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Final Report to the Natural Resources Institute

# A Review of Energy Utilisation in Peri-urban Production Systems

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**Final Report to the Natural Resources Institute**

# A Review of Energy Utilisation in Peri-urban Production Systems

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# EXECUTIVE SUMMARY

## PURPOSE

ODA have identified the peri-urban interface as one of the targets for sectoral research support within the Natural Resources Systems Programme. The purpose of the NRSP programme is the improved management of peri-urban resources, optimised through a combination of improved productivity and energy efficiency; intensified crop production on a sustainable basis; productive potential increased by greater use of "waste" materials and recycling of resources. This project is in response the call for concept notes issued by the NRSP Production System Leader dated 2 August 1995. The work is, therefore, demand-led at the level of one of the main purposes of the NRSP, which reflects the perceived needs of developing countries in this topic. This project is aimed specifically at an identified need in the NRSP Peri-urban Interface Production System Programme.

The purpose of this project is to provide the required background information and literature review on the methods of assessing the efficiency of energy utilisation for the peri-urban system as a whole. The analytical review aims to identify technologies which can be used most cost-effectively for increasing the availability of energy resources, and for improving energy efficiency in the context of the peri-urban interface.

## RESEARCH ACTIVITIES

This study comprises an analytical literature review of the opportunities for, and constraints on, peri-urban production systems which might be incurred through the adoption of new energy supply and utilisation technologies and strategies. It identifies the relevance of technologies and strategies on five key aspects of socio-economic development, namely: household choices, gender issues, energy markets, environmental impacts and market acceptance. A wide range of traditional and alternative energy supply options have been examined, including those providing heating, electricity and motive power and substitutions between human, animal and mechanical power. In addition, methods for improved end-use of energy have been considered.

## OUTPUTS

### Analysis matrix

The review establishes a simple matrix for the analysis and selection of the most appropriate technologies and energy management options for peri-urban production systems. The input/output matrix has the technical options/approaches as one axis and the impacts of each option on demand side issues as the other axis.

### Conclusions

For developing countries to improve productivity and the standard of living, the focus of energy planning and energy supply should be on appropriate technologies compatible with sustainability, environmental protection, reliability, affordability and general development. An energy transition is needed which involves a movement away from inefficient use of biomass fuels, towards biomass used more efficiently and sustainably, along with the use of renewable energies and fossil fuels. Appropriate incremental steps have a better chance of resulting in a more sustainable energy system, in contrast to large jumps from traditional fuel to commercial fuels used in many western countries.

The peri-urban interface is by definition an area undergoing transition, which means energy demand is complex. Complex situations require a combination of energy resources and energy technology. The integration and management of both traditional and modern energy sources will be needed to satisfy the specific energy needs and rapidly changing character of peri-urban areas.

An additional "rung" on the energy ladder is needed to help close the gap between traditional and commercial energy systems in peri-urban areas. One way of achieving a more sustainable energy system in peri-urban areas would be to develop decentralised grids based on appropriate and renewable energy technologies. This would avoid placing additional demands on the urban grid which in many cases is already under strain, poorly managed, inefficient and barely capable of meeting the demands of the urban population.

It is difficult to evaluate energy options on a general basis due to the rapidly changing and wide ranging characteristics of peri-urban areas. Case specific analyses need to be carried out.

## CONTRIBUTION OF OUTPUTS

Based on the analysis and conclusions, the following observations and recommendations have been made to help identify ways in which peri-urban resources can be utilised more efficiently. Better management of pen-urban energy resources has the potential to improve quality of life by reducing poverty, suffering and deprivation. As peri-urban areas will be the focus of population growth over the next 20-30 years, such improvements will be of great importance, and will help contribute significantly towards ODA goals. Development of the peri-urban interface will in particular help fulfil objectives under the Natural Resources Systems Programme (NRSP).

### Observations

Future research projects regarding the peri-urban production system should consider the following points:

1. Future programmes need close involvement of local communities at all stages.

2. There should be more attention on social and cultural issues and implications.

3. The role of women should be central to all energy projects. The benefits to women and children should be given proper consideration along with other socio-economic factors when planning and implementing schemes.

4. Energy resource sustainability and environmental protection need to be high on the agenda in order to encourage and support development in a more sustainable way.

5. Appropriate investment and financial support needs to be provided, including loan systems which will allow farmers and the peri-urban community to invest in more efficient and appropriate energy technologies and modern fuels.

6. A series of small steps rather than big leaps in technology are more likely to be successful in pen-urban production systems due to the dynamic nature of peri-urban areas and lack of investment funds.

7. A mix of traditional and conventional energy sources and technologies should be considered, recognising the continued importance of biomass, and introducing a range of options that can be adopted as the peri-urban interface changes.

8. Energy options need to be appropriate, sustainable, affordable and efficient.

**Recommendations**
This review identified gaps in knowledge where useful work could be carried out.
Recommendations for further research have been made as follows:

***Understanding the needs and characteristics of the peri-urban interface***

- Case studies should be carried out with filed work in peri-urban areas to identify specific energy service needs and transport needs. The dynamic nature of peri-urban areas should be analysed and potential demand for energy identified.

- Gender specific regional review should be carried out in peri-urban areas with regard to the energy sector and the transport sector.

- An analysis should be carried out to identify the impact of energy transition and economic transition in the peri-urban areas on social and cultural issues.

- A study of the commercial fuel market in peri-urban areas should be carried out, with the aim of identifying ways of improving and developing the market structure (e.g. reducing shortages and black market pricing).

***Identifying appropriate energy options***

- A methodology needs to be developed, and criteria identified, which is capable of evaluating the multiple benefits associated with different energy options (e.g. health, education, general development, resource stability, productivity and environmental protection).

- A more detailed analysis matrix needs to be developed which can evaluate the potential of specific energy options to meeting specific energy service requirements.

- A study needs to be carried out to identify and assess the benefits associated with farmer co-operative agroprocessing plants and collective transport. The conditions needed to encourage farmer co-operatives also need to be identified.

- Technical aspects of linking decentralised grids in developing countries needs further research.

***Improving the success of strategies and programmes***

- A study of critical success factors, specific to peri-urban areas, should be carried out with respect to selection, adoption and implementation of sustainable energy options.

- A study should be carried out to identify the most appropriate levels of local participation, monitoring, evaluation, education and training, which are required if programmes are to be successful.

- A detailed analysis of appropriate financial measures for peri-urban production systems needs to be carried out.

# CONTENTS

# 1. BACKGROUND

## 1.1 BACKGROUND TO THE STUDY

The peri-urban interface is characterised by strong urban influences, easy access to markets, services and other inputs, ready supplies of labour, but having relative shortages of land and being subject to risks from pollution and urban growth. The efficient management of the beneficial resources available to domestic, agricultural and industrial sectors at the peri-urban interface is sub-optimal as a result of environmental degradation, inefficient use of energy and low productivity rates. Research aimed at finding and implementing technical and other solutions is needed **in** order to improve the quality of life and reduce poverty **in** low income countries. This fits the goals identified in the ODA's Renewable Natural Resources Research Strategy (RNRRS).

At the present moment there is an emerging interest in cities which are seen as the leading edge for development opportunity. Cities represent the areas of greatest demographic growth and currently enjoy an effective subsidy in energy from rural areas. They are also the niche where, because energy services are already monetarised and cultural change is most rapid, technological change is most likely to succeed.

The urban areas of developing countries are increasingly powerful magnets for rural dwellers who come to urban areas in search of new livelihood opportunities. The majority of the rural-urban migrants will settle on unplanned residential areas on the urban fringes, thus making up a large proportion of the peri-urban population. On arrival at the urban zone, new opportunities will arise in household production systems, but there will also be new constraints. The poor generally cope with these constraints through complex survival mechanisms based on communal organisation which maximise the few opportunities open to them, making otherwise impossible situations tolerable or opening doors to social and material advancement (Williams, 1993). An additional important aspect to the peri-urban system is that many settlers from the rural areas are expected to send remittances back to their areas of origin, thus contributing to the hardship and poverty of peri-urban life.

For the peri-urban poor, satisfying their energy needs is just one of the many challenges of daily life. It is also necessary for this group to secure the essential needs of food, shelter, water, health care, transport and education, most of which may have been free or provided by the community in the rural areas where they came from. Thus meeting basic needs is a struggle which is as severe as, if different in nature to, that facing the rural poor (Williams, A, 1993).

In determining national supply-demand energy balances for developing countries, there is usually a distinction between urban and rural household consumption. Rarely, however, is the total urban energy system considered by itself, although there are some early examples of urban ecological accounting for India. Transport and industrial energy use are usually accommodated in a national demand aggregation and not specified in an urban sectoral manner.

Previous research in this field has tended to concentrate on the energy efficiency of supply and end-use in either rural or urban settings, and has failed to take account of the particular needs of the pen-urban interface. Traditional fuels in rural areas and the modern-traditional mix in pen-urban areas are relatively understudied. Whilst much can be learnt from the technologies, implementation strategies and operating experiences of energy efficiency technologies in either rural or urban settings, it is necessary to establish a new methodology and a clear set of criteria for the analysis and selection of the most appropriate technologies and technology transfer mechanisms for the peri-urban interface.

## 1.2 THE PERI-URBAN INTERFACE

In the last five years there has been much talk of the peri-urban interface and an acknowledgement that issues of production and consumption that relate to peri-urban areas are neither urban or rural in character, but an amalgamation of the two. In all the discussions surrounding the peri-urban interface there has not been, as yet, a working definition put forward. This is partly due to the fact that each sector of the system, be it agriculture, health or energy, has different connotations and characteristics that are apparent in the peri-urban areas. It is also partly due to the range of conditions that exist in urban areas in different cities in developing countries.

Problems of definition also arise if one is looking at the area under urban influence (which supplies the urban area) or the urban fringe (which is the area of demand). The latter is a very dynamic and fluid system which may also supply its own population; for example the rise in milk production in the urban fringe in southern Delhi has meant that it is partly supplying the local population's energy needs, in the form of dung.

The sphere of urban influence decreases in various stages from the immediate urban area to what may be an essentially rural environment on the peri-urban fringe. On the fringe of the peri-urban environment, the connection to the urban area may be related only to changing systems of production (i.e. in agricultural production systems) to access the large urban market. A distinction can be made between peri-urban *urban* and peri-urban *rural.*

Peri-urban areas can widely vary in terms of their land use and planning systems. In many cities in developing countries the urban fringes are set aside specifically for industrial development or expansion which have very stringent planning regulations. In other cities however the urban fringe is an area which is characterised by the expansion of unplanned, low-income housing. There are therefore many different peri-urban conditions, which change as urban areas grow.

Peri-urban environments may frequently be characterised by rapid growth of settlements accompanied by housing shortages, pressure on all forms of infrastructure and increased poverty levels (Williams, 1993). Energy planning in these areas will thus need to occur against a background of great complexity and change.

In terms of energy use in the urban fringe, the consumption patterns will be urban in character but will be superimposed on the characteristics of the particular peri-urban area. These include the energy consumption patterns of low, middle and high income groups.

Although a spatial definition is difficult, a practical definition of the peri-urban area would be the interface between the rural and urban environment where an individual can reach a range of urban services using non-motorised transport (e.g. a bicycle) and is able to return to the home in one day.

On a macro-level, the peri-urban environment is the mixing point of the rural system and the urban system, on a micro-level there are countless variations and characteristics which are particular to the specific urban/rural situation. The latter point makes any specific definition difficult. For this reason, the reviewed literature used a range of different definitions when commenting on issues which relate to the peri-urban interface, including reference to rural and urban areas. Where issues were relevant to peri-urban areas, the literature was assumed to be generally applicable to the periurban interface as described in this report.

# 2. PROJECT PURPOSE

ODA have identified the peri-urban interface as one of the targets for sectoral research support within the Natural Resources Systems Programme. The purpose of the NRSP programme is the improved management of peri-urban resources, optimised through a combination of improved productivity and energy efficiency; intensified crop production on a sustainable basis; productive potential increased by greater use of "waste" materials and recycling of resources. This project is in response the call for concept notes issued by the NRSP Production System Leader dated 2 August 1995. The work is, therefore, demand-led at the level of one of the main purposes of the NRSP, which reflects the perceived needs of developing countries in this topic. This project is aimed specifically at an identified need in the NRSP Peri-urban Interface Production System Programme.

The purpose of this project is to provide the required background information and literature review on the methods of assessing the efficiency of energy utilisation for the pen-urban system as a whole. The analytical review aims to identify technologies which can be used most cost-effectively for increasing the availability of energy resources, and for improving energy efficiency in the context of the peri-urban interface.

# 3. RESEARCH ACTIVITIES

## 3.1 LITERATURE SEARCH

A literature search for this review was carried out using a range of printed , CD and electronic information sources, along with personal communications with organisations and institutions.

*Printed Indexes*

- Compendex
- Science Citation Index
- Social Science Citation Index

*CD Rom*

- ETDE (energy database)
- CAB Abstracts (agriculture and Landuse)

- TreeCD (forestry)
- BIDS (Bath Information and Data Services) Science Citation Index
  Social Science Citation Index
- First Search (access to bibliographic databases) Science database
  Social Science database

*Electronic*

- Internet (sites listed in detail in Annex D)

*Personal communications included:*

- World Bank (Washington)
- Stockholm Environment Institute (Sweden)
- Environment Unit, Leeds University
- International Institute for Environment and Development (London)
- Natural Resources Institute
- ETC Mozambique (Maputo)
- Energy Unit (ETC Netherlands)

Peri-urban issues cover many disciplines, so it was very difficult to focus the literature searches. Finding relevant case study literature in the public domain proved difficult, hence the analytical review was unable to be as specific as intended. Generalisations had to be made with regard to the potential for alternative energy technologies for improving energy utilisation in peri-urban production systems.

