energy use for cooking and lighting in the case study villages

	Dompoase	Atonsu-Agogo	Chirapatere	Esereso	Aburaso	Akokoamong
Electricity (%households)	95	95	90	80	40	
Kerosene (%households)	5	5	10	20	60	100

5.2.1.4 Fuel Preferences

Apart from access to affordable electricity, most PUI inhabitants are conservative about fuel choices and are constrained only by availability and cost.

Table 5.5: Ranking of Fuel Preferences

Wealth Category	***Process heat***	***Lighting***	***Entertainment/ Refrigeration***
Rich	1. LPG 2. Charcoal 3. Sawdust 4. Kerosene 5. Fuelwood 6. Biogas	1. Solar PV 2. Electricity 3. Kerosene 4. Biomass 5. Candles and batteries	1. Solar 2. Grid 3. Batteries
Medium	1. Charcoal 2. Fuelwood 3. Sawdust 4. Kerosene 5. LPG 6. Biogas	1. Solar PV 2. Electricity 3. Kerosene 4. Biomass 5. Candles and batteries	1. Solar 2. Grid 3. Batteries
Poor	1. Fuelwood 2. Charcoal 3. LPG 4. Sawdust 5. Kerosene 6. Biogas	1. Grid 2. Solar PV 3. Kerosene 4. Biomass 5. Candles and batteries	1. Grid 2. Solar 3. Batteries

A number of interesting inferences can be drawn from these preferences:

- Charcoal is the favourite fuel for process heat.
- Whilst LPG is the favourite fuel amongst the rich, the medium class are not very willing to adopt this fuel. The poor however, have a higher rating for LPG. The reason is that the medium class have heard a lot about the negative side of LPG. The poor on the other hand have little knowledge of this fuel except for the fact that it is modern and better.
- The poor prefer fuelwood for cooking which is normally done in large quantities. Fuelwood is cheaper in this case.
- Solar PV makes a lot of sense to PU inhabitants since they would like to see less dependence on the national grid.

- Biogas is not particularly interesting to most people especially when it is derived from nightsoil.
- Grid access is the number one choice of electricity for poor without grid access.

5.2.1.5 Gender and Age Issues in Energy Use

There is a gender mix in fuel collection and usage in the PUI. Women are normally the sole managers of domestic meals and therefore of fuels for process heat. They determine the most economical and fastest way of delivering meals from tight budgets. Through experience, they know more about the traditional fuel qualities and market trends than men do.

The role of men in fuel issues is prominent with commercial (modern) fuels and bulk purchases. Children as young as 8 years are involved in the sale or purchases of kerosene, dry cell batteries and even firewood. In many homes, older children are totally relied upon, under the supervision of their mothers for the purchases of small quantities of fuel.

5.2.2. Energy in Small-Scale Enterprises

5.2.2.1 Energy Demand

There is a proliferation of entrepreneurs in the PUI whose activities may be energy intensive (eg. bakers) or may require little or no energy (eg. hawkers). Such small-scale industries support hundreds of families and provide employment to many (especially women) throughout Kumasi's PUI.

Charcoal usage in the industrial sector is minimal, compared to fuelwood. This is because it cannot deliver economically the large amounts of heat required by food processors. Availability is nevertheless high and consistent. Charcoal is favourite amongst many small roadside food processors because of its convenience.

Fuelwood is the main energy provider in the food industry. The sawmills have contributed significantly towards the provision of cheap fuelwood. The main cost incurred in acquiring this fuel is the cost of transportation. Sometimes, agents with tractors or light trucks deliver fuelwood to their customers, sometimes on hire purchase basis. A tractor load sells between ¢40,000 and ¢70,000 depending on the quality of residue (wood species and degree of fragmentation) and travel distance. Hard wood attracts higher costs and is less available than soft species. Other industrialists depend on human carriers or fetch their own firewood from the forest. Currently, firewood application is less common, except in Aburaso.

LPG application is most common amongst bakers. Users commended it for its economy and convenience. LPG fired ovens are manufactured locally in different sizes. A typical oven can bake dough from about two bags (100kg) of flour in a day. It will take about three days to bake this quantity in an earthenware. Weekly consumption is about 40kg of LPG. The disadvantage and constraints of LPG devices are the possibility of gas leakage, which can be very dangerous and the high capital cost of equipment.

Electricity is extensively used for lighting, motive power, refrigeration and entertainment appliances. Requirements for motive power by grain millers and refrigeration by traders and bar operators are the highest. Tariffs continue to increase year after year making the cost of energy a significant percentage of the overall production costs of industries. Small scale industries (grain millers, electric welders, etc) have a demand charge of ¢10,000 ($4.35), energy charge of ¢180/unit (7.8 Cents) and service charge of ¢20,000 ($8.70).

Diesel, during power crises or prolonged outages, saves quite a number of industries from closing down by powering small generator sets. This fuel is available in most filling stations almost always and is sold for ¢3200 per gallon. Since it is over thrice more expensive to run generators for electricity, entrepreneurs normally reduce their operational time to avoid incurring heavy expenditures.

Table 5.6: Summary of Small-Scale Industries and their Energy Service Requirements

Industry	Energy Service Requirements	Fuel
Food Processing Industry		
• Canteen	• Process heat, lighting, entertainment	• Sawmill residue*, firewood, electricity, charcoal, kerosene
• Fish processing		• Sawmill residue, firewood, fibre
• Bakery	• Process heat	• Sawmill residue, firewood, LPG
• Oil extraction	• Process heat, lighting, motive power	• Palm kernel, electricity, diesel
• Mill	• Process heat, motive power, lighting	• Electricity, diesel
	• Motive power, lighting	
Beverage Industry		
• Pito** brewery	• Process heat	• Firewood
• Alcohol distillery	• Process heat	• Sawmill residue, firewood
Other enterprises		
• Shops, bars and stalls	• Lighting, entertainment, refrigeration	• Electricity, kerosene
• Hairdressing	• Process heat, lighting	• Electricity
• Dressmaking	• Process heat, lighting	• Electricity, kerosene
Charcoal production	• Process heat	• Sawmill residue, Firewood

*Offcuts and barks
** Pito is a local alcoholic drink.

Food Processing Industry

Food processing is the most common entrepreneurial activity in the PUI and also the most energy intensive. Process heat is the most demanded and indispensable energy service and woodfuel is the most frequently used fuel. The section below describes the various components of this industrial sector.

(i) Canteens and Fish Processing

This is the largest and most common food-processing sector. Canteens comprise of small wayside sellers and hawkers and different sizes of local restaurants. Fish processing involves frying and roasting of fish. End-devices employed are the traditional mud/block stoves designed to carry large pots. Activities are normally performed outdoors or away from homes. Therefore fuelwood is most suitable since it is cheap. Dependence on sawmill offcuts and barks is about 90% in communities near sawmills. Communities remote from sawmills such as Akokoamong totally depend on firewood since the cost of transporting the cheaper sawmill residue is significantly high. The heat output of charcoal is far less than that of fuelwood though it is easier to light. Economically, charcoal is much more expensive to use in this sector since large volumes will be required for the equivalent heat output of fuelwood. Dependence on kerosene for lighting is 60% in PU areas with grid access. The contribution of women to this sector is in excess of 95%. Tables 5.7 and 5.8 summarise the energy consumption, cost and availability of fuels for an average sized canteen.