The study of peri-urban areas is a new field and hence, some gaps were identified in the literature. Recommendations for further research have been made, in order to fill these gaps in knowledge.

### 3.2 ANALYTICAL REVIEW

The analytical review (which can be found in Annex A of this report), looks at the opportunities for, and constraints on, peri-urban production systems which might be incurred through the adoption of new energy supply and utilisation technologies and strategies. It identifies the relevance of technologies and strategies on five key aspects of socio-economic development, namely: household choices, gender issues, energy markets, environmental impacts and market acceptance. A wide range of traditional and alternative energy supply options have been examined, including those providing heating, electricity and motive power and substitutions between human, animal and mechanical power. In addition, methods for improved end-use of energy have been considered.

The options considered are divided into demand and supply issues. Demand issues cover the social, environmental and economic impacts of energy options in peri-urban areas. They are considered under the following headings:

- household livelihood strategies;
- gender issues;
- the structure of pen-urban energy markets;
- energy costs;
- environmental and social impacts of energy use;
- participation and energy demand;
- indigenous knowledge and energy planning.

Supply side issues cover a range of traditional and alternative energy options for light, heat shaft power and transport.

The review considers improved energy utilisation in peri-urban production systems which include: increased agricultural production; energy for improved household production and consumption strategies; and energy for general development, including community development and access to markets via transport. The energy supply options considered include the following:

- substitutions between human, animal and mechanical power;
- farmer production of energy - traditional and `modern' biomass resources;
- access to "urban" energy sources - grid electricity, fossil fuels, energy from waste
- alternative energy technologies - renewable energy sources, decentralised grids
- energy utilisation strategies - energy management, appropriate technology/fuel
- changing rural/urban transport modes.

## 4. OUTPUTS

### 4.1 MATRIX EVALUATION OF ENERGY OPTIONS

Two matrices were used to assess the potential of different energy options for improving productivity and energy utilisation in peri-urban production systems. One matrix deals with energy used for light, heat and shaft power on farms, in households and for general development (the energy matrix), and the other matrix deals with energy used for transporting produce and people to markets (the transport matrix).

Ratings given in the following two matrices are only rough indications of the potential for each option to satisfy demand side issues relating to transport or energy requirements. The scores are summed in the final column to show relative potential as follows: A total score of 6 indicates low potential for all demand side issues in the matrix
A total score of 12 indicates an average of medium potential for the group of demand side issues
A total score of 18 indicates high potential for all demand side issues in the matrix

# PERI-URBAN ENERGY MATRIX

Potential to increase productivity in peri-urban production systems by contributing towards a sustainable energy system and addressing issues of demand: I - Low potential, 2 - Medium potential, 3 - High potential (An explanation of total score is on the previous page).

| | Demand side issues | | | | | | |
|---|---|---|---|---|---|---|---|
| **Energy supply options** | **household** strategy | gender issues | **market structure** | knowledge and | **environmental** impact | **cost/ economics** | **Total** |
| Wood | 3 | 2 | 3 | 3 | 2 | 3 | 16 |
| Charcoal | 3 | 2 | 3 | 2 | 2 | 3 | 15 |
| Kerosene | 2 | 2 | 1 | 2 | 1 | 2 | 10 |
| Diesel | 2 | 2 | 1 | 2 | 1 | 2 | 10 |
| LPG | 2 | 2 | 1 | 1 | 1 | 1 | 8 |
| `modern' biomass resources | 3 | 3 | 3 | 2 | 3 | 2 | 16 |
| Anaerobic digestion (agricultural residues, human /animal waste, industrial effluent) | 2 | 2 | 2 | 2 | 3 | 2 | 13 |
| Hydro power | 1 | 2 | 1 | 1 | 2 | 2 | 9 |
| **Wind pumps** | 2 | 2 | 3 | 2 | 3 | 2 | 14 |
| Wind turbines | 1 | 2 | 1 | 1 | 3 | 1 | 9 |
| Solar thermal | 3 | 3 | 2 | 2 | 3 | 2 | 15 |
| Solar PV | 3 | 2 | 2 | 1 | 2 | 1 | 11 |
| Decentralised grid based on renewables | 3 | 2 | 2 | 1 | 3 | 1 | 12 |
| Extension of **urban grid** | 3 | 2 | 1 | 1 | 1 | 1 | 9 |
| **Energy management options** | | | | | | | |
| Energy efficiency (improved technology and `best practice') | 3 | 2 | 2 | 1 | 2 | 2 | 12 |
| Demand side management | 2 | 2 | 1 | 2 | 2 | 3 | 12 |
| Load shifting | 1 | 1 | 1 | 1 | 2 | 2 | 8 |

# PERI-URBAN TRANSPORT MATRIX

Potential to improve transport of produce and raw materials between peri-urban areas and markets and addressing issue of demand: 1 - Low potential, 2 - Medium potential, 3 - High potential

| | **Demand side issues** | | | | | | |
|---|---|---|---|---|---|---|---|
| Transport options | **household strategy** | gender **issues** | market structure | **knowledge and support** | **environmental** impact | **cost/ economics** | **Total** |
| Walking | 2 | 2 | 3 | 3 | 3 | 3 | 16 |
| bycycle, rickshaw | 3 | 2 | 3 | 2 | 3 | 2 | 15 |
| Animal and cart | 2 | 1 | 1 | 2 | 3 | 2 | 11 |
| motorbike, autorickshaw | 2 | 1 | 2 | 2 | 2 | 2 | 11 |
| Collective transport (lorry) | 3 | 3 | 3 | 2 | 2 | 2 | 15 |
| Public transport (bus, train) | 2 | 2 | 2 | 3 | 2 | 1 | 12 |
| Private motorised vehicle (lorry, car) | 2 | 2 | 2 | 1 | 1 | 1 | 9 |
| **Transport management options** | | | | | | | |
| Demand side management | 2 | 2 | 1 | 2 | 3 | 2 | 12 |
| Energy efficiency `best practice' | 3 | 2 | 2 | 1 | 2 | 2 | 12 |

### 4.1.1 Energy for light, heat and shaft power

A series of small steps rather than big leaps in energy technology and alternative energy sources are more likely to be appropriate and successful in peri-urban production systems as people can not afford to invest large sums of money at a time. For example a household using wood for cooking is more likely to be able to afford an improved biomass stove long before they can afford a shift to LPG. Thus there are substantial barriers to switching between fuel sources.

The peri-urban energy matrix shows a range of energy options for peri-urban production systems. These options cover the main energy service demands from households (e.g. cooking, light, space heat and water heating), farms (e.g. cultivating, pumping, drying, milling and grinding) and for general development (e.g. refrigeration and street lighting ). Ratings from 1 to 3 have been given to each energy option regarding their potential to address demand side issues discussed in Section Al, Annex A (household, gender issues, market structure, knowledge and support, environmental impact and cost), thus contributing to more sustainable energy utilisation.

The ratings show in the matrix are only a rough guide to aid comparison of options, as each energy option can represent a range of energy technologies and applications in the household, on a farm or for general development. The total scores from the matrix are assumed to split into high, medium and low potentials as follows:

| **Overall potential** | **Total score** |
|---|---|
| High | 18 to 15 |
| Medium | 14 to 10 |
| Low | 9 to 6 |

Using this assumption, the matrix suggests energy options with the highest potential to satisfy demand side issues and contribute to sustainable development in peri-urban areas are: traditional biomass (wood, charcoal, etc.), 'modern' biomass and solar thermal. Energy options suggested to have a medium potential in peri-urban areas include: wind pumps, anaerobic digestion, a decentralised grid (based on renewable energy technologies), solar PV, energy management options, diesel and kerosene. However, many of the medium ranked options could occupy substantial niche markets e.g. solar PV powered water pumping. Energy options suggested to have a low potential in peri-urban areas include: urban grid extension, small scale hydro power, wind turbines and LPG. It should be noted that renewable energy technologies (such as solar thermal, improved biomass technology, `modern' biomass resources, solar PV and wind pumps), have the potential to contribute significantly to the provision of more sustainable energy services in peri-urban areas. The feasibility of decentralised grids based on renewable energy technologies needs to be investigated further for application in pen-urban areas. Research is needed regarding the stability and practicalities of linking such grids in peri-urban areas, before their true potential can be assessed for providing the "additional rung" on the energy ladder to help the transition from traditional to commercial energy options.

It is *difficult* to assess energy options generally, due to the range of characteristics found in peri-urban areas. Specific options should be assessed for particular case studies. Further work needs to be done in assessing the benefits of energy options with respect to demand side issues in peri-urban areas, and the appropriateness of technology to meet peri-urban energy service needs.

### 4.1.2 Energy for Transport

As with the energy ladder, it is more likely that alternative transport modes requiring low investment, or small steps in technology will be affordable and appropriate in peri-urban areas. For example the use of farm animals to pull carts, or the purchase of a bicycle or rickshaw are more feasible options than adoption of motorised transport for many people.

The transport matrix shows a range of transport options for transporting produce to market (and people to jobs). Ratings from 1 to 3 have been given to each transport option regarding their potential to increase access to markets and movement of produce in a sustainable manner, with regard to demand side issues discussed in Section Al, Annex A (household needs, gender issues, market structure, knowledge and support, environment and cost).

The ratings are only a rough guide to aid comparison of transport options. The total score represents the general potential for transport options to provide access to markets which would support and encourage development of the peri-urban area in a more sustainable manner, while at the same time addressing demand side issues. The total scores from the matrix are assumed to split into high, medium and low potentials as follows:

| **Overall potential** | **Total score** |
|---|---|
| High | 18 to 15 |
| Medium | 14 to 10 |
| Low | 9 to 6 |

Using these ratings, the matrix suggests transport options with the highest potential to satisfy demand side issues and contribute to development of the peri-urban areas are: walking, bicycle/rickshaw and collective transport. Transport options suggested as having a medium potential in peri-urban areas include: public transport, transport management options, animal and cart, and motorbike/autorickshaw. Transport options suggested as having a low potential in peri-urban areas are individually owned vehicles such as lorries and cars. It should be noted that human powered transport has a major role to play in peri-urban areas, and that collective transport has a potentially high contribution to make as an "additional rung" to the transport ladder.

As with the energy options, it is difficult to assess transport options generally due the wide range of characteristics found in peri-urban areas. Specific transport options should be assessed for individual case studies. Further work needs to be done in assessing the benefits of transport options with respect to demand side issues in peri-urban areas, and the appropriateness of transport modes to meet the peri-urban needs.

## 4.2 CONCLUSIONS

For developing countries to improve productivity and the standard of living, the focus of energy planning and energy supply should be on appropriate technologies compatible with sustainability, environmental protection, reliability, affordability and general development. An energy transition is needed which involves a movement away from inefficient use of biomass fuels, towards biomass used efficiently and more sustainably, along with the use of renewable energies and fossil fuels. Appropriate incremental steps have a better chance of resulting in a more sustainable energy system, in contrast to large jumps from traditional fuel to commercial fuels used in many western countries. Where possible, developing countries should try to avoid jumping from traditional fuels to the inefficient and inappropriate use of modern fuels.

The peri-urban interface is by definition an area undergoing transition, which means energy demand is complex. Complex situations require a combination of energy resources and energy technology. The integration and management of both traditional and modern energy sources will be needed to satisfy the specific energy needs and rapidly changing character of peri-urban areas.

An additional rung on the energy ladder is needed to help close the gap between traditional and commercial energy systems in peri-urban areas. A move to urban grid extension is not desirable if sustainability is of high priority, as urban grids are often poorly managed and are largely based on imported fossil fuels. One way of achieving a more sustainable energy system in peri-urban areas would be to develop decentralised grids based on appropriate renewable energy technologies. This would avoid placing additional demands on the urban grid which in many cases is already under strain, poorly managed and inefficient. Technical barriers to the integration of such decentralised grids should be investigated further.

Non technical barriers to the development and utilisation of alternative energy sources also need to be addressed when planning programmes. Social, cultural, and economic issues need to be given more consideration when planning energy services.

Local communities need to participate in energy programmes if social and cultural issues are to be addressed appropriately. The involvement of local communities also helps to focus on the specific energy needs of the peri-urban area. Appropriate loan systems and credit facilities are lacking in many cases. Involving local communities will identify the requirements of the people that need to invest and want to invest in alternative energy technologies.

As the peri-urban interface is an area of rapid transition, the present and future characteristics of peri-urban areas need to be considered when assessing the potential for renewable energy technologies, due to their site specific nature. Both renewable energy and fossil fuel technologies range from those that need little knowledge and expertise to operate and maintain, to those that need quite detailed knowledge and specific skills. The implementation of all new energy and transport technology should be complemented by appropriate training and support. This applies equally to renewable energy systems and fossil fuel based systems, so energy can be used in the most efficient way possible. Steps should also be considered to avoid encouraging inappropriate and unsustainable demand for energy services and technologies e.g. large grids, individual cars.

Energy for the expansion of agricultural production will usually come via the least cost, best known option, which will tend to favour internal combustion technologies. In addition to this, the simple matrix analysis of energy options suggests the following options have a potential role to play in increasing agricultural production: `modern' biomass, solar thermal, wind pumps and small scale hydro power.

Technologies with a potential to increase household productivity will tend towards those with energy security, due to the reliance on them for basic needs such as cooking, space heating, water heating and light. Such technologies will include: traditional and `modern' biomass, solar thermal, solar PV and kerosene.

For general development such as health, transport and communications, adoption of energy options will come with the move from a product based economy to a cash based economy. Energy options with a potential to bring benefit in peri-urban areas include: human and animal powered transport, collective transport, solar thermal, solar PV and a decentralised grid based on appropriate renewable energy technologies (e.g. small scale hydro, 'modern' biomass, biogas from anaerobic digestion, solar and wind).

Transport plays a vital role in the location and character of peri-urban areas. Transport needs to develop in parallel with increased productivity, to maximise the commercial benefits of accessing markets. Human transport should be encouraged to continue playing a major role, with animal transport where possible. Though motorised transport puts higher demands on energy, its use will grow with economic development. Communal or collective forms of transport should be encouraged where possible to maximise the efficiency of energy use (a strategy needed world-wide) and the benefits of market access.

All investment in peri-urban production systems should begin with participatory projects designed to help identify the specific energy service needs of the peri-urban area. Projects should acknowledge other community concerns and interests (e.g. poverty, health and education), and work in harmony with schemes to alleviate these problems and look for synergy with them.

There are currently gaps in knowledge regarding peri-urban production systems which need to be filled in order to identify the needs for energy service and meet those needs in an appropriate and more sustainable way. Gaps in knowledge occur in the following areas:

- understanding the specific characteristics and dynamics of peri-urban production systems;
- critical success factors, specific to peri-urban areas, for the adoption and efficient use of energy sources;
- technical aspects of decentralised grids linked to other grids;
- specific transport needs in peri-urban areas and related benefits;
- gender issues with respect to energy in peri-urban areas;
- gender issues with respect to transport and mobility in peri-urban areas;
- releasing suppressed demand for energy services in peri-urban areas could cancel out any improvements made;
- social and cultural issues relating to energy transition from traditional to commercial fuels;
- social and cultural issues relating to economic transition from a product based economy to a cash based one;

- evaluation of benefits from energy services other than the provision of energy, i.e. benefits to health, education and general development, resource stability and environmental protection;
- appropriate investment and financial support, including loan systems that encourage farmer co-operatives to develop agroprocessing industries and collective transport;
- the operation of commercial fuel market systems in peri-urban areas and ways to improve them to aid peri-urban energy development.

All peri-urban energy interventions should start by addressing the following crucial issues:

- project purpose (needs clear output and activities to enhance production strategies);
- contribution towards and attainment of medium to long term objectives;
- income generation opportunities;
- basic skill utilisation of peri-urban population;
- social support to create energy service businesses;
- market opportunity; •

finance opportunity.

The building blocks for successful energy planning and management in peri-urban areas are: market knowledge, the harnessing of market forces, provision of appropriate financial mechanisms, good institutional infrastructure and a strategic framework operating with strong control.

## 5. CONTRIBUTION OF OUTPUTS

The following observations and recommendations will help identify ways in which peri-urban resources can be utilised more efficiently. Better management of peri-urban energy resources has the potential to improve quality of life by reducing poverty, suffering and deprivation. As peri-urban areas will be the focus of population growth over the next 20-30 years, such improvements will be of great importance, and will help contribute significantly towards ODA goals. Development of the peri-urban interface will in particular help fulfil objectives under the Natural Resources Systems Programme (NRSP).

## 5.1 OBSERVATIONS

The following points should be addressed by any further work done on peri-urban production systems:

1. Future programmes need close involvement of local communities at all stages.

2. There should be more attention on social and cultural issues and implications.

3. The role of women should be central to all energy projects. The benefits to women and children should be given proper consideration along with other socio-economic factors when planning and implementing schemes.

4. Energy resource sustainability and environmental protection need to be high on the agenda in order to encourage and support development in a more sustainable way.

5. Appropriate investment and financial support needs to be provided, including loan systems which will allow farmers and the peri-urban community to invest in more efficient and appropriate energy technologies and modern fuels.

6. A series of small steps rather than big leaps in technology are more likely to be successful in peri-urban production systems due to the dynamic nature of peri-urban areas and lack of investment funds.

7. A mix of traditional and conventional energy sources and technologies should be considered, recognising the continued importance of biomass, and introducing a range of options that can be adopted as the peri-urban interface changes.
8. Energy options need to be appropriate, sustainable, affordable and efficient.

## 5.2 RECOMMENDATIONS FOR FURTHER RESEARCH

The following recommendations are for research that should be carried out in order to gain a greater understanding of the needs and characteristics of the peri-urban interface:

- Case studies should be carried out with field work in peri-urban areas to identify specific energy service needs and transport needs. The dynamic nature of peri-urban areas should be analysed and the potential for energy demand identified.

- Gender specific regional reviews should be carried out in peri-urban areas with regard to the energy sector and the transport sector.

- An analysis should be carried out to identify the impact of energy transition and economic transition in the peri-urban areas on social and cultural issues.

- A study of the commercial fuel market in peri-urban areas should be carried out, with the aim of identifying ways of improving and developing the market structure (e.g. reducing shortages and black market pricing).

The following recommendations are for research that should be carried out in order to identify appropriate energy options and transport options:

- A methodology needs to be developed, and criteria identified, which is capable of evaluating the multiple benefits associated with different energy options (e.g. health, education, general development, resource stability, productivity and environmental protection).

- A more detailed analysis matrix needs to be developed which can evaluate the potential of specific energy options to meeting specific energy service requirements.

- A study needs to be carried out to identify and assess the benefits and problems associated with farmer co-operative agroprocessing plants and collective transport. The barriers to farmer co-operatives also need to be identified.

- Technical aspects of linking decentralised grids in developing countries needs further research.

The following recommendations should be carried out in order to improve the success of strategies and programmes:

- A study of critical success factors, specific to peri-urban areas, should be carried out with respect to selection, adoption and implementation of sustainable energy options.

- A study should be carried out to identify the most appropriate levels of local participation, monitoring, evaluation, education and training, which are required if programmes are to be successful.

- A detailed analysis of appropriate financial measures for peri-urban production systems needs to be carried out.

# ANNEX A: ANALYTICAL LITERATURE **REVIEW**

## Al. ENERGY UTILISATION IN PERI-URBAN PRODUCTION SYSTEMS: ISSUES OF DEMAND

### A1.1 INTRODUCTION

The concept of demand has to be used with caution, as consumers or potential consumers may not be able to express their social needs adequately through the market (Eberhard and van Horen, 1995). Demand used in an economic sense implies a good that is desired from the market at a given price but this definition may be inappropriate when looking at energy issues in developing countries. Not only do social and cultural factors influence and distort demand, as well as market imperfections and rapid technological changes, but ability to pay remains the critical issue. Consumption of product is not synonymous with demand because consumption levels hide demands that are never fulfilled. It is more appropriate to talk of requirements for energy and energy services, as demand is managed or regulated according to social, economic or environmental objectives (Eberhard and van Horen, 1995).

The case studies in Annex B on household energy use in Gambia and transport in India contain useful additional information which can be referred to throughout the next two chapters.

### A1.2. HOUSEHOLD LIVELIHOOD STRATEGIES

The peri-urban area is always in a state of transition. Its economy, situation and environment is in a state of change from a rural area to an urban area, and as such shares some characteristics of both. Because of the dynamism of the rural-urban interface, there is great pressure on the household to employ strategies to optimise production and consumption at the household level to ensure survival. These survival strategies may be more complex than in either rural or urban areas alone. The general description of these strategies is the informal sector. This implies:

- a non-differentiated labour market;
- employment of extended family members;
- turnover maximising rather than profit maximising strategies;
- limited market range of products;
- little energy utilisation in product transformation.

Consumers in these areas will choose between fuels on the basis of their cost, their availability, their convenience and the availability of the appropriate appliances. These factors will determine the decision of the household on which fuels to use, i.e. the energy choice (Soussan and O'Keefe, 1992). Energy expenditure occupies a prominent place in the economies of poor households and usually accounts for a large proportion of monthly expenditure; a number of studies of household expenditure patterns have consistently found that households with the lowest incomes tend to spend a higher proportion of income on energy (Eberhard and van Horen, 1995).

The household sector dominates energy use in most areas of the developing world and, as the World Bank (1987) indicates, most household energy use is for cooking; typically using the three-stone fire or home-made clay stoves. Woodfuel remains the major fuel source for cooking. Indeed, the proportion of woodfuels used in meeting household energy demand typically remains high irrespective of the country's income or urbanisation level, although rising incomes and increased urbanisation result in gradual upward fuel switching. This change is likely to incorporate an increase in charcoal use rather than an abrupt fuel shift to kerosene, bottled gas or electricity.

In the peri-urban areas, woodfuel continues to dominate household energy use but there is an increased use of multiple fuel technology types, i.e. mixing woodfuel with charcoal, kerosene and some LPG. A dominant feature in energy use patterns in peri-urban and urban households is their tendency to include multiple energy-technology combinations; this is the result of a rational decision making process to maximise energy security.

Traditional fuels dominate household consumption for a number of reasons. Ease of availability of both energy and technology are important determinants in household decisions, considerations of fuel costs include not just the prices of the fuels themselves but also equipment costs and the ability to purchase in small quantities on a daily basis. The latter being in order to match low income household budget constraints (Soussan, 1991).

People prefer to use woodfuel for a number of reasons:

- wood is perceived as being inexpensive (this refers to the overall economics of using woodfuel including stove costs and the ability to purchase in small quantities, and not just the price per unit of fuel);
- convenience and ease of purchase;
- free access to sources of the fuel (scrap and construction wastes),
- woodfuel stoves cook more quickly and they are more flexible in their usage than kerosene or LPG stoves;
- the low cost (or no cost) of fuelwood stoves; •

the taste of food cooked with wood.

Source: Soussan, 1991.

### A1.2.1 Household energy conservation

The way peri-urban households respond to changes in energy availability will depend largely upon the economic status of the household and on the existing structure of energy provision and use.

Close to the urban area, middle to high income households are likely to use a wide range of fuels. Thus an increase in the cost of woodfuel, for example, is unlikely to be significant because households will be able to balance the cost and availability of alternative fuels and respond rapidly to locate a substitute fuel. Low-income households, however, are unlikely to have access to commercial fuels, and may be as adversely affected by changes in fuelwood supplies as those in more rural areas.

Where there is access to a range of fuels, energy density can also play a role in fuel choice. For example, charcoal from wood has a higher energy density than the original wood. The higher cost of charcoal is not prohibitive in urban areas.

Box Al.1 describes the properties of a range of fuels available for cooking in developing countries.

**Box A1.1 The Fuels** (adapted from Munslow et al, 1988)

There are five basic fuels available for cooking in developing countries, all of which have certain properties which make them more or less attractive:

Electricity is clean at the point of use, efficient, instantly available and can simmer or boil food at the turn of a dial. It also involves no time spent on transporting supplies from the market and is permanently available in the home. Bottled gas (LPG) has many similar properties as electricity for purposes of cooking but does not have the versatility in providing lighting, heating, air conditioning and entertainment (TV, radio, etc.). LPG also involves collecting heavy bottles which need some form of transport.

Kerosene is suitable for lighting and is a good fuel for quick water-heating, but the cooking of main meals takes too long and the stoves may be so small that they are unstable given the size of traditional cooking utensils. They may be dangerous to children. The smell of kerosene makes people say it gives the food a bad taste.
Charcoal is easier to transport long distances than fuelwood. Both are smoky but give food a taste which people like, or at least have become accustomed to. Both wood and charcoal provide more heat than kerosene. Fuelwood, in an open fire, also provides light.

These properties mean that not all fuels are direct substitutes for each other.

Households under stress from increased energy costs or reduced availability may implement a variety of conservation strategies. Soussan (1992) states that changes to fuelwood stress are likely to occur gradually, within the existing structure of fuelwood use. Other changes may be more dramatic, indicating a more profound crisis. The various household management strategies that can be employed can be summarised as follows (Howorth, 1992):

- utilising woodfuel as efficiently as possible and retaining every scrap of wood from the fire for later use. Such conservation measures are likely to take more time, but will result in beneficial efficiency gains;
- a move to prepared food, perhaps by cooking excess food at the midday meal so that half can be saved and eaten at the evening meal. This may be eaten cold or reheated with scraps of wood left over from the midday meal;

- some meals may be omitted (this is most likely to be breakfast) which may have significant dietary implications;
- a shift to food requiring less cooking (or processed food);
- saving woodfuel by participation in communal cooking.

These management strategies clearly focus on improving the efficiency of existing energy use rather than a switch to a different energy source. Such responses are likely to be stimulated by poverty rather than a reluctance to fuel switch.

Singh (1993) cites a study of low-income groups in Rio de Janeiro, and suggests that the poor do not have adequate information about, or access to, more efficient fuels. Furthermore, because the formal distribution network functions poorly, or is absent in the poorer sections of the city, those in poverty are served by a parallel market in which they pay more than the more affluent, making it more difficult to afford other available options. In addition, low-income families often settle in undesirable (but affordable) sections of the city that may suffer from energy-generated pollution. Clearly, the social and environmental impact of energy use at the household level is strongly influenced by poverty.

Case study 1 in Annex B describes household energy consumption in Gambia.