Table 5.7: Fuel Usage Pattern of Food Processors

Process Heat		
Fuel	**Monthly Consumption**	**Dependence**
Sawmill offcuts and barks	Tractor load	70%
Firewood	Seven adult headloads	26%
Charcoal	2.5 sacks	4%
Lighting		
Fuel	**Monthly consumption**	**Dependence**
Electricity	Under 50kWh	40%
Kerosene	1 gallon	60%

Table 5.8: Energy Supply Table of Food Processors

Energy Source	Local cost (Cedis)	Resource Base	Collection point/ time	Availability
Sawmill off-cuts/barks	30,000/ tractor-load	Local sawmill	Delivered by agents	High
Firewood	3,000/headload	Local, forest	Local, forest 20 – 180 min	Medium
Hard charcoal	8,500/sack	Northern districts	Local Under 20 min	Low
Kerosene	2,500/gallon	Nearby filling station	Local/filling station 20 – 40min	Medium
Electricity	150/kWh	National grid		High

(ii) Bakery

Bakeries are not common in the PUI though bread is never in shortage. No such industry exists in rural PU areas such as Esereso, Aburaso and Akokoamong the reason being that most bakers are non-indigenous and would like to be as close to Kumasi as possible. On the average, there are two bakeries per urban community. Process heat is the dominant energy service requirement and sawmill offcuts and barks are the most commonly used fuels. There has been a fuel switch to LPG in about 30% of the bakeries. Users highly commend LPG for its economy, convenience and rapidity. Lighting is not a priority in most bakeries. A particular baker depends heavily on electricity for operating dough mixers and cutters on commercial basis. Tables 5.9 and 5.10 summarise the energy activities of an average bakery.

Table 5.9: Fuel Usage Pattern of Bakers

Process Heat		
Fuel	***Weekly consumption***	***Dependence***
Barks and offcuts	½ truck load	70%
LPG	40 kg	30%
Lighting		
Fuel	***Monthly consumption***	
Electricity	50kWh	40%

Table 5.10: Supply Table of Bakers

Energy Source	Local cost (Cedis)	Resource Base	Collection point/ time	Availability
LPG	867/kg	Filling station	0 – 60 min.	Medium
Sawmill off-cuts/barks	30,000 per tractor - load	Local sawmill	Delivered by agents	High
Electricity	0 – 250/kWh	National grid		High

Oil Extraction

The only oil extraction industries in the study areas are in Chirapatere and Dompoase. Availability of land and electricity may be the strongest reason for their existence in these communities. The product is palm kernel oil, which is used by many fish and food processors. The raw material, unshelled palm nuts, is shipped in from outside the Ashanti Region. The main processes in this industry are as follows;

- milling of the raw material to extract the nuts from the shells; electricity is required to provide motive power to mills.
- frying of the nuts; the industry is self-sufficient on process heat. Palm shells provide abundant heat.
- milling of the fried nuts into fluid.

- cooking or heating to extract oil

After shells have undergone primary burning which is very smoky and oily, they turn out to be quality fuel, which is sold to blacksmiths. Woman are solely responsible for the cooking and frying processes whilst one or two men operate the mills and manage the entire operation of the industry.

Table 5.11: Fuel Usage Pattern of Palm Kernel Oil Producers

Process Heat			
Fuel	***Weekly consumption***	***Cost***	***Dependency***
Palm kernel shells and fibre	5 sackfuls (80kg)	Free	100%
Lighting and Motive Power			
Fuel	***Monthly consumption***	***Cost (Cedis)***	***Dependency***
Electricity	140kWh	150/kWh + surcharges	95%
Diesel	40 gallons	3000/gallon	5%

The Charcoal Industry

There has been a proliferation of charcoal producers in Kumasi's PUI in recent times. Stricter environmental laws and land reclamation are however serious threats to their existence. One of the largest production units in a PU area was forcibly closed down in late 1998. The activities of charcoal production sites cause great inconvenience to nearby residents and badly damage surrounding vegetation. Their presence however has contributed to the abundance of charcoal in the city. The many sawmills in Kumasi sustain their operations with offcuts, sawdust and wood barks. Carpenters and commercial food processors are their main competitors for wood residue not used by sawmills and the domestic sector is their best market. Tables 5.11 and 5.12 below show the energy consumption, cost and availability for this industry. It is the only industry where the product is a direct derivative of fuel. The wood is arranged in a particular pattern on the ground and covered with sawdust and soil. This improvised earthenware kiln (moulds) have a low conversion efficiency of 16% by weight.

Table 5.12: Fuel Usage Pattern of Charcoal Producers

Energy Source	Weekly Usage	Local cost (Cedis)	Resource Base	Collection point/ time	Availability
Firewood	Tractor-load	70,000/tractor load	Local, forest	Delivered by agents	Low
Sawmill off-cuts and barks	Tractor-load	50,000/tractor load	Local sawmill	Local sawmill	Moderate

5.2.3. Energy Resources

5.2.3.1. Charcoal

Availability

Charcoal has overtaken fuelwood as the main energy source for domestic process heat in urban and PU areas. The supply of charcoal may not be sustainable over the future if repletion of forests does not match depletion. The region with the highest production of hard-charcoal, Brong-Ahafo (about 120 - 250km north of Kumasi) is facing severe deforestation. The Government and other private and non-governmental organisations are setting up a number of tree plantations in some of the forest regions of the country. However, not many are intentionally dedicated towards fuelling the energy sector. Producers normally get wood illegally or from fallen trees and boughs. Local charcoal producers, who are pre-dominantly women, get their raw materials from sawmill residue, their main competitors being small-scale carpenters and commercial food processors. Charcoal produced from this source is called 'soft'. For households, it is readily available from vendors and can be bought in large and small quantities, although supplies sometime are short in the rainy season. Some local analysts suggest that as present policies promoted by the forestry department are aimed at reducing the activities of the timber processing firms, that there could be serious shortages of charcoal in the near future.

Significant production of hard-charcoal is now limited to a few areas of Ghana and is rapidly reducing. This type of charcoal is liable to shortages since wholesale supplies are extremely dependant on transporters from the northern districts. Locally, hard-charcoal is available on all markets and also from roadside retailers. In communities like Atonso-Agogo where there are soft-charcoal producing sites, households close to these sites buy charcoal directly from producers since market prices can be as much as a 10 - 15% higher.

Collection Time
Charcoal can be obtained within 30 minutes on the average in all PU areas.