### A1.2.2 Fuel switching

The concept of a fuel switch or an energy transition is central to any understanding of the periurban (and urban) sector. As urbanisation, and consequently peri-urbanisation, proceeds, there is a tendency for household energy use to increase, diversify and switch fuels from wood and charcoal to modern fuels. The key issue in this sector is the relative price and availability of different fuels and technologies. Where sustainable fuelwood supplies can be provided, they should be encouraged however there is little confidence in the potential of wood and charcoal as major long term fuels (ETC UK, 1990). Energy transitions are not unidirectional; fuel shortages can encourage hoarding (i.e. stocking) or switching `downwards', i.e. from a commercial fuel back to a traditional fuel. Bensel and Remedio (1993) state that, generally speaking, the extent to which modern fuels have replaced woodfuels in a particular urban area has been determined by the size of the city and the level of economic development of the country involved. For example, Bangkok, Kuala Lumpur and Harare only have a small percentage of their populations reliant on woodfuel, Port-au-Prince, Haiti and Ouagadougou remain reliant on woodfuel.

Household fuel switching may be a seasonal or short-term response to changes in supply, or a more long term measure. LCHS (1993) state that it is quite common for households with access to electricity to still rely on charcoal or wood for cooking because of inadequate supplies, power cuts or high electricity prices. The concept of an energy ladder, where people change to higher quality fuels and technologies based on growing income elasticity is complicated in peri-urban areas as energy-technology security is a key issue.

Close to the main urban area, wood is likely to be a market commodity, and people are generally aware of the cost (in monetary terms) of their fuel. It is in such cases that fuel-efficient stoves are more likely to have an impact and fuel-switching is likely to be a higher priority, as well as more feasible. Katerere (1990) indicates that there are two essential criteria.

for fuel-switching to occur. Firstly, people must have sufficient income to be able to afford the asking price (both for the fuel and for the necessary equipment); secondly, the fuel supply must be maintained. Two issues are apparent: income and infrastructure. As individuals become wealthier (and assuming the infrastructure can maintain alternative fuel supply), fuel-switching will occur.

**Box A1.2 The cooking fuel crisis in Kenya**

Lee-Smith and Lamba (1993) cite the results of a study into household energy livelihood strategies in Kenya. The study covered families in four main income groups (very low, low, middle and high) across the urban - peri-urban sector. Charcoal was found to be by far the most versatile and widely used source of energy for cooking, with 82 percent of all households using it. It is used by the poor because it is cheap and more accessible compared to commercial fuels and it is used preferentially by the middle and high income groups.

Urban and peri-urban communities were typically heavy consumers, but not producers, of fuelwood. Apart from charcoal, 19 percent of urban residents used firewood for cooking, either exclusively or in addition to other fuels. Such consumption created an unsustainable reliance on already strained forest resources, which were sometimes located on the peri-urban fringe.

While middle and high income families could use gas or electricity, this was not always an option for the poor, who comprise 70 percent of the urban population. For them, there were no affordable alternatives to charcoal and firewood. When scarcity pushed prices upwards, the poor (who already pay a much higher portion of their income for fuel than higher income families) were forced to pay even more, simply do without, or adapt fuel-saving practices.

The lowest income households, who can least afford it, paid the highest portion of monthly income for fuel. People in the very low income group (over half the urban population) spent 20 percent of their income on fuel, even though they supplemented purchases with fuelwood collected free. People on low incomes spent 10 percent of their total income on cooking fuel, middle income families spent 6 percent and high income families spent only 4 percent.

Very low income families clearly suffer disproportionately. Whereas very low income households on the peri-urban fringe were able to gather fuelwood free, this was often not possible for the urban poor. The cost of fuel is a burden on incomes already inadequate to purchase food for the household, thus risking the nutritional status of families. In order for low income households to be adequately fed, they have to spend an estimated 30 percent of their income on food and another 10 - 30 percent on cooking fuels. Clearly this is a significant part of their expenditure, given the additional demands on income for housing, transport, school fees and so on. The result is that both the quality and quantity of food consumed is lessened. When fuel is too expensive, people switch to prepared or processed foods, or they drink only tea for breakfast instead of preparing porridge. Such measures may have significant implications for diet and health.

There are a number of factors that work against a fuel switch. Kerosene is often seen as unsafe and a fire-hazard; it is also seen as a `dirty' fuel which leaves prepared food with a bad taste (Bensel and Remedio, 1993). If a household has had experience of kerosene at an earlier stage, it can often prompt the same household to switch to another, higher fuel, i.e. to skip a stage. However, a mitigating factor with kerosene is the ability to be able to purchase it in small quantities, which is a major factor in explaining why people *do* use kerosene. Furthermore, it is suitable for two specific end-uses, namely lighting and boiling water for drinks.

In core urban areas the energy transition from wood to charcoal through to kerosene, LPG and electricity has been seen in many different countries. It may be a slow or a very rapid process. In peri-urban areas this transition will be patchy as different sectors of the peri-urban zone use modern fuels, traditional fuels and a mix of fuels, depending on income and availability.

### A1.2.3 Improved stove programmes

Improved cooking stove programmes are being re-evaluated all over the world. New approaches are being tried which place improved stoves in the wider context of household fuel planning and cooking efficiency, and which take into account women's cooking needs, preferences and purchasing power (Cecelski, 1987).

In the largely rural areas of the peri-urban fringe, fuel savings may be of less interest, since fuel may be gathered free by women and children, and cash is scarce for purchasing new stoves. Populations are also scattered, making marketing of new stoves difficult. In general, stoves programmes in rural areas face greater obstacles than in towns and should be considered as part of a carefully designed long-term process where:

- woodfuel is traded for cash or produce, so households will benefit materially from fuel savings;
- women's labour has a high economic value to the household, for example in agriculture or commerce, so their time savings in fuel collection and cooking will be valued;
- as part of nutrition and health extension (emphasising smoke reduction), the safety and cleanliness features of new stoves are promoted;
- new stove adoption is considered in the context of reforestation programmes, including education about the fuel problem.

Katerere (1990) indicates that in Zimbabwean households, the fireplace is the focal point of the kitchen and of family life. One reason why stoves have not been successful is that they cannot substitute for the traditional fireplace. However, the construction of a mud wall which acts as a windbreak can have the desired effect of increasing the efficiency of fuel use. Lowering the height of the metal grates above the fire can also lead to greater efficiency, with the same result. Both of these innovations are seen in areas where fuel is becoming scarce, and both are local developments that are appropriate responses to the particular problem of fuel shortages.

Whilst it is not evident that improved cookstove programmes have resulted in energy savings, it is clear that an improved stove increases the well being of the user. If the stove is correctly installed and used, the living environment is cleaner. An energy saving stove is no guarantee for reducing household energy consumption, but the `saved energy' can be used for other household purposes like extra cooking or heating water. LCHS (1993) state that Vietnamese women found that cooking on new Thai bucket stoves gave them extra fuel to cook snack foods to sell, which improved the household income.

## A1.3. GENDER ISSUES

### A1.3.1 Introduction

"The household management strategies employed by the women... have their own rationality which warrants further investigation and understanding and should be taken into careful consideration in the planning of a "woman friendly" [energy planning approach]. " Annecke, 1993.

Women dominate household energy collection and utilisation in the peri-urban environment. However, very little is known about how women make decisions over expenditure or how they order their priorities, particularly when survival is an issue (Williams, 1993). Equally little is know about women's perceptions of fuel and its use in appliances (Annecke, 1993).

In a systematic end-use approach, the views of women should be central to the design of energy programmes, projects and policy. As yet, however, gender issues have seldom been incorporated in energy policies (Hill, O'Keefe and Snape, 1995).

Clearly, energy resources are critical for women to meet their families basic needs. This is because women's work depends more than men's on access to energy and biomass. The most obvious use of energy is for cooking, with the same fire often used for space and water heating and as a centre of social activities. Fires are also used for food processing and for small industries such as pottery and charcoal making which are important sources of income and employment for women (Parikh, 1995).

When gender issues are included in the energy debate, they are most often confined to the household sector (since women are supposed to manage households, energy analysts are typically content to include their needs in the household sector). Parikh (1995) takes issue with this assumption, and cites three main contradictions:

- much of women's work goes beyond the household sector and spills into agriculture and food processing, service and manufacturing, this is not sufficiently recognised or quantified;
- households are typically assumed to consist of entities which are homogenous, ignoring the fact that intra-household resource and labour allocations differ between gender;
- women are also part of the energy supply system; they make a contribution to the energy supply ranging from 10% to 80% of total energy use in developing countries, not only gathering fuel (biomass, animal dung, fuelwood) but also producing charcoal and briquettes.

There is, however, a paucity of available gender specific case studies in the energy sector. This is significant, as such case studies could be used to inform policy and address the present lack of concern and understanding of gender issues by energy policy makers and analysts.

The peri-urban environment represents the interface between two different energy systems and the transition to a cash economy: in rural areas, where availability of commercial fuels is low, management of non-commercial fuels falls on women's shoulders. This includes fuel gathering, fuel transport, fuel processing i.e. making dung cakes, chopping sticks, making charcoal or peat briquettes and finally cooking (Cecelski, 1987).

Urban women, on the other hand, have problems with sanitation, transport and also with cooking fuels and water. They may also have to pay a higher price for non-commercial fuels, and availability of commercial fuels may be limited by foreign exchange scarcity. Limited availability results in quotas and queues. Alternatively, they have to purchase at high prices on the black market.

In peri-urban areas, women may have access to commercial energy sources such as electricity, kerosene or bottled gas. However, availability and transport is a problem as is pricing; Parikh (1995) indicates, when population increases and commercial fuel availability does not increase at the same rate, the need for fuelwood increases. Box A1.3 gives an example of women and fuel wood in the peri-urban areas of Addis Ababa.

### A1.3.2 Women and access to technology

Transport will vary - both in terms of needs and mode - with economic development and spatial location within the peri-urban environment. At subsistence level (typically on the periurban fringe), the transport needs relate to basic needs such as transporting food, fuel, water, marketing and related activities. Most of this work is done by women, on foot, carrying headloads. Byceson and Howe (1993) have indicated that women spend nearly 1800 hours annually transporting 70 tonne km in Ghana and Tanzania. In terms of time, this is three times more than able-bodied men in Tanzania. Clearly, affordable transport could reduce this burden. Non-motorised transport equipment, such as hand carts and wheelbarrows and rickshaws, are some measures which could alleviate the physical effort.

In urban and some peri-urban areas, the availability of affordable and secure transport plays an important role in allowing women to participate in socio-economic activities. However, this may create conflict between the working role of the women and family care, especially, when children are young. Parikh (1995) advocates special transport for working women; for example, during peak hours, there are special buses for women in Bangalore and special trains in Bombay.

Though renewable technologies have a role in reducing drudgery and enhancing quality of life, they are capital intensive. This may be most problematic for communities on the peri-urban fringe, who are likely to have limited purchasing power, and may not have the necessary cash to invest in renewable energy options. This raises the issue of financing alternatives such as credit schemes, loans and rebates.

It is important to explore the response of women to renewables. Often, women are not consulted, or their time is assumed to be `free', in the cost benefit analysis of renewable options. Yet, new technologies make demands on women's time so there are opportunity costs. Additionally, women's ability to manage technologies is often assumed without inputs of training and extension.

For example, solar cookers have the potential to substitute for fuelwood and other non-commercial resources. Parikh (1995) argues that even if solar cookers are used only part of the time, fuelwood savings over the lifetime of a cooker are sufficient to offset capital costs. However, this assumes the use of a solar cooker matches the daily Iabour burden of women which is frequently not true.

**Box A 1 . 3 Women and fuelwood in the peri-urban areas of Addis Ababa**

After Addis Ababa was founded in the late 19th century, the surrounding indigenous forests were rapidly depleted as a result of increased urban wood fuel demands. The situation was near crisis point until eucalyptus *(Eucalyptus globus)* was introduced from Australia. The success of eucalyptus as a fast growing source of fuelwood resulted in extensive planting and spreading of the tree, supported by the colonial government through tax exemption and distribution of seeds. In the early 20th century, a peri-urban forest of eucalyptus trees stretched out beyond the boundaries of the city.

The forest is now protected from over-exploitation because of its value in soil and water conservation and as a sustainable source of energy. Indeed, the forest provides the major source of fuel for the city and is also an important source of building materials. The trees can be cut every 2-3 years with new sprouts growing from the stem. Replanting is necessary only after 40 years.

The forest also provides a source of income to members of the peri-urban community (and to people from the city itself), who collect fallen leaves, twigs, fruit and pieces of bark (it is illegal to cut branches off trees and armed guards patrol the plantation). These products are used primarily for fuel, although the leaves may also be used as a food source. This work is predominantly carried out by women, who carry branches and leaves in large bundles on their back to sell in Addis Ababa. As one walks up the road through the forest, it is common to be passed by groups of women all carrying back-breaking loads down the hill into the city. The following stories are taken from interviews with some of these women.