Cost
Suppliers of hard-charcoal deliver their ware in 6 to 8-ton trucks to local markets. Their favourite places are where competition from soft-charcoal is very low such as Aburaso and Akokoamong. Retail prices range from ¢6,000 - ¢10,000 per bag. For households who can afford bulk purchases, a bag of charcoal could serve a family of five for three weeks. Unfortunately, many households can only afford to buy in small quantities. Petty vendors arrange small heaps (about 3 handfuls) of charcoal priced at about ¢200 - ¢1000. A family may need about ¢800 worth of charcoal for an evening meal. There are many soft-charcoal producers within Kumasi's PUI. Prices are between ¢6000 - ¢8000 per bag and consumption is about a bag per week for a family of five. Generally, charcoal is less expensive in very low-income remote communities such as Aburaso and Akokoamong.

Benefits
Charcoal has the reputation of being easy to combust and also safe. Most people prefer a blend of hard and soft charcoal. Availability is high almost all year round and declines slightly during the rainy seasons. Charcoal production and marketing is providing a livelihood to many.

Disadvantages
Traditional charcoal production methods are not environmentally benign. Most vegetation around such places are scorched by hot smoke. End-use devices are crude and inefficient.

Constraints
The growing demand for charcoal is a threat to its future availability. Sustainable production and use of charcoal are constrained by lack of research activities in the efficient conversion of wood to charcoal; there are too few community initiatives to establish fuelwood plantations and too many inefficient end-use devices.

Changes over time
The availability of hard-charcoal is gradually declining whilst that of soft-charcoal is increasing. The exact trend of this is not known. Generally, price escalation is about 5% per annum. The demand for this fuel far outweighs fuelwood demand. 85% of Kumasi's population depend on charcoal and requirements could exceed 65% by the year 2010. The development of the PUI is accompanied by better infrastructure, over-crowding and increasing non-indigenous settling. Each one of these factors contributes to increased charcoal usage, at the expense of fuelwood use.

Opportunities
Charcoal will for a long time remain the most favourite energy source for domestic cooking. Many research activities are required for innovative technologies in areas of the production and use of charcoal. Though quite a number of such studies have been carried out by organisations such as the University of Science and Technology, implementation has been challenged by various social and economic factors. Research rarely has a social component or community input. Therefore, new devices such as improved cook stoves have not really found a niche in communities.

5.2.3.2 Firewood

Availability

Fuelwood availability is being challenged by the escalating demand for wood products, energy and dwindling forest reserves. Places like Akokoamong and Esereso represent rural PUI's where fuelwood is in scarcity. Since there are no nearby sawmills, firewood is the only fuelwood source in these areas. Unfavourable land tenure regulations by the Government and Monarchy over forests surrounding these communities have left the villagers with little access to firewood. Aburaso is traditionally one of the chief firewood sources of Kumasi. Most of their surrounding lands are under the jurisdiction of the local Monarchy. About 65% of its households use firewood. Firewood availability is low in urban PUI's like Atonsu-Agogo where only about 10% of its families use firewood domestically. However, sawmill offcuts are easy to come by because of proximity.

Collection time
Firewood collection is generally difficult - apart from its heavy weight, it may take about 3 hours to collect firewood from the forests. In most areas, firewood sellers are sporadic and prefer custom delivery. Aburaso is one of the few communities where firewood availability is high and reliable. It could take as little as 20 minutes to reach a firewood vendor and about 3 hours to fetch from the forest. Sawmill offcuts and barks are not well used due to access difficulty to the premises of sawmills, the normally high moisture content and low density of their wood.

Cost

Firewood is free for those who fetch from forests. The market for firewood is small in the case study villages. Local vendors group firewood in sizes ranging from small head-loads to big bundles. The price of an adult head-load is about ¢2500 in rural PU areas and ¢4000 in urban PU's. A headload may serve a family for about a week.

Benefits
Woodfuel stoves are most suitable for large cooking pots. Fuel is cheap and does not require primary processing.

Disadvantages
Woodfuel stoves are sooty and difficult to light. Fuel is difficult to collect and store. Sawmill offcuts are normally low-density wood and therefore large volumes are required for cooking.

Constraints
Poor land management does not augur well for the sustainable availability of firewood. Low-tech end-devices relegate woodfuel to a low esteem. Congestion and the lack of outer kitchens in many urban PU household structures do not encourage the use of firewood.

Changes over time
Dependence on fuelwood has declined significantly over the past years. Deforestation, loss of agricultural land to developers and access restrictions to forests by the government and local chiefs are factors contributing to the decreasing supply of firewood in the case study area. In the more urban villages firewood has become scarce and increasingly difficult to collect for free (i.e. excluding the opportunity cost of labour) as farmland and bush are converted into residential areas. For example, in Dompoase villagers now have to go very deep into the bush, sometimes as far as three to five miles to get any substantial amount of wood. In Esereso it takes about three hours to fetch a headload of wood. While in the more rural villages of Aburaso and Akokamon it takes about 2 hours to collect a headload. In fact, Aburaso used to be the principal firewood supplier for Kumasi, but this has changed though some women and children still collect firewood for sale in the village and neighbouring towns.

Opportunities
Much research has been done to identify appropriate fast-growing wood for fuel. Financial and technical mechanisms are however required to implement community plantations in communities. This applies to improved firewood stoves as well. Stakeholder involvement and Government interventions are important elements.

5.2.3.3 Crop residues

The supply of crop residues, mainly maize cobs, for cooking is in decline due to the increasing urbanisation of the case study areas and consequent loss of agricultural land. A more readily available supply is found in the more rural villages.

5.2.3.4. LPG

Availability

Since the beginning of this decade, the Government has strongly publicised and encouraged the use of LPG to supplement or replace traditional fuels. This was in reaction to the huge volumes of excess LPG flared up by the countries' refinery at Tema (about 280km from Kumasi) and depleting forest resources. As much as 40% of the countries' energy requirement for cooking could be met by its LPG production. All the oil companies in the country have been actively involved in the distribution of cylinders and LPG to filling stations and other reservoirs. The private sector is also contributing significantly towards the installation of refill stations (reservoirs) and manufacture of gas cylinders and stoves. The elite or educated in urban centres have been the main recipients of these services. Generally, LPG supply is higher than consumption. Some customers prefer refills rather than the older but more popular system of exchanging empty cylinders for already filled ones shipped from Tema. This is sometimes problematic if refill points are not working due to operational problems like power outages.

Collection time

On average, there is a filling station or LPG vendor within 3km's reach in the Kumasi Metropolis. A round trip may take at most 30 minutes by public transport. Urban PU areas have better access to LPG stations or vendors - sometimes, as close as a 10 minute walk.

Cost

The price of LPG is fairly even throughout the country due to bulk transportation by oil companies. 15kg LPG cylinders are refilled (or exchanged) at a cost of ¢13,000 (¢867/kg). This may serve a family for about 6 weeks (2.5kg/week).

Benefits

The running cost of LPG is relatively very economical. Combustion is cleaner and more efficient than that of biomass and kerosene. Its good availability and easy storage can free up a lot of time spent by people in collecting/purchasing other fuels like fuelwood. LPG lanterns are also available on the market.