*Tegset lives in a small village 3 km outside of Addis Ababa. She is 30 years old and has 6 children. Her husband was a soldier who fought and died in the civil war. Because he was on the militia side, however, she receives no pension. Tegset caries wood bundles weighing approximately 30 kg down the steep 2 knn walk into Addis Ababa three times a day. She receives around 3 Ethiopian birr per bundle (1 birr = £0.10), which constitutes her sole income. Her children sometimes help her after school to carry wood.*

*Almetu is 18 years old and she lives with her parents Since she left school at 16, collecting wood has been her only source of employment. She collects wood 2 - 3 times everyday, and receives between 3 - 4 Ethiopian birr per bundle. It takes her about 3 hours to collect and transport each bundle to a market in the city. The bundles are usually fuel wood, but leaves may also be collected as they can be used in cooking to make a local bread called injera Leaves command a better market price of 6 - 7 birr per bundle. Almetu sells to a buyer who will then sell the bundles in the market at a higher price.*

*Assed collects wood every day and also collects leaves for h jara. Assed usually makes one trip to Addis Ababa per day, collecting wood and leaves in the evening and then carrying then down to market the following morning. She has an additioturl source of income through cooking food (it jara mid wat, a hot sauce) for a number of households in the city. She usually receives about 1 S burr per household. She uses the money to pay for the education of her four children.*

Source: O'Keefe, Kirkby and Convery, 1995

### A1.3.3 Health issues

In the peri-urban sector, the reliance on biomass fuels and muscle power to meet most energy needs has direct negative impacts on women's working conditions and health. Cecelski (1987) states that the World Health Organisation (WHO) has begun to document the relationship between serious eye and respiratory diseases common among women in the developing world, and their exposure to pollutants from biomass fuels in smoky kitchens. One study in India estimated that women cooks were inhaling benzpyren (a serious carcinogen) equivalent to 20 packs of cigarettes per day (Singh, 1993).

At the household level, dwellers in the immediate urban area are exposed to excess levels of indoor air pollution, which results from the lack of proper ventilation and incomplete combustion of biomass, coal, and other fuels used to meet household energy needs (Singh, 1993). Health effects include acute respiratory infection, low birth weight and eye disorders. The groups that are most at risk are women and children because they are indoors and responsible for cooking in most cultures.

The production of more efficient, clean burning cookstoves is often advocated to address this environmental health risk but, as Katerere (1990) indicates, such schemes are unlikely to be successful because stoves cannot substitute for the socio-cultural importance of the traditional fireplace. Longer term approaches are required which include formulating pricing policies that result in energy conservation and the substitution of cleaner fuels for household use.

The physical size and shape of stoves have an impact on their safety in the household. As the kitchen or cooking area is often a central area and because cooking is carried out by women there are often many children around the stoves. The three stone stove has a wide diameter and is a large presence in the kitchen area, the wood to feed the fire often has a radius of up to one metre. The three stone fire also produces smoke and flames; it is a significant presence and even children are unlikely to trip over it. New, improved stoves are often small, compact and the flames are hidden inside the stove. These used in conjunction with large cooking pots becoming unstable and dangerous. Numerous serious burns and scalds suffered by children are a testimony to this danger. Kerosene stoves present similar disadvantages and have the added problem of the kerosene itself igniting on the child, ground or clothes. There are fears expressed by many women that the LPG stoves may explode and so such stoves are treated with extreme caution.

Heavy manual tasks such as carrying fuelwood, collecting water and grinding grain also affects the health status of women. Women are also usually the last to eat in the family, and their calorific intake is often less than their energy output.

### A1.3.4 Energy pricing and investment

In general, energy pricing and imports are short-term policies, whilst energy investment policy requires an understanding of long-term considerations. Parikh (1995) suggests that energy pricing should not resort to large-scale subsidisation. Since women constitute nearly 50 per cent of the population in any country, it is difficult to provide a large-scale subsidy for all women.

At the macro level, energy analysts and policy makers have long assumed the energy sector to be outside of gender considerations. However, these assumptions are not borne out by micro level studies (Parikh, 1995). Women's needs for energy differ depending on their income level, and whether they are engaged only in household related activities or also need energy for transport, manufacturing or commercial activity.

## A1.4. THE STRUCTURE OF PERI-URBAN ENERGY MARKETS

*"Once in the city, the woodfuel trader begins what is often a long and complicated delivery process" (Bensel and Remedio, 1993)*

Energy markets and trading systems are highly varied, flexible and complex entities, with the form actually taken depending on a host of factors particular to that situation (Bensel and Remedio, 1993). Energy markets need to be separated into the traditional (or biomass) energy market which include woodfuel, charcoal and briquettes, and the commercial energy market which includes, kerosene, Liquid Petroleum Gas (LPG) and electricity. The complexity of these energy markets is due to a number of interlinked factors:

**Table A1.1 Factors contributing to the complexity of peri-urban energy markets**

| Traditional energy market | Commercial energy market |
|---|---|
| • a diverse and varied supply base<br>• seasonality<br>• buyers characteristics (daily small purchasing)<br>• Government levies and taxes<br>• complex trade routes<br>• preferred species | • receives Government subsidies<br>• insecurity of supply<br>• poor access to energy user technologies<br>• influenced by global trends<br>• black market trading<br>• structural adjustment programmes<br>• im lications for national balance of trade |

Traditional energy markets are highly developed and effective distribution systems. The same cannot be said for commercial fuels, which suffer from shortages, black-market pricing and tend not to reach the peripheral areas where the poor live (the further one gets from the urban centre the more difficult access to these fuels becomes). Commercial fuel market systems are poorly understood and their improvement is a priority for peri-urban energy development.

In addition to the two different types of market, household needs are served either by non-traded markets or traded markets. The non-traded markets characterise rural energy supply systems but they do share similarities with the peri-urban areas, where there remains access to a cultivated area or scrubland/woodland. In non-traded markets, collection of traditional fuels is carried out by women and children, and though it bears no monetary price, the effort of collection and opportunity cost represents a cost in human labour (World Bank, 1987). As increased pressure is placed on the biomass resource, as is the case in peri-urban areas, it shows up in terms of more time spent on collection and increasing substitution of fuelwood by crop residues (like rural areas, the peri-urban areas may have the `safety net' of being able to use agricultural residues where the urban household cannot). Traded markets serve urban markets, and are increasingly seen to serve peri-urban markets and here, scarcity is likely to show itself in higher prices or fuel switching (World Bank, 1987).

In urban and peri-urban areas, a variety of different energy sources are available for a number of different end uses. They are in direct competition through their relative prices, but there is more to it than a simple price relationship. Consumers choose between fuel technology combinations according to their availability, price, convenience and security. The degree of substitutability is very limited for some end users; for example transport, where oil fuels are the only real choice. The range of fuels which can fulfil the use is far greater for activities such as cooking, where consumers have a number of options (Soussan, Mercer and O'Keefe, 1992).

Security and availability of fuel supplies is a more serious problem than their cost. The poor development of the market systems for many fuels means that peri-urban (like urban) households adopt strategies, such as multiple fuel use, using less preferred fuels, or adopting household management strategies, which ensure that some energy is available all the time, i.e. a risk minimisation strategy. Likewise wood is widely used, not because it is cheap, but because it is available in places and quantities which fit into the lives of the peri-urban poor (Soussan, Mercer and O'Keefe, 1992).

**Table A1.2. Characteristics of energy wholesalers and retailers (adapted from Bensel** and Remedio, 1993)

| • **Wholesalers** | • **Retailers** |
|---|---|
| • specialise in biomass fuels (charcoal, woodfuel)<br>• receive large shipments from rural traders<br>• sell to large scale customers (bakeries, restaurants, etc.) and charcoal re-packers<br>• sell in bulk<br>• cluster in several areas of the city (in the urban fringe) | • sell a range of other products<br>• purchase products from wholesalers<br>• sell to households and to homebased commercial enterprises<br>• sell in small units<br>• scattered throughout the city (urban and peri-urban<br>• higher profit margins |

Because the peri-urban energy market is dominated by traditional fuels, the markets are heavily influenced by seasonality. On a most basic level, availability and price are affected in the rainy season in most developing countries because of road quality and access to wood stocks. Poor roads in the rainy season, increased incidence of transport breakdown and the inaccessibility of remote villages (supply areas) all contribute to a supply problem. By contrast, in the dry season, households in the peri-urban areas (in contrast to the inner-urban areas) may still be able to collect dry, scrap wood, fallen branches and other forms of biomass from around and about (Bensel and Remedio, 1993). There, is also a better supply for the wholesalers in the dry season as there is an increased incidence of off-farm activities, of which fuel harvesting is a large part, giving the trader greater choice and access.

External factors also affect domestic energy markets. For example, the Persian Gulf crisis of 1991 increased prices of LPG and kerosene in Thailand and thereby increased the price of traditional fuels as there was a greater demand. Diesel prices also rose which limited the truck access to rural areas. Natural disasters, like floods, can restrict access to traditional fuels, thereby pushing up prices (Bensel and Remedio, 1993).

The city centre traders themselves experience problems of declining sales of traditional fuels caused by increased competition, declining residential demand because of fuel switching and declining commercial sector demand as a result of these establishments obtaining supplies directly from rural traders. Other problems include increasing difficulty in obtaining regular supplies of good quality fuelwood and charcoal (Bensel and Remedio, 1993).

The location of the market will affect market prices and the transport and producer costs. In many cities charcoal and woodfuels depots will be located in the peri-urban areas, this will make fuelwood and charcoal easily accessible and, if not a lower cost price, at least the same as inner urban areas. However, in other peri-urban areas (which generally have a wider spread, i.e. they are a significant distance from the city centre) fuel costs may be higher because traders will take their produce into the urban area where they enjoy higher prices. For example, in the peri-urban area of Mbezi (15km from Dar es Salaam) in Tanzania, people pay higher prices than in the city centre charcoal markets. Economies of large-scale transportation and marketing permit a lower price in the central market. Out in Mbezi, people paid 240-260 Tanzanian shillings for a bag of charcoal, rather than 170-180 shillings in the city centre markets (Munslow et al, 1988). This is because they rely on people bringing in the charcoal on bicycles or they pay premiums to lorries passing through on other business for temporary transport assistance (Munslow et al, 1988).

Because of the wide and varying nature of peri-urban areas, general market characteristics are difficult to identify.

## A1.5 ENERGY COSTS

There is little price comparison for competing production technologies because it is difficult to find a common expression of cost to energy. One way to calculate comparison is by assuming energy transformation to electricity output. However, this approach has the drawback that it costs energy rather than the utility or service that energy brings.

It must be acknowledged, however, that all project cost calculations are now done, for energy investment including electricity, on the basis of long-run marginal supply costs. Such analysis assumes energy is not a basic human need and right but a commodity that must bear full market cost. The following analysis is based on that assumption.

A large range of generation technologies are available which must be judged by their power output and cost. Both power output and cost must match end-use.

**For small, medium and large scale peri-urban power requirements, fossil fuel and hydro generation dominate.**

Fossil fuel and hydro generation account for around 55 and 37 per cent respectively of all electricity supply in developing countries. Both supply technologies can be scaled down to power demands of less than 1 M Renewables other than hydro generation, can deal with low power demands; solar and wind power are particularly suited to meeting lower power demands. Table A1.3 outlines economic ranges where minimum and maximum figures are determined for each fuel source. Actual economic performance depends on technology type and, especially with renewables, local conditions. Economic capacity issues must also be considered against the nature of effective demand for base and peak electricity. Demand is peaky, often with gaps in demand rather than troughs. Encourage base load growth could help smooth the peaks.

**Table A1.3 Economic Capacity Ranges by Fuel Source**

| | Fossil | Biomass | Nuclear | Hydro | Wind | Solar PV | Solar Thermal | Geo-thermal |
|---|---|---|---|---|---|---|---|---|
| <100 W | | | | | + | + | + | |
| 10OW - 1kW | + | | | + | + | + | + | |
| 11W - 1OkW | + | + | | + | + | + | + | |
| 10kW - 100kW | + | + | | + | + | | + | |
| 100kW - 1MW | + | + | | + | + | | + | + |
| 1MW - 10MW | + | + | | + | | | + | + |
| 10MW - 100MW | + | | | + | | | + | + |
| 100MW - 1000MW | + | | + | + | | | ? | + |
| 1000W - 10000MW | + | | | + | | | | |

(adapted from Hill, O'Keefe and Snape. 1995)

**Comparative costs of generation facilities favour conventional not renewable technologies.**

Table AI A contains details of a range of costs associated with different fuel-technology combinations for electricity generation. Comparative capital costs favour fossil generation rather than renewables. Comparative fuel and Operation and Maintenance, which together are recurrent cost, are higher for conventional fuels than for renewables. Of particular note is the recurrent cost associated with small scale diesel generation. The comparative cost per unit of delivered electricity indicate that relative cheapness of conventional generation, with the exception of small scale diesel generation, and high maximum costs associated with the deployment of all renewables except hydro generation. Comparative costs do not totally explain the dominance of grid extension and stand alone diesel generation for peri-urban electrification programmes. To understand the complexity of this issue, analysis of end-use demand is necessary.

For end-uses in peri-urban areas, capital costs and costs of delivered electricity are inversely proportional to the size of the system - the smaller the generation system, the higher the cost of electricity. However, the total demand for capital is greatest for the larger system. This is reflected in the final energy price which for conventional fuels has a high fixed cost element that is a high unavoidable cost. On the other hand many traditional and renewable energy sources have a lower fixed cost element and hence a lower avoidable cost. It is low avoidable costs that are often sough in developing countries (i.e. they need to be able to avoid paying if necessary).

Stand-alone diesel generation sets again are the standard against which other generation technologies should be judged. Table A1.5 contains details of these relationships where smaller systems have higher capital costs, shorter working lives, more expensive fuel costs and higher costs for delivered electricity.

Small stand-alone diesel generation (<1 kW) is difficult to maintain. If assured supply is required, two generation sets are necessary. Fuel costs, when fuel is available, will account for 50 - 75 per cent of the recurrent cost. Operation, maintenance and repair - when personnel and spare parts are available - will account for the remainder of the recurrent cost. For this reason, a series of renewable technologies, namely solar, wind, micro-hydro and biomass can compete as power generation technologies where problems with stand-alone diesel generation, particularly over recurrent costs, indicate a higher initial capital investment in a renewable technology, with no fuel and little maintenance problems, will better service end-use demand.

**Table A1.4**

| | Comparative Capital Costs US$/kW 000's | Comparative Fuel and O&M Costs US cents/kWh | Comparative Costs of Delivered Power US cents/kWh |
|---|---|---|---|
| Coal | 1.0-2.0 | 2.0-4.0 | 5- 10 |
| Fuel Oil | 0.5-1.0 | 3.0-6.0 | 9-14 |
| Natural Gas | 0.4-0.9 | 2.5-5.5 | 6-12 |
| Nuclear | 1.0-1.5 | 1.5-3.0 | 6-15 |
| Small Diesel | 0.4-1.0 | 8.0-30 | 10 - 80 |
| Solar PV | 4.0-10 | 0.0-1.0 | 9-90 |
| Wind | 0.5-0.9 | 0.5-1.0 | 6-50 |
| Large Hydro | 1.1-3.0 | 0.5-1.0 | 5-15 |
| Small Hydro | 2.0-6.0 | 0.5-1.0 | 5-30 |
| Biomass | 0.5-2.5 | 1.0-7.0 | 5-30 |

(Source: World Bank, 1993)

**Table A1.5**

| | Capital Costs $/kW | Working Life hours | Fuel Consumption 1/kW | Cost of Delivered Electricity c$/kWh |
|---|---|---|---|---|
| 10 kW | 700 | 7,000 | 0.53 | 41 |
| 20 kW | 500 | 10,000 | 0.42 | 28 |
| 30 kW | 400 | 12,000 | 0.35 | 19 |
| 100 kW | 250 | 25,000 | 0.29 | 12 |

Source: Foley, 1992

Quality, reliability and durability in energy development. The discussion of end-use requirements has to be placed in a broader context of energy and

development. The energy situation in many developing countries is deteriorating, especially the provision of household energy requirements of poorer sections of the population.

**Major long term strategies must emphasise the maintenance and enhancement of woody biomass and energy efficiency.**

Woody biomass dominates the energy balance of the developing world. Woody biomass is mainly consumed as household energy where most of the woody biomass is used in cooking. Commercial energy, particularly electricity, is of marginal significance to the poor.

Demand for commercial energy must address issues of energy efficiency. Addressing issues of energy efficiency allows developing countries to minimise capital and recurrent cost expenditures as well as addressing environmental issues.

## A1.6 ENVIRONMENTAL AND SOCIAL IMPACTS OF ENERGY USE

Localised environmental problems, particularly acid rain, urban air pollution and deforestation, will accompany the uncontrolled transition from traditional to modern energy use; from a rural to a peri-urban or urban energy use pattern.

By 2050, half of the world's population will live in cities. This change of habitat is itself producing environmental problems. The combustion of hydrocarbons has led to levels of air pollution in developing countries' cities which rank amongst the highest in the world. Transport is the largest contributor to air pollution but the combustion of hydrocarbons, in electricity generating units and households, also contribute to it. Emissions of nitrogen oxides, particulates, sulphur dioxide, carbon dioxide and carbon monoxide are high. Coal (which is increasing in use in developing countries) is the most polluting of all of the fossil fuels in terms of emissions per unit of energy consumed, particularly when fired in inefficient plants (as in many developing countries).

These urban environmental problems are paralleled by more regional problems of which the greatest is acid rain. Sulphur oxides and nitrogen oxides, emitted by the combustion of carbon fuels, have increased acid precipitation. Urbanisation can consequently produce not just urban but also rural pollution.

The impact of urban fuelwood use on rural supply areas is well established and few commentators would disagree that the consequence of urban wood markets is environmental deterioration and greater pressure on rural fuel supplies. Urban and peri-urban wood dealers do not pay the full cost of the wood and extraction techniques are damaging. Profit margins are typically high, with wood prices reflecting the cost and availability of alternative fuels rather than wood supply and demand conditions. There can be no doubt that growing demand and diminishing resources means that urban and peri-urban fuelwood is unsustainable in many parts of Africa. Action to mitigate these impacts is an urgent priority if urban and peri-urban energy is to be provided and rural environments preserved (ETC, 1990).

The environmental challenge to maintain and enhance energy resources is not simply a challenge to pollute less and move from non-renewable to renewable resources, it is also a. challenge of equity.

Solving one environmental problem can frequently lead to other environmental problems but, on the bottom line, no solution will work if there is not greater equity to access resources.

Women and children in rural areas (and on the peri-urban fringe) spend increasing amounts of time in gathering biomass fuels, commonly two to three hours per day and in some cases up to five hours. They pay an increasing price in time devoted to securing energy subsistence. Poorer urban households pay an increasing cash price because for most of them, collection of fuel is not possible as supplies around towns become more and more depleted.

A proportion of income in urban and peri-urban areas is spent on fuel switching to a more advanced fuel. In Addis Ababa, for example, by 1986, 70 per cent of households had switched to kerosene because wood and charcoal prices had risen. Paradoxically, as the price of energy rises, the demand does not fall. Therefore in developing countries, over the last twenty years, oil consumption continued to grow steadily, reflecting the original low consumption base, while in developed countries oil consumption variation followed movement in oil prices, indicating both the higher volume of consumption and an ability to lower consumption through investment in energy efficiency.

Developing countries must have a right to the economic opportunities enjoyed by developed countries. For that purpose there needs to be more investment in state-of-the-art technologies that maximise efficiency, minimise environmental damage, and are budget neutral, especially for poor people. Furthermore, the concentration of energy investment in urban economic centres does not encourage significant rural development without which rural resource depletion and rural to urban migration will grow (DGIS, 1991).

## A1.7 PARTICIPATION AND ENERGY DEMAND

Participation by local communities in the project or programme cycle is now firmly in the mandate of development institutions; development in the 1990s is increasingly being carried out with communities, instead of for communities. For some reason which may be hidden in the technical bias of energy solutions, energy planning and development seems to have `missed the (participatory) boat.' Energy planners continue to talk about supply side options, especially in urban and peri-urban areas, in which the demand side is addressed with simple questionnaires at best. Not surprisingly, in many instances the results of conventional energy assessment and planning activities have been unsatisfactory, as they did not link people's priorities and needs (ETC, 1996). The concentration is still on developing newer, more compact and efficient technologies that can be transferred (in the old fashioned sense of the transfer of technology) on a large scale to large sectors of the population. The experiences in the fields of agriculture, health and water in the `transfer of technology' approach have not taught energy planners a great deal. Increasing the supply of electricity and fossil fuels for a growing demand has been the major concern in most countries, without analysing first the energy services actually required by the different end-users and how these can be best fulfilled in the short and long term (ETC, 1996). This general lack of participation by the local population in urban and peri-urban energy planning means that the planning results rarely reflect the local actors' priorities or demands. What first must be realised is that energy is interwoven with nearly all other sectors, which makes it a complex matter.

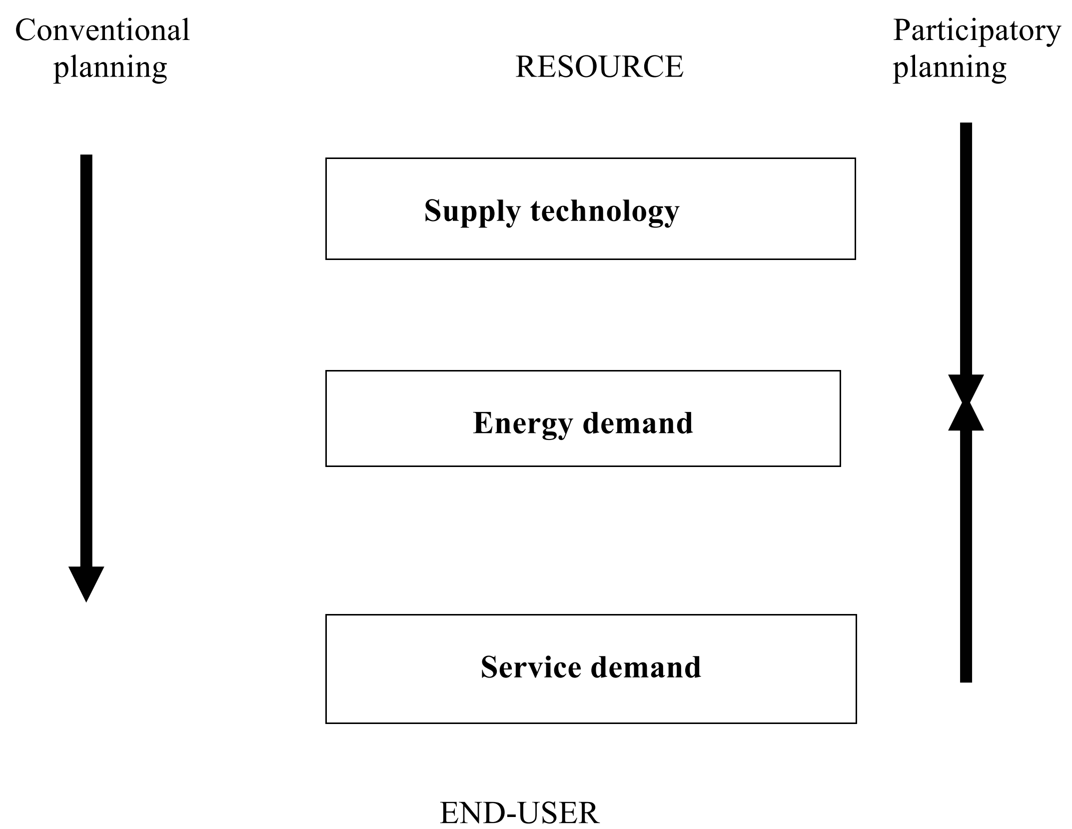
To illustrate this complexity Ross, (1993), illustrated that fuel-use decisions are much more complex than economists would have us believe:

*In order to examine and explain fuel use in [peri-urban] settlements it is necessary to look at the micro-context of the resident's lifestyles, at the conditions of tenure and security which they experience, and most of all, at the ways in which they are able to use and construct social relationships around fuel. It is these relationships which shape fuel patterns ... rather than overtly economistic decisions to utilise the most efficient fuel.*

The general parameters of a participatory process remain the same. The approach to energy development in peri-urban (and urban and rural) areas should be a participatory one where:

- a form of bottom-up planning where the local beneficiaries are involved is more effective than an approach that is top-down;
- a form of planning that looks at options that are beneficial to most sectors of society is more effective than one that produces only benefits for a few selected groups of society and results in negative effects for others;
- a form of planning that elaborates themes prioritised by the majority of the population is more effective than one that works with non-prioritised issues;
- a form of planning that recognises that different demands can be best identified by classifying the population according to degree of relative economic wealth; gender; age and the sectoral actors, will achieve more equitable results.

**Figure ALL Conventional top-down versus participatory planning (ETC, 1996)**




Energy is an issue that traditionally involves centralised planning at the macro level (e.g. grid extension) and local management at the other end of the scale (e.g. household management).

Energy use is also limited by severe pressure put on natural resources (e.g. deforestation due to fuelwood scarcity) and financial resources (a significant proportion of the household and foreign exchange budget spent on energy). This situation calls for an approach in which the energy demand is met with technology that uses a minimum amount of resources, and has a maximum chance of successful adaptation by end-users. The cornerstone to such an approach is participatory planning. Figure A1.1 illustrates contrasting approaches to energy planning.

## A1.8 INDIGENOUS KNOWLEDGE AND ENERGY PLANNING

In many peri-urban areas in developing countries there will be a large proportion of the population that will have relatively recently arrived from the rural areas in search of employment and new production opportunities. An important aspect of this demographic change is the transfer of rural knowledge systems to an urban context which will eventually lead to a mix of options based on the *melange* of urban and the rural knowledge systems. Others that have a range of urban experience, particularly job experience, will have a command of mechanical and electrical technologies.

Rural livelihood systems have their own, very specific, logic and techniques of production and subsistence which are, again, specific to the particular geographic and cultural situation. There will be specific patterns of farming systems, off-farm employment, health care systems, energy use patterns (production as well as consumption) and community organisation, all of which have evolved, usually, over a long time frame. When the rural family or individual member arrives in the urban area, they will carry over these knowledge systems and attempt to adapt them for living in the urban area. In terms of energy use this has several important connotations for household energy use.

Firstly, because rural energy use is dominated by woodfuels, household energy needs in the peri-urban context will be continue to be supplied by woodfuel as it is the preferred fuel. Recently arrived families will attempt to continue rural eating patterns which frequently include three or four cooked meals per day, which uses significant amounts of woodfuel. Because woodfuel use is so entrenched in their livelihood system, households from rural areas may be very reluctant to use different forms of energy.

Second, there is normally a transfer of farming, landuse and food processing systems that reflect traditional methods of a different environment. Adaption to the specifics of peri-urban farming is slow, especially the growing of niche fruit and vegetables. Energy systems in production usually reflect rural, not urban, production.
The substantial change comes in access to energy for general development, particularly transport and communication and perhaps formal water distribution points available in the peri-urban areas. These services are however consumption, not production activities. Even where electricity is available, it tends to be limited to lighting.

Despite this there is knowledge of energy resources and technology that need to be addressed. The beginnings of peri-urban energy interventions need to address several critical issues, namely:

- project purpose with clean output and activities to enhance household production strategies;

• income generation opportunities;

• basic skill utilisation of peri-urban population;

• local support to create energy service businesses;

• market opportunity;

• finance opportunity.