Disadvantages

LPG devices are potential hazards due to the highly inflammable and volatile gas. LPG fires are virtually impossible to quench unless the source is disabled. Devices on the market are not child-proof and do not have adequate safety systems. The capital cost of equipment are relatively high.

Constraints

Access to LPG services can directly improve the quality of the lives of PU inhabitants. The penetration of this technology is hampered by the following factors;

Social: The majority of PU inhabitants are resitant to LPG and often refer to previous accident cases. Most landlords would not permit the use of LPG's.

Economic: No incentives exist to promote the widespread use of LPG amongst the disadvantaged.

Technical: Lack of education and exposure may be singled out as the greatest factor prohibiting the acceptance and widespread use of LPG. The structures of most communal houses, especially in the low-income areas are without kitchens, which is a major drawback on LPG.

Changes over time

LPG has not made much impact on the PUI over the past years.

Opportunities

The key research areas are ways to make LPG devices safer and technology dissemination strategies. Social scientists and technologists will be instrumental in this venture.

5.2.3.5 Kerosene

Availability
Kerosene is the traditional fuel for lighting. Small quantities are sometimes used for starting up fires. Its resource base is the nation's oil refinery at Tema. Oil companies are the main distributors through private transporters. Kerosene is available in most filling stations and vendor shops. Quite a number of teenagers are involved in the sale of kerosene in bottles. Shortages are infrequent due to relatively low demand for this fuel.

Collection time
Kerosene vendors are within 30 minute's reach for many households.

Cost
Kerosene sells at ¢2000 per gallon at filling stations and ¢2500 at vendor stalls. Most households however purchase kerosene in bottles (640ml) from petty vendors at ¢700 per bottle. For major users, consumption is about a gallon per week for cooking and 5-6 bottles per week for lighting.

Benefits
Kerosene is neither highly inflammable nor volatile. This makes it safe to use in households. Lanterns fuelled by kerosene are easy to light and handle and serve as reliable backup lights. The high availability and affordability of kerosene is ideal for the impoverished.

Disadvantages
Kerosene devices require regular cleaning or servicing since effluence is sooty. Traditional lanterns do not produce convenient light for reading (for students). Quality lanterns such as the type that uses atomised kerosene are expensive and delicate.

Constraints
Not much attention has been accorded to kerosene utilisation by researchers, technologist and tradesmen. Grid connectivity is gradually phasing out kerosene applications in most parts of the country. It will however continue to be the favourite [backup] fuel for lighting.

Changes over time
Increasing grid access has caused a major switching over to grid electricity for lighting over the past years

Opportunities
The future of kerosene application in the country is challenged by substitution. Currently, technologists are advocating the replacement of kerosene lanterns by photovoltaic systems. Research opportunities still exist in the area of hybrid kerosene/biomass systems.

5.2.3.5. Electricity

Availability
All the villages except Akokoamong are connected to the grid, but the percentage of households without electricity varies between 5% in the more urban villages to 60% in Aburaso. The reasons given for the low number of household connection in Aburaso are the new high connection fees (650,000-700,000 cedis), coupled with low incomes in the vicinity. Moreover, with higher electricity prices and penalties for defaulting on payment, the demand and consumption of electricity, especially by low-income households may decrease.
Due to last year's national energy crisis, doubts have been raised about the reliability of supply and power cuts are a fairly regular occurrence.

The Government is determined to extend grid services to every district capital by the year 2000 and to achieve total national connectivity by 2020. At the moment 5% of electricity is consumed in rural areas. At a demand growth of 13%, electricity requirements will be 2382MW by the year 2011. This means that an additional 1400MW will be needed. Generation, transmission and distribution problems give rise to occasional power outages, which can persist for days. On average, outages are about 12 hours per week.

Cost

Electricity rates are regulated at bulk supply and retail levels. The bulk supply tariff is the price at which VRA (Volta River Authority) sells power to ECG, NED and large consumers (such as the mines and a few large manufacturing concerns). The utilities submit their tariff adjustment requests for governmental approval as and when necessary, usually on an annual basis. Tariff studies are conducted by international consultants from time to time to provide guidance to both the Government and the donor agencies, particularly the World Bank. Price regulation is also cost-based with an 8 % rate of return on net fixed assets required of ECG (by the Ghana Government) and 7.3 % on average equity employed for VRA (by the World Bank)

The 1998 domestic electricity tariffs are as follows;

Life-line monthly rate = ¢ 4,000 ($1.74) Rate ¢ 80/ unit (3.5 Cents)

RESIDENTIAL CONSUMERS

CONSUMPTION (Units)	RATE/UNIT
51 - 150	¢120 (5.2 Cents)
151 - 300	¢150 (6.5 Cents)
301 - 600	¢220 (9.6 Cents)
> 600	¢350 (15.2 Cents)

[*EXCHANGE RATE : US$ 1.00 = ¢2,300.00*]

[A unit of electricity is kWh]

Monthly electricity bills for a cross-section of the PUI vary from [illegible]000 to ¢15,000 per room or family. The lower values are for houses that are not metered and where fixed rates are paid whilst the higher range ones are for metered houses. The bill is split between individual families in metered houses based on the number and type of appliance used. People in houses without meters normally pay equal rates irrespective of what appliances are used.

Benefits

Grid electricity offers ready energy for any service demand. Since it is produced in bulk, charges are relatively low.

Disadvantages

Technically, power outages are unpredictable and can persist for days when there are generation or transmission problems. Most end-use devices such as incandescent bulbs are highly inefficient. Also, electrical fire outbreaks are likely and dangerous. Financially, connection fees are too high for most rural dwellers. Most communal houses can afford only one meter for the entire building. Therefore, bills are not too fairly shared amongst individual families. Default of payment by some families may result in the disconnection of electricity supply to the house by the utility authority. Some inhabitants complaint of faulty meters, which they believe read high. Many of them do not know how to channel such grievances to the right authority.

Changes over time

Domestic demand for electricity has increased appreciably in the PUI with widening grid access.

Opportunities

Potential research areas in electricity generation and consumption include demand/supply side management through efficiency measures and alternative generation techniques. Replacement of inefficient end-devices and power factor corrective measures could lead to tremendous energy savings. Alternative generation techniques include small hydro-dams, co-generation using biomass, and solar electricity. Decentralised systems such as photovoltaics, co-generation plants and fuel-cells are good for remote areas if technologies are robust and reliable. PU areas are most likely to face problems as demand increases. Many transformers may have to be replaced in order to meet growing PU demands for electricity.

5.2.4. Summary and Conclusion

In the selected peri-urban (PU) communities, which are representative of Kumasi's peri-urban interface (PUI), energy demand is mainly for cooking and lighting by both small-scale industries and households.

Charcoal has overtaken fuelwood as the dominant energy source for cooking in households. For small enterprises, such as canteens, fish processing and bakeries, fuelwood is still the dominant energy source for process heat. Palm kernel oil producers use the palm shells and fibre to meet all their process heat needs.