Discussion of these issues is essential if successful energy investment is to occur.

# A2. ENERGY UTILISATION IN PERI-URBAN PRODUCTION SYSTEMS: ISSUES OF SUPPLY

## A2.1 INTRODUCTION

It is widely recognised that energy has a major role to play in the process of development. The planning, management and use of energy sources in developing countries needs to be more sustainable in order to complement, support and sustain economic development.

Traditional fuels in developing countries are wood, charcoal, agricultural residues, dung, grass, leaves and other biomass materials using open fire, three-stone cookstove, and other traditional burning methods. Alternative fuels in developing countries include liquid fuels (e.g. LPG, diesel and kerosene), electricity, coal and renewable energies (e.g. wind, solar thermal, -solar PV, small scale hydro, `modern' biomass).

A range of technology options for generation and distribution of energy for agriculture and rural development have been developed and field tested in developing countries, including:

- improved wood fired cookstoves, kilns and baking ovens;
- wind powered equipment for water pumping and electricity generation;
- direct solar energy devices for water heating and crop drying;
- photovoltaic equipment for lighting, refrigeration and communication;
- grid electricity for lighting and for providing power to rural agroprocessing and manufacturing units;
- small scale hydro plants for electricity generation and shaft power;
- biogas units for cooking and lighting;
- diesel powered machinery for mechanised agriculture, transport, agroprocessing and electricity generation.

Past energy programmes and schemes in developing countries have had varying degrees of success in introducing alternative fuels, energy technologies and energy management policies aimed at increasing productivity and energy access to the rural and urban poor. **In** some cases, this is due to the push of selected technologies which have shown to be technically promising, but when applied to the field are inappropriate and unsuccessful. The failure of schemes is often due to non-technical issues such as:

- lack of a market (and associated market pull);
- social and cultural issues;
- economic issues.

Bottom up planning and the involvement of local communities helps external planners to understand and address the specific and distinctive character of local energy needs. A recent study by ETSU on critical success factors for renewable energy (ETSU, 1995a), identified a set of basic attributes and requirements that renewable energy projects and programmes should have in order to maximise the probability of their success. ETSU analysed selected institutions, renewable energy programmes and projects in Western Europe (LJK, Germany, Greece and Spain) and in selected Developing Countries (Botswana, India, Thailand and Zimbabwe). Interviews were carried out to obtain information on what had helped the projects be successful, and what things had caused problems or acted as barriers to success. The results of the interviews were analysed and a set of fourteen `universal' critical success factors were identified as being the basic attributes and requirements needed for all renewable energy projects to be successful, examples of which include:

- Economics of the project are acceptable
- Appropriate finance packages are available
- Project fits in with medium term energy strategies
- Adequate market support
- Establish that a market exists
- Consider site specific factors
- Adequate project review, feedback and records

In addition to these `universal' critical success factors, others were identified for funding bodies, managing agencies, the provision of basic energy services, rural electrification and individual technologies. To ensure the best results, critical success factors need to be addressed at all stages of a programme from initial planning to implementation, and for all parties involved in the programme or project.

Basic energy needs are closely linked to equity issues in developing countries. The choice and implementation of energy options must be considered carefully, as inappropriate technologies can have the effect of widening income gaps rather than closing them. For example, in some cases the biogas programme in India made it more difficult for the rural poor to have access to cattle dung for use as fuel and fertiliser because of the competing demands on its use *from* the rural middle class who started to use the dung for biogas production (Karekezi, 1992). Such situations occur when schemes are not thoroughly thought through at the planning and implementation stages and the wider implications and impacts of the scheme are ignored.

All energy options should be considered as part of the bigger agricultural, economic and social picture, rather than in isolation. Some of the related issues which should be considered when assessing energy options, particularly biomass options, in peri-urban areas are listed in Box A2.1.

A more efficient use of traditional biomass resources via improved technologies and techniques would act as a good complement to the adoption of alternative energy sources and technologies. As with traditional fuels there is also a large potential for energy efficient practices to be adopted where alternative fuels are used, for example in motorised transport, mechanised agriculture and agroprocessing industries (Karekezi, 1992).

**Box A2.1 Issues to consider when assessing energy options in developing countries**

| | |
|---|---|
| Land availability | Appropriate technology |
| Food production priorities | Technology scale |
| Land / soil protection | Technology flexibility |
| Climate | Technology cost |
| Biodiversity | Fuel transport |
| Sustainability | Energy supply integration |
| Forestry protection | Availability of local skills and knowledge |
| Local environment (emissions / pollution) | Rural, urban, peri-urban energy use |
| Global environment (GHG) | Size and nature of energy use |
| Resource availability | Energy prices |
| Competing demand for resources | Finance opportunities |
| Seasonal variability | Socio-cultural issues |
| Conversion technology | |

Population growth in developing countries is likely to occur mainly in urban and peri-urban areas over the next 20 to 30 years, putting peri-urban areas under increasing pressure to provide food and traditional power sources for both areas.

### A2.1.1 Shifts between human, animal and mechanical power

A shift from human power to animal and mechanical power in peri-urban areas facilitates increased productivity on farms through irrigation and tilling. Mechanisation can improve the quality of life by reducing levels of hard physical labour, and by raising the farmers income from the sale of additional produce. Mechanisation also facilitates increased productivity in agroprocessing industries and other rural industries through crop processing, milling and grinding. Mechanised transport reduces travel time and can allow access to new markets.

If this progression to mechanical power is to be maintained in farming systems, industry and transport, the communities must have access to reliable, diverse and sustainable energy sources, as an increase in mechanisation will inevitably place greater demands on available energy sources.

The next two sections look at the 'energy ladder` for heat, light and shaft power used in households, on farms and in peri-urban industries, and the `transport ladder' for transporting produce and people between rural, peri-urban and urban areas.

The use of the terms "energy ladder" and "transport ladder" in this report are done assuming the following definitions:

- fuels are used as a simple way of representing a combination of fuel and technology on the ladder
- movement up or down the Iadder is possible
- rungs on the ladder are not mutually exclusive, i.e. they can overlap or run parallel
- rungs can be missed out
- a step up the ladder allows additional fuels and technologies to be accessed along with those already being used i.e. a combination of fuels and technologies from several rungs can be used at any time.

## A2.2 THE ENERGY LADDER

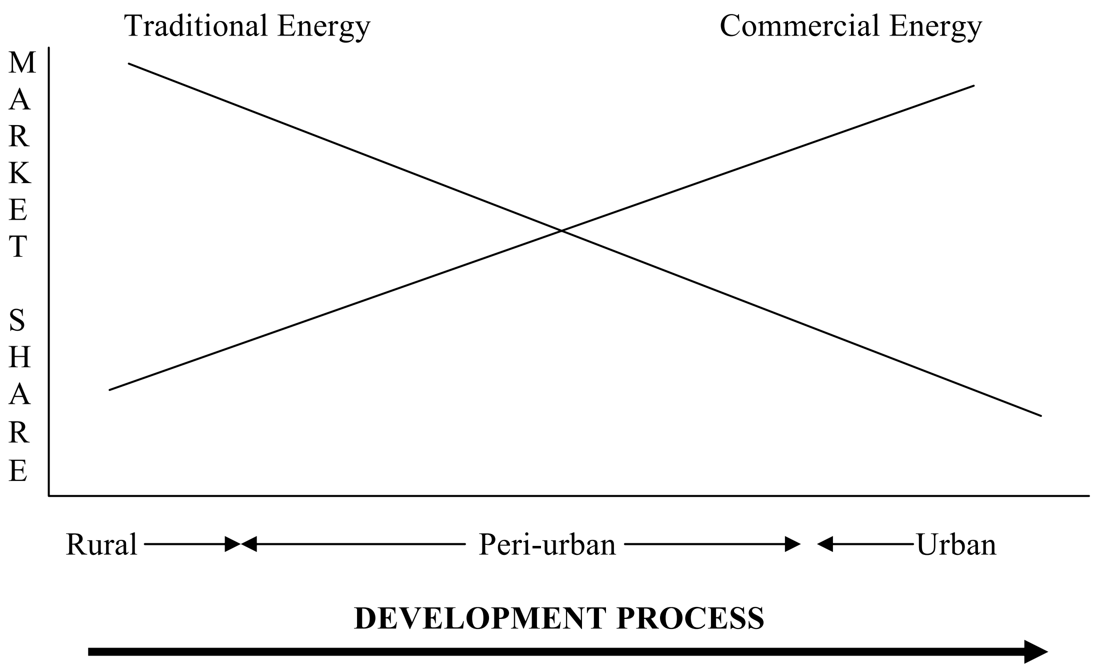
In urban areas, energy is already commercialised with the underpinning drive for increased energy intensity coming from industry. In contrast to this rural areas have farming as the primary industry and the majority of energy demand is met by wood, dung and leaves, while fertiliser needs are met by compost and digested biomass.

Figure A2.1 is a simple diagram showing that as an area moves from being rural in character to peri-urban and eventually urban, there is a transition from using traditional fuels (wood, dung and leaves) to commercial fuels (kerosene, LPG and ultimately grid electricity). The peri-urban area can in simple terms be described as a transition zone between traditional energy use and commercial energy use. It is also an area where the rural product trading economy changes to the urban cash based economy. Thus the ratio of traditional energy to commercial energy used will define where you are in the peri urban area (i.e. closer to a rural or an urban area in character).

There is an underlying trend of a move from traditional to commercial energy in developing countries, but this is not a smooth transition, and there are barriers to this move up the energy ladder. The energy ladder that has commonly been planned and aimed for is a shift from traditional fuels to kerosene, LPG and ultimately grid electricity. The large drive for rural electrification in developing countries is evidence of this.

The jump from traditional fuels to LPG and grid electricity is often too big for people, as they can not afford the technology or fuel costs. In terms of sustainable development, a shift from traditional to commercial fuels is not necessarily desirable either. This can be seen by looking at traditional and commercial energy in more detail.

**Figure A2.1 The Change in Energy mix from Rural to Peri-urban and Urban areas**



### A2.2.1 Traditional Energy

The existing use of biomass as a source of energy in developing world is very extensive. Around 35% of the developing world's energy needs are met from biomass - the single largest supply of energy (Hall et al, 1992).

The use of biomass as a source of energy is directly linked to agricultural and forestry practices.
There are two main types of biomass energy sources produced in developing countries, plants grown specifically for energy recovery and residues from agriculture and forestry practices. Box A2.2 provides a list that illustrates the broad range of biomass feedstocks that have been demonstrated as useful sources of energy in developing countries.

Most of the above demonstrated energy sources can be classified as agricultural or forestry residues. Very few, if any, can be accurately considered as dedicated energy crops. Bagasse and rice husks are now routinely used.

In time, however, this list is likely to expand to include other fast growing biomass, sometimes described as "modern" biomass, cultivated specifically for energy recovery. This concept has not been widely taken up in the developing world, but ongoing research, development and demonstration programmes in a number of countries illustrate the level of interest. Work includes tree breeding studies in Thailand, Sri Lanka, Indonesia, the Philippines and Nepal, studies of the environmental impact of plantation grown Eucalyptus tress in India, through to feasibility studies looking at the prospects of establishing multi-megawatt electricity generation projects based on plantation wood fired gasification plant in China.

**Box A2.2 Biomass sources in developing countries**

| | |
|---|---|
| Eucalyptus | Coconut husks |
| Rubber wood | Nut shells (cashew, coconut, groundnut) |
| Mangroves | Palm shells |
| Conventional forestry residues | Rubber seeds |
| Wood industry waste (chippings and sawdust) | Kapok seeds |
| Chicken litter | Oil crops |
| Cotton stalks | Food processing wastes (e.g. fait processing wastes) |
| Cassava stalks | Animal wastes (often mixed in with other wastes such as domestic waste or sewage) |
| Paddy straw | Dried dung |
| Sugarcane field residues<br>Sugar processing residues (bagasse) | Herbaceous biomass (e.g. water hyacinths) |

A third biomass resource category is surplus agricultural products such as starch or sugar crops which can be fermented to ethanol to produce a valuable liquid fuel. The potential for such crops partly depends on the availability of suitable land, which might have competing demands placed upon it for growing cash crops or food crops.

**Biomass conversion to energy sources**
Biomass can be used as a source of energy directly, or can be converted to a perhaps more convenient secondary fuel. The choice of direct or secondary conversion to useful energy, and the choice of conversion technology to use depends on the nature of the biomass feedstock, the cost of both the resource and the technology, the availability of local skills to build and/or operate the plant, and the scale and nature of the energy demand (and therefore the scale of the technology).

Traditional uses of biomass in developing countries are direct combustion of wood fuels (for example in cookstoves) and the processing of biomass to produce charcoal and briquettes for combustion.
There are three main categories of biomass conversion:

1. thermal conversion (e.g. direct combustion, charcoal production);

2. mechanical conversion (e.g. pressing to extract oil or compressing to produce briquettes);

3. biological conversion (e.g. anaerobic digestion, or fermentation).

*Combustion*
The technology of biomass combustion can range from very basic small scale burners and stoves for rural domestic cooking and heating to multi-megawatt high pressure boilers coupled to steam turbines for electricity generation.

Small scale combustion of biomass is used throughout the world, and is by far the most significant source of energy for many rural developing economies. Often, however, the technology is inefficient and polluting. Current themes for work in this area are associated with improving efficiency and hygiene, and developing more flexible appropriate technologies that can be used effectively with a wide range of biomass fuels.