The main concern is that large volumes of precious woodfuels are required to provide process heat and crude end-use devices and combustion methods fail to deliver 80% to 90% of the total heat produced for useful purposes. A household of 5 to 8 persons uses one sack of soft charcoal per week. Charcoal production converts about one tractor-trailer load of woodfuel into 6 to 8 bags of charcoal. This means that the average family consumes a tractor load every seven weeks or about 7 tractor loads annually.

Obviously, better methods of charcoal production and domestic combustion of woodfuel are needed. Much research has been done in these areas but little has been achieved on the ground. The reason is that new devices may imply the alteration of the lifestyles of communities. The peri-urban dweller wants readily available commodities, like charcoal sold next door – or cheap/free fuel which would have little effect on profit margins - not briquettes which require some touring to find a dealer, or sophisticated/delicate stoves which require special attention, etc. Sawdust stoves are too smoky and lighting is cumbersome; transporting and storing sawdust is also impractical.

Generally, LPG is under-utilised in the country and very little is known about it in the rural PUIs. Many residents in urban PUIs have seen or heard of LPG's but in a negative light – for example, high capital costs of equipment and risks. PUIs need credit and incentive facilities to help them acquire LPG devices. The biggest constraint may be the nature of houses (most houses have only one kitchen) shared by several families and tenancy restrictions.

6. Comparative Analysis and Recommendations

The results and analysis from the studies in both Hubli-Dharwad and Kumasi have highlighted constraints to production and to the maintenance of domestic quality of life. In this section we examine these constraints for each area and make recommendations for overcoming the constraints in terms of energy resources, technologies and management options.

6.1 Energy Constraints

6.1.1 Hubli-Dharwad

In Hubli-Dharwad, the survey team found that there has been no perceived change in energy use over the last 10 years. Use of the traditional *chulla* for cooking dominates domestic energy use but fuelwood has been substituted by other combustible biomass (e.g. crop residues such as cotton stalks) as this has become available.

In general, the energy profile in this region is typical of that in the developing nations. The richer households in a community move up the ‘fuel ladder’ with increases in wealth, using higher energy density fuels and more efficient conversion technologies to meet their energy service needs than poorer people.
Even the poorest sections of the study communities express a clear preference for ‘modern’ rather than ‘traditional’ fuels and the main barrier to their achieving this is said to be the high initial capital input required to purchase new equipment.

In parallel with this, the fuel supply chain for LPG seems to be weak in terms of both availability and distribution infrastructure. LPG itself is not seen as high cost, but delivery of it is. It is not possible here to ascertain whether this is in part due to the relatively low level of demand for LPG in the study areas.

From the fact that it takes women in the poorer households roughly twice as long to collect firewood as it did five years ago, we can conclude that the availability of firewood has declined. However, it is also clear that there is no perceived shortage of firewood in the villages surveyed. Moves from the use of traditional fuels ‘up the fuel ladder’ to modern fuels such as LPG are seen as an improvement of quality of life rather than a response to a shortage of lower energy density fuels.

Research has shown that the domestic use of traditional fuels in fires for cooking can be linked to the incidence of respiratory disease in women and children. The surveys in Hubli-Dharwad suggest that combustion of crop residue is perceived as producing more smoke than fuelwood. This may well indicate that women and children in households burning crop residues are exposed to higher smoke levels than those using other fuels. This, linked to the volatility of cash crop prices and the anxieties expressed by other investigators about decreasing levels of soil fertility would suggest that the possibility of composting of these wastes should be investigated.
It is worth noting, however, that were the wastes to be removed from the fuel stream, there may be an immediate perception of shortage of cooking fuel in general.

There is a reported decrease in the ruminant population of the area and this is ascribed to decreasing availability of fodder and to recent droughts. This would suggest that the availability of cow and buffalo dung for use as both soil treatment and fuel has been curtailed. In practice, the sections of the population that collect small quantities dung on a ‘casual’ basis (e.g. as they travel towards home in the evening) seem not to be affected by this decline, and report no shortage in the dung they use to make dung cakes for starting fires.
However, there is a low level of use of the biomass plants installed in the region, and this could be linked in part to a decline in the amount of dung available to fuel these installations. The generous 70% state subsidy on the capital cost of installing these installations undoubtedly contributed to the high number found throughout the region. However, in common with many biogas programmes worldwide,

this one may have fallen into the trap of raising initial installation rates, without perhaps considering support that might be required for sustainable operation of the plants in future.

The key energy constraint linked to productive activities that the survey identified was the shortage of motive power for pumping irrigation water from boreholes and tanks onto agricultural land. While this was expressed as a shortage of *electricity* and linked to the unreliability of the electricity supply, we can reasonably assume that it is the pumping of water that the farmers need rather than the electricity *per se*.

The farmers seem to perceive that they have no choice other than to power their pumps with electricity. In part this is probably due to the fact that very low electricity tariffs have, until recently, been imposed by government across the whole of India and that linked to this there is a widespread perception that access to electricity is a human right.

With (artificially) low price levels, it is impossible for alternative power sources to compete with grid electricity, and this may be the main reason why the farmers have not considered using diesel pumps, treddle pumps, wind pumping, PV pumping etc. However, it is also worth noting that shortages of irrigation water might well become the next major constraint to agricultural production were the power problem to be solved.

Small and medium enterprises in the study areas are subject to some constraint on their fuel supplies. These are mainly linked to problems with the transportation of fuels such as coal. There is some perception that the increasing cost of fuelwood has resulted in a decline in the number of potters in one village (Mugad). However, it is reported that the demand for pottery goods has also declined over the same period, so it is difficult to see that the availability of fuel wood can be separated from this as a cause of the decline.

It is reported that *when* there are fuel shortages (which suggests that there sometimes are some), small scale producers such as brick and lime kiln operators move down the fuel ladder to use fuels with lower energy density. The survey produced no information on whether this puts pressure on sections of the population that use those fuels habitually.

Small scale productive enterprises also report problems with the unreliability of the electricity supply. However, we have no quantification of the impacts of this.

In summary, the energy constraints within the communities around Hubli-Dharwad appear to be:

1. Low income groups cannot access higher energy-density fuels and conversion technologies
2. High initial capital input required for new equipment (such as LPG stoves)
3. Weak supply chain for LPG
4. High delivery and/ or transportation costs of fuels such as coal (and LPG)
5. Reduction in local availability of firewood
6. Constraint to health of women and children due to use of ‘smokier’ crop residue fuels
7. High risk of dependence on crop residues from cash crops subject to price volatility
8. Lower availability of ruminant dung for biogas plants (and for the production of compost)
9. Other unspecified reasons for disuse of biogas plants
10. Shortage of motive power for irrigation pumping due to heavy reliance on intermittent electricity supply

6.1.2 Kumasi

In Kumasi, in contrast to Hubli-Dharwad, there has been a perceived change in domestic energy use over the last few years. In general, the survey found that there has been a shift away from the use of fuelwood for cooking to the use of charcoal.

This has been attributed mainly to the ban, by landlords, on the use of fuelwood for cooking inside their properties. However, other reasons are also cited, such as the declining availability of fuelwood and the design of new living spaces, which do not allow people room either to store fuelwood or to cook with it.

In parallel with the survey in Hubli-Dharwad, the researchers found that with an increase in wealth, households move from using traditional, low energy-density fuels to more modern fuels and conversion technologies.

In general the cash market for fuelwood around Kumasi is perceived as small and prices are quite high in the more urban settlements.

In the villages more distant from the urban centre, people use fuelwood to a greater extent, and this was linked partly to the greater availability of wood in these areas and partly to the fact that these communities are in general poorer than their more urban counterparts.

The use of crop residues as fuel has declined, mostly because increasing urbanisation of the region has been accompanied by a loss of agricultural land.

Charcoal dominates as a cooking fuel in most communities, with supplies of so-called ‘hard’ and ‘soft’ charcoal seemingly unconstrained apart from shortages during the rainy season.
‘Hard’ charcoal is produced in Northern Ghana and transported to Kumasi for sale. ‘Soft’ charcoal is manufactured locally from off-cuts from the timber industry. It is possible that future restrictions on the activities of timber processing companies may result in a decline in the amount of soft charcoal available.

Wealthy families are more likely to use modern fuels such as kerosene for cooking in the more urban regions of the study area. In the rural villages it was perceived as expensive. No shortages were reported in either kerosene or LPG, which is the fuel of choice for the wealthier owner-occupiers who were not subject to restrictions on fuel choice by their landlords.

The electricity supply is unreliable, and there are frequent power cuts. Electricity tariffs have recently risen, due to the restructuring of the electricity industry by the government. Connection costs are high and this is cited as the main reason why poorer households do not have an electricity supply.

In summary, the energy constraints within the communities around Kumasi appear to be:

1. Low income groups cannot access higher energy-density fuels and conversion technologies
2. Bans by landlords on the use of fuelwood and LPG for cooking
3. Shortages of fuelwood
4. Lack of space for storage and use of fuelwood
5. Shortages of crop residues for fuel use due to increasing urbanisation and a loss of agricultural land.
6. Shortages of charcoal during the rainy season
7. Risk of constraint to ‘soft’ charcoal supply once government restrictions imposed on the timber industry
8. High initial capital input required for new equipment
9. Electricity supply unreliable
10. High connection costs and tariffs for electricity.

6.1.3 Common Constraints

It is apparent that, of the two study regions, Kumasi displays signs of being more advanced in the ‘urbanisation’ of its energy use. Villages in Hubli-Dharwad are reliant on locally produced fuelwood and crop residues to a much greater extent than those in Kumasi, and may therefore have more autonomy when it comes to switching between supply chains. The reliance on charcoal in Kumasi is typical of urban communities in the developing nations.

While some energy constraints observed by the research teams are particular to the communities under investigation, some are common to both regions.

In particular these are:

- Low income groups cannot access higher energy-density fuels and conversion technologies
- High initial capital input required for new ('modern') equipment
- Electricity supply unreliable
- Decline in availability of fuelwood.
- Dependence on 'residue' fuels is high risk due to external threats to supply chain

6.2 Recommendations

In this section we recommend future actions that we believe should be pursued in the light of the findings of this study.

For each of the two study areas, we divide the recommendations (where appropriate) into:

1. *Direct Actions* : Actions we believe could be carried out in the study areas themselves;
2. *Intermediate Actions :* Actions we suggest could be carried out both with participants in the study areas and with intermediary bodies working to achieve development goals within the region; and

We conclude the section with a set of recommendations for DFID.

6.2.1 Recommendations for Actions in Hubli-Dharwad

Direct actions

Within Hubli-Dharwad itself the study has highlighted five main areas for action to overcome energy constraints:

1. Investigation of the possibility of a programme to develop and use an improved *chulla*, in participation with local manufacturers and users;
2. Revitalisation of the biogas programme, with an emphasis on supporting (perhaps rewarding) the *output* of the plants rather than the installed capacity;
3. Investigation of the possibility of an improved LPG supply chain, with the particular aim of increasing access of the poorer households to LPG as a fuel and to low-cost LPG stoves;
4. Demonstration of a range of irrigation pumping systems using treddle pumps, wind power and PV as sources of motive power;
5. Energy efficiency actions developed participatively with brick and limekiln makers and users.

In addition to these actions, we recommend that:

- An investigation is carried out of the relative cost/ benefits of processing ruminant dung and crop residues for fertiliser and using it for energy production.

Intermediate actions

Within Hubli-Dharwad, in participation with intermediary organisations, we recommend that the following actions are undertaken:

1. Capacity building in energy efficiency in the small scale productive sector, in order to improve industry efficiency in terms of both energy use and cost;

2. Development of Financing Options (such as micro-credit, revolving funds, etc) for small scale enterprises and households to allow them to overcome capital barriers not only to acquiring 'modern' energy conversion equipment but also to other equipment that would improve their productivity and quality of life.

6.2.2 Recommendations for Actions in Kumasi

Direct Actions

Within the study areas around Kumasi we recommend:

1. The setting up of a participative research and promotion programme for the use of sawdust waste as an energy resource, including the participative development and promotion of sawdust briquette stoves, sawdust briquetting procedures etc;

2. An investigation into the possible energy impacts of the restrictions that may be imposed by government on the timber industry.

3. An investigation together with the local electricity supply utility and consumer associations of low-cost options for grid connection, learning from international experience, such as that of the ESKOM corporation in South Africa (which has pioneered the use of ready boards, pre-payment meters etc); and

4. Demonstration of the use of renewable energy resources (such as low-cost PV devices) to provide power for lighting and entertainment, including a participative investigation of the possibility of local manufacture of low-cost devices such as PV-powered lanterns and radios.

Intermediate Actions

Together with intermediary bodies in the Kumasi region we recommend that:

1. An investigation is carried out into ways of changing restrictions imposed by landlords on fuel choices such as LPG. This investigation could include options such as: investigating the perceived risk together with landlords; improving building safety standards; improving LPG appliance safety standards; a safety campaign for residents; the awarding of permission to use LPG on agreement of standards of use and regular inspection;

2. Links are established between community forestry programmes and charcoal production.

6.2.3 Recommendations for future research for DFID

We recommend that two pieces of work are carried out that are non-specific to the study regions:

1. Further investigation is carried out of the risks inherent in dependence on 'residue' fuels (such crop residue and timber residue). However, in the light of the fact that the researchers identified 'survey fatigue' as a problem, at least in Hubli-Dharwad, we recommend that the

investigation is carried out in such as way that there is some direct benefit to the communities concerned.

2. DFID investigate in an ongoing way how the transition settlements make from being characterised as 'rural' to being characterised as 'urban' can be managed more effectively in terms of energy use and supply. We believe that this study has provided the study team with an unique opportunity to experience the way in which the NR and Energy sectors can interact, which has been a valuable learning experience in both cases. In the light of this, we recommend close links between the Departments in DFID concerned with the development of Natural Resources and the development of Engineering Capacity.

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APPENDIX 1

GENERAL VILLAGE GROUP INFORMATION

VILLAGE PROFILE

1. Name of the village______________________ Gram Panchayat_____________________

2. Population

	Total	SC	ST	Above poverty line	Below Poverty Line
Population					
Households					

3. Sex Ratio:

4. Literacy rate: (%age or numbers) - Male ________ Female_________

5. Occupational Pattern of the village:

	Farming	Agril labourers	Process industries	Industrial units	Service jobs
Population					
Households					

6. Landuse Pattern:

Landuse Type	Area
Cultivated-Irrigated	
Cultivated Non-Irrigated	
Cultivable-waste	
Village Common Lands	
Forest	
Uncultivable Lands	
Total	

7. Industries:

Types	No.	Capacity	No. of local persons employed		Working days
			Male	Female	

8. Civic Infrastructure in the Village and accessibility:

Infrastructure	**Number**	**Accessibility (Distance from the village)**
Post Office		
Telecommunications (Local and STD facility)		
Police Station		
Nearest Market		
Nearest Bus Stop		
Nearest Railway Station		
No. of Electrified Houses		
Health Care Facilities - Public Health Centres - No. of hospital beds - No. of doctors - No. of nurses - Medical Shops - Mobile hospital - Health camps - Private Clinics - Private Doctors		
Veterinary Hospitals		
Frequency of public transport to Hubli-Dharwad		
Drinking water facility - Wells - Hand Pumps - Distance Covered for fetching water - Water quality - Availability of water		
Input suppliers - Fertilizers - Seeds - Pesticides/insecticides - Implements		
Educational Institutions (also collect no. of students and teachers) - PS - MS - HS - PUC - Degree		

9. Agricultural Pattern - Crops cultivated and outputs (1998) (Mention if large variation over the last 5 years)

Crop	**Varieties**	**Season (K/R/S)**	**Irrigated/ Unirrigated**	**Area (Ha)**	**Yield of main produce (ton/acre)**	**Type/s and Yield of subsidiary produce**

10. Kind of Houses: Total________, Thactched_________, Mud Houses_________, Pucca___________

11. Asset Ownership:

Assets	Numbers
Tractors	
Pumpsets	
Bicycles	
TV Sets	
Radio	
Others	

12. Land ownership pattern

- Marginal & Small Landowners
- Medium landowners
- Large landowners
- Landless

13. Government Schemes in operation in the Village:

a)
b)
c)
d)

14. Live stock population:-

Livestock	No. of animals	Stall fed	Grazing
Cattle			
Sheep			
Goats			
Others			

Fuel Consumption:

Fuel Type	Used for (with %age usage for each service)	Combustion device	No. of families using

Fuel Source (Supply):

Fuel Type	Consumption (kgs/week)	Bought		Collected		Generated	
		Qty	From	Qty	From	Qty	From

If collected

Fuel type	Who collects	Time Taken	Frequency	Labour charges	Transportation

If purchased

Fuel type	Who buys	Frequency	Quantities Bought per transaction	Cost per unit	Any exchange	Lead time

If generated

Fuel type	Quantity generated	Consumed	Manure	Burnt	Given away (to whom)	Sold	selling price	Sold to

Changes in time:

Fuel type	Changes				Why?
	Cost (when & by how much)	Availability (when & by how much)	Source of fuel (when)	Collection time	

1. How have the above changes affected your consumption pattern?

Scarcity:

1. Have you ever experienced any scarcity in fuels' supply?

1a. If yes, which fuel, when and why?

1b. How did you cope with the fuel shortages?

Availability:

1. Is it easily available? Can you always get it?

2. What if it is not available (in near past or in future)?
   - Change over to new/alternate fuel
   - Consume less of same fuel
   - Buy at higher cost or by spending more resources such as labour, time
   - Others

3.1. <u>If you change over to new/alternate fuel:</u>

3.1.1. which fuel do you change to?

3.1.2. How much does it cost?

3.1.3. Is it easily available?

3.1.4. Do you like using this fuel? Why?

3.1.5. What don't you like about it?

3.2. <u>If you consume less of same fuel:</u>

3.2.1. How do you try to use less fuel?

3.2.2. Does this have any impact on your family?

3.3. <u>If procured by spending more resources:</u>

3.3.1. How do you fulfil your requirement?

3.3.2. Do you spend more time in collection/purchase (relative increase)?

3.3.3. (Consider other associated impacts)

3.4. POTENTIAL DEMAND: Would you like to use more of it, or use it for something else in your home too – if you could afford it or it was more available?

Alternate Uses:

1. Is there any other use of fuel sources?

2. What are these other uses and how important are these?

<u>Change in Fuel Consumption:</u>

1. Have you always used these fuels?

1.1. If yes - Do you use it more now? How much more? WHY and WHEN did you start using more?

1.2. If not – what did you use instead? WHY and WHEN did you change over?

1.3. If not – where and how did you get the old fuel?

1.4. What were the benefits / disadvantages of the old fuel?

1.5. Have many people in the village changed to this fuel? How many? In how many years?

1.6. Has anything in village changed because of this? What, Why, How?

Preferred Fuel:

1. What would you like to use for each service (or what are your preferred fuels) & why:

Cooking	Water Heating	Lighting	Any other use

2. What fuels / other "energies resources" would you like to be available in this area?

3. What is stopping you or the village using/getting these fuels?

4. What are the advantages and disadvantages of using these fuels?

5. How much extra would you be prepared to pay to use this fuel?

Consumption Pattern among the poor:

1. Does the consumption of fuels vary across different income groups?

2. If yes, how & why?

Conversion devices

1. How much did it cost?

2. How long have you had it?

3. What did you use before (before whatever he is using now)?

4. Why did you change over?

5. What do you like about the new? What don't you like about it?

6. What would you prefer to have (type or model)? Why?

7. ABILITY TO PAY: How much would you pay for it?

USE OF BIOMASS

Fuel	Units	Availability (Quantity)	Domestic Fuel Usage/ Consumption				Fodder	Industrial	Thatching	Mulching	Total	Burnt	Sold	In
			Cooking	Water Heating	Space Heating	Total								

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APPENDIX 2

HOUSEHOLD SURVEY QUESTIONNAIRE

Name: Age:

Address: Caste:

Education: Occupation:

No. of Family Members: Adults: Children:

No. of Earning Members: Their Occupation:

Land owned (ha):

Crops Cultivated (with acreage):

Crops	Area under cultivation	Yield

Fuel Consumption:

Fuel Type	Used for	Combustion device

Source of fuel:

Fuel Type	Consumption (kgs/week)	Bought		Collected		Generated	
		Qty	From	Qty	From	Qty	From

If collected

Fuel type	Who collects	Time Taken	Frequency	Labour charges	Transportation

If purchased

Fuel type	Who buys	Frequency	Quantities Bought per transaction	Cost per unit	Any exchange	Lead time

If generated

Fuel type	Quantity generated	Consumed	Manure	Burnt	Given away (to whom)	Sold	selling price	Sold to

Changes in time:

Fuel type	Changes				Why?
	Cost (when & by how much)	Availability (when & by how much)	Source of fuel (when)	Collection time	

What have been in the impacts of above-mentioned changes?

Scarcity:

1. Have you ever experienced any scarcity in fuels' supply?

1a. If yes, which fuel, when and why?

1b. How did you cope with the fuel shortages?

Availability:

2. Is it easily available? Can you always get it?

3. What if it is not available (in near past or in future)?

- Change over to new/alternate fuel
- Consume less of same fuel
- Buy at higher cost or by spending more resources such as labour, time
- Others

3.1. If you change over to new/alternate fuel:

3.1.1. Which fuel do you change to?

3.1.2. How much does it cost?

3.1.3. Is it easily available?

3.1.4. Do you like using this fuel? Why?

3.1.5. What don't you like about it?

3.2. If you consume less of same fuel:

3.2.1. How do you try to use less fuel?

3.2.2. Does this have any impact on your family?

3.3. If procured by spending more resources:

3.3.1. How do you fulfil your requirement?

3.3.2. Do you spend more time in collection/purchase (relative increase)?

3.3.3. (Consider other associated impacts)

3.4. POTENTIAL DEMAND: Would you like to use more of it, or use it for something else in your home too – if you could afford it or it was more available?

4. Preferred Fuel

4.1. What would you like to use for each service (or what are your preferred fuels) and why:

Cooking	Water Heating	Lighting	Any other use

4.2. What fuels / other "energies resources" would you like to be available in this area?

4.3. What is stopping you or the village using/getting these fuels?

4.4. What are the advantages and disadvantages of using these fuels?

4.5. How much extra would you be prepared to pay to use this fuel?

5. Changes in time

5.1. Have you always used these fuels?

5.1.1. If yes - Do you use it more now? How much more? WHY and WHEN did you start using more?

5.1.2. If not – what did you use instead? WHY and WHEN did you change over?

5.1.3. If not – where and how did you get the old ?

5.1.4. What were the benefits / disadvantages of the old fuel?

5.1.5. Have many people in the village changed to this fuel? How many? In how many years?

5.1.6. Has anything in village changed because of this? What, Why, How??

6. Conversion devices

6.1. How much did it cost?

6.2. How long have you had it?

6.3. What did you use before (before whatever he is using now)?

6.4. Why did you change over?

6.5. What do you like about the new? What don't you like about it?

6.6. What would you prefer to have (type or model)? Why?

6.7. ABILITY TO PAY: How much would you pay for it?

Income indicators:

1. What do you spend on food per week?

2. What do you spend on other things: school, health, transport.

3. What do you spend on fuel per week

4. OBSERVATION: what assets? Electrical appliances?

Selling of surplus biomass

a) Do you sell/sold biomass Yes________1, No __________2.

b) If yes, sold/sell what? ___________________ Sold/sell to Whom __________________________
Price/unit quantity ___________________

c) Quantity/price picked by buyer from field or you transport?
1) Picked by purchaser from field
2) Transported by self

a) Method of transportation _________________________ Cost of transportation __________

b) Time of sale?
Immediately after harvest _____________1

Much later after harvest (occasion?) _____________2

Disposal by burning

a) Do you dispose by burning? Yes _________1, No _________2.

b) Which type of material do you burn?

c) Time when burnt
Immediately after harvest _______________________1

Much later after harvest _____________________2, (specify months)__________________

d) Place where disposed-
in the field ______________________
Others specify ______________________

c) If the biomass is not removed, burnt, sold or used elsewhere, reasons:

	Reasons	**Rank**
Manurial value		
No purchaser		
Other reasons specify		

Role of Women

What is the role of women in household energy management?

APPENDIX 3

INDUSTRY SURVEY QUESTIONNAIRE

1. Village Name : ……………………… Gram panchayat: …………………………
2. Type of industry: ………………… Year of Commencement:………………….
3. Name of the Owner:
4. Production :

PRODUCT	RAW MATERIAL	SEASON	

Fuel Consumption:

Fuel Type	Used for	Combustion device

Source of fuel:

Fuel Type	Consumption (kgs/week)	Bought		Collected		Generated		Stocks maintained
		Qty	From	Qty	From	Qty	From	

If collected

Fuel type	Who collects	Time Taken	Frequency	Labour charges	Transportation

If purchased

Fuel type	Who buys	Frequency	Quantities Bought per transaction	Cost per unit	Any exchange	Lead time

If generated

Fuel type	Quantity generated	Consumed	Manure	Burnt	Given away (to whom)	Sold	selling price	Sold to

1. When do you generate the above mentioned resources?

Changes in time:

Fuel type	Changes				Why?
	Cost (when & by how much)	Availability (when & by how much)	Source of fuel (when)	Collection time	

What have been in the impacts of above-mentioned changes?

Scarcity:

1. Have you ever experienced any scarcity in fuels' supply?

1a. If yes, which fuel, when and why?

1b. How did you cope with the fuel shortages?

Availability:

2. Is it easily available? Can you always get it?

3. What if it is not available (in near past or in future)?
   - Change over to new/alternate fuel
   - Consume less of same fuel
   - Buy at higher cost or by spending more resources such as labour, time
   - Others

3.1. If you change over to new/alternate fuel:

3.1.1. which fuel do you change to?

3.1.2. How much does it cost?

3.1.3. Is it easily available?

3.1.4. Do you like using this fuel? Why?

3.1.5. What don't you like about it?

3.2. If you consume less of same fuel:

3.2.1. How do you try to use less fuel?

3.2.2. Does this have any impact on your family?

3.3. If procured by spending more resources:

3.3.1. How do you fulfil your requirement?

3.3.2. Do you spend more time in collection/purchase (relative increase)?

3.3.3. (Consider other associated impacts)

3.4. POTENTIAL DEMAND: Would you like to use more of it, or use it for something else in your home too – if you could afford it or it was more available?

Preferred Fuel

4. What would you like to use for your operations (or what are your preferred fuels) and why:
   -
   -
   -
   -
5. What fuels / other "energies resources" would you like to be available in this area?

6. What is stopping you or the village using/getting these fuels?

7. What are the advantages and disadvantages of using these fuels?

8. How much extra would you be prepared to pay to use this fuel?

9. Changes in time

9.1. Have you always used these fuels?

9.1.1. If yes - Do you use it more now? How much more? WHY and WHEN did you start using more?

9.1.2. If not – what did you use instead? WHY and WHEN did you change over?

9.1.3. If not – where and how did you get the old ?

9.1.4. What were the benefits / disadvantages of the old fuel?

9.1.5. Have other similar industries changed to this fuel? How many? In how many years?

9.1.6. Has anything in village changed because of this? What, Why, How??