At the other end of the spectrum is large scale biomass combustion. For example, the Biomass Integrated Gasification-Gas turbine (BIG-GT) demonstration plant in Brazil (Elliott and Booth, 1993). In some industrial sectors, biomass residues from the process provide useful heat and electricity for the industrial plant. Examples include the wood processing and sugar industries of South East Asian countries (using wood wastes and bagasse respectively). Dedicated plantation-based systems have yet to be extensively established, although there is extensive interest and R&D activity.

*Charcoal production*
The potential for increased biomass efficiency with improved charcoal kilns has been recognised since the early 1980's. There are now many designs of energy-efficient charcoal kilns for use in both small-scale and industrial-scale production. The adoption of more efficient designs has been hampered by the informal and in some cases the illegal nature of charcoal production. Technical innovations, complemented by regulatory measures, systematic training and demonstration programmes are needed to convince traditional charcoalers to adopt such improvements (Karekezi, 1992).

*Vegetable oils*
Many nuts and seeds are rich in oil, which can be extracted when the nuts are pressed or passed through an expeller. The oil can be used as a fuel to provide heat, work, or electricity. The chemical and physical properties of the oil depend on the original source material. The potential for vegetable oil crops grown for energy use is limited due to competition for land to grow cash crops and food.

*Briquettes*
Significant efforts have been put into developing more efficient briquetting techniques and processes, particularly for developing appropriate binders for briquettes and small scale equipment suitable for rural areas. The main constraints are the high cost of, collecting raw material, capital, operation and maintenance (Karekezi, 1992).

*Anaerobic Digestion*
Biomass with high water content such as sewage, farm slurry, some crop wastes and certain industrial effluents, can be utilised via anaerobic digestion to produce a methane rich gas `biogas' that can be collected and combusted in much the same way as any fossil derived fuel gas. Anaerobic digestion of human and animal wastes is normal practice **in** many rural societies in developing countries, particularly in Asia. Using low-tech, often inefficient digesters, all putrescible wastes from a community is digested to provide biogas for heating, cooking and lighting. In China, there are reported to be between 4.5 and 7 million such small scale digesters and over 330,000 in India. Work has been carried out to improve the efficiency of these devices through incorporating passive solar heating into their design, so increasing biological activity, or through improving the loading and mixing process (often carried out by hand) to optimise the process yield.

*Fermentation*
Ethanol fermentation is the yeast based fermentation of sugars and starches to produce ethanol, which can be used as a liquid fuel. This use of biomass is a well demonstrated technology in some of the newly industrialised countries, most notably in Brazil, where 12 billion litres of ethanol are produced annually from sugar cane, supplying fuel to more than 5 million cars operating on pure hydrated ethanol, and over 6 million cars operating on an 80:20 gasoline: ethanol mixture. Smaller scale programmes are in place in other countries, including Indonesia.

The use of biomass resources in some developing countries is becoming unsustainable. This is clearly shown in Table 131.3 of Case study I contained in Annex B. The table shows a comparison of demand and potentially sustainable supply of wood in Gambia in 1990 and a projection for the year 2020. This projection suggests that wood demand could be nearly six times in excess of local supplies by 2020. Better management of wood resources is needed, along with the introduction of alternative fuels to help achieve a more sustainable use of energy.

**Managed wood fuel production**
The introduction of wood plantations and woodlots in the late 1970's and early 1980's to reduce deforestation and increase production of wood, was expensive and of limited success. A shift back to farm forestry and natural forest management is now playing an important role in solving the wood shortages in many areas including Asia, Africa and Latin America. Farm forestry and natural forestry programmes address farmers needs for food, fodder and other

valuable non-wood products as well as for wood, and the farmers can sell surplus wood products to boost their income. With a more effective supply of wood resources, agricultural residues which might other wise have been used for cooking fuels can instead be used to improve soil fertility.

### A2.2.2 Commercial Energy

**Grid electricity**
The provision of energy services via electrification is seen as a crucial step in providing opportunities for individuals and communities to gain access to many of the benefits and amenities electricity offers. The political and social pressures to increase the pace and scope of rural electrification programmes in developing countries is intense, but the financial resources for such schemes are scarce. The reason that there is so much political pressure, is that electrification is viewed by some to be a way of boosting development. Contrary to this view, is the view that electrification does not cause development, but that it is a derived demand occurring only when an area has reached a certain economic level (Foley G, 1992).

Characteristics of peri-urban areas such as good links to markets and services and ready supplies of labour, make them prime areas to benefit from access to electricity, as the economy of such areas is ready to develop. Benefits could be achieved in the household on farms and for the general community. Examples of which are:

- Households - electric light is more effective than other sources of light such as kerosene lamps or candles. Light allows families to work or study in the household during the evenings when it would otherwise be too dark;

- Farms - productivity of farms can be improved with the use of electricity for crop processing or irrigation where water is available;

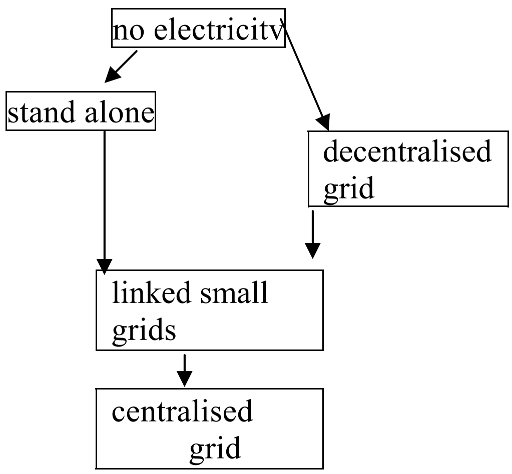
- Community - electricity can benefit the community if supplied to hospitals and schools, used for street lighting, communications or in agroprocessing industries.

Even if it is technically practical to extend the urban grid to peri-urban areas on the urban fringe, the high cost of first connection combined with a lack of appropriate credit systems to finance the connection costs, is still a barrier which needs to be addressed by government policy measures and electrification programmes. Large, centralised government subsidies that fail to serve poor people and undermine the financial position of the electricity industry should be avoided. Policies such as lifeline rates for electricity kept at low levels and limited credit subsidies for initial service are examples of better planned approaches. There are many energy utilities in developing countries are technically bankrupt and grid extension merely worsens their economic position, especially if tariffs are too low.

The main barrier to grid connection for a large proportion of peri-urban areas which are closer to rural areas in character is the dispersed location of households and farms making it difficult and uneconomic to connect them to the grid. In these areas stand alone systems are more likely to be viable options in the medium term. As peri-urban areas have good access to markets and are likely to become more urban in character, it is important to consider the compatibility of stand alone systems with decentralised grid connection and ultimately connection to the main grid, so investments made in stand alone systems are not made redundant when a grid becomes a viable option and stand alone systems can be linked up to grids. Figure A2.2 illustrates the path that could be taken in developing access to electricity in peri-urban areas.

If the aim of moving up the energy ladder is one of sustainable development, then it must be noted that grid electricity in developing countries in most cases can not be considered as sustainable. There are two main reasons for this. The first is that the electricity is generated from finite fossil fuel sources generally imported from other countries (detailed information on alternative technologies for electricity generation from fossil fuels and nuclear power can be found in ETSU 1994a). The second reason is that the inefficient production, distribution and use of electricity incurs high losses to the system. Electricity grids need to be well managed and maintained to reduces losses to the system. There are often unauthorised connections to the grid in developing countries, which means reduced revenue for the electricity supply companies, and less money to invest in making generation and transmission more efficient. Grid electricity needs large sums of money to be invested in the power generation plant, in addition to the cost of the grid.

**Figure A2.2 Access to electricity in peri-urban areas** I




Losses to the grid increase with increased distance of transmission. It is likely to be more efficient to develop decentralised electricity grids for smaller areas, thus avoiding long distance distribution losses and allowing greater control and monitoring of the grid. Decentralised grids are likely to run on lower voltage lines that the larger grid, i.e. running on 11-33kv lines as opposed to bigger urban areas which might reach 132kv. These decentralised grid can eventually be linked to other decentralised grids or into the main grid for increased stability. The implications of connecting decentralised grids together needs further evaluation with regard to the difficulties of overcoming differences in frequency and phase characteristics. More research needs to be carried out on this subject.

Developing a series of decentralised grid systems follows the thinking that it would be more efficient to plan peri-urban areas to develop in a series of decentralised hubs rather than one massive urban sprawl, locating amenities and markets within the peri-urban areas, and reducing the need to travel to the urban centre. This is discussed in more detail in Case study 2 on transport in India, which can be found in Annex B.

**Fossil fuels**

Although fossil fuels are finite and therefore unsustainable, they can play an important role in the medium term providing energy for specific applications while more sustainable energy resources are established. Fossil fuels have a high energy density at point of use and can provide an important stepping stone to aid energy transition in developing countries whether they are used for heat, light electricity or mechanical power. Fossil fuels are costly to import if they are not indigenous to the country. If developing countries become too dependent on imported sources of fossil fuel, there is the danger that it can hinder economic development.

Even if fossil fuels are too expensive for most peri-urban farmers to adopt, access to fossil fuels often keeps the price of wood and charcoal at levels poor people can afford. Limited access to alternative fuels was found to result in some people having to pay more for wood than other types of fuel for cooking. This is not strictly the case, however, as it has also been seen that if taxes are places on fossil fuels dealers are encouraged to increase the price of wood.

Fossil fuels such as kerosene, LPG and diesel are used in rural and urban areas in developing countries. These fuels can be stored, transported and used in most locations, so the dispersed nature of peri-urban areas does not prohibit the use of such fuels. The limitations of their use are the cost of the fuels, the investment needed in appropriate technology and their market availability. However, fossil fuels are often used where low investment technologies such as kerosene lamps are available, as this allows the user to purchase fuel when it is available and they can afford it, without incurring large capital costs.

Adoption of kerosene or LPG for cooking and heating in households is more energy efficient than the use of traditional wood fired methods. Diesel is used for electricity generation, or used in farm machinery such as irrigation pumps, tractors and tillers, or in grinding mills. The use of fossil fuels for motorised agricultural machinery and transport vehicles will become more dominant as peri-urban areas develop.

Fossil fuels have a good potential to be used in peri-urban production systems along side renewable energy sources. This potential can only be realised if appropriate loan systems are available to allow investment in the required technology and local communities are provided with appropriate training and education regarding the operation and maintenance of the technology.

In developing countries where coal is available, it is most likely to be used in urban areas or in power generation systems. It is less likely to be available, affordable or appropriate for use in non-industrialised applications in peri-urban or rural areas.

**Energy from Waste**

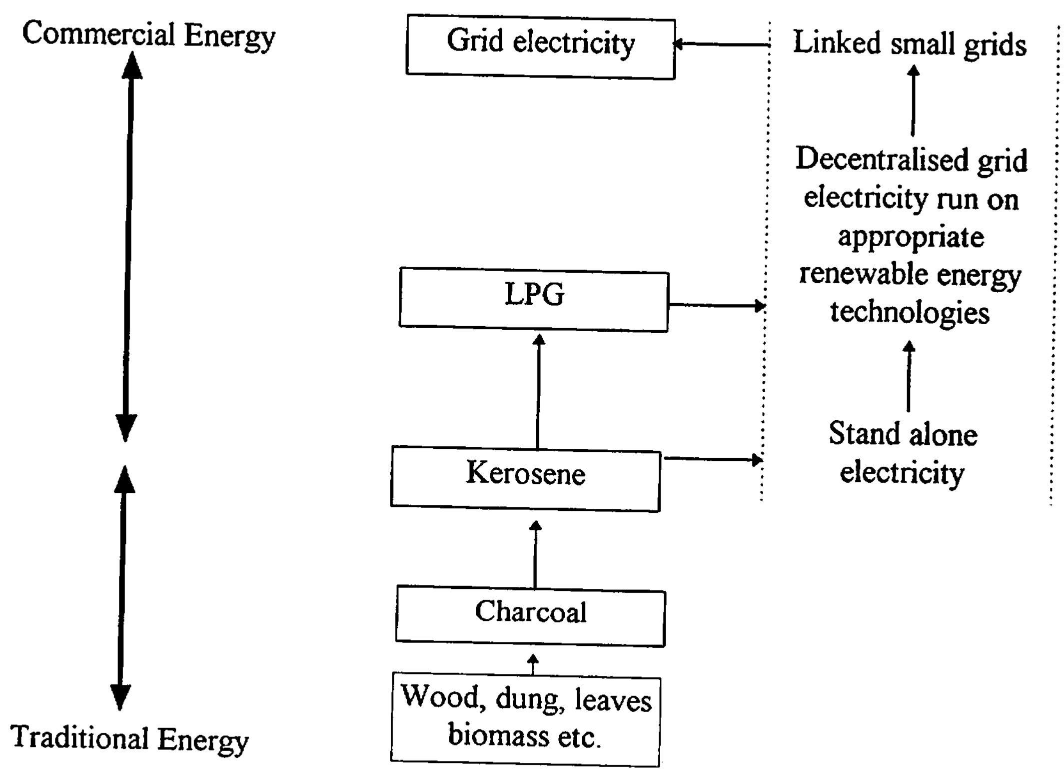
Energy generated from urban waste can be considered a more sustainable source of commercial energy than from fossil fuels. But countries in the early stages of economic development generate waste which is not suitable for western style combined heat and power (CHP). This is because much of the rubbish is "manually" recycled by people who pick it over to find anything that they can use or sell. The majority of waste that is left has a low calorific value and high moisture content making it unsuitable for mass burn incineration. For example in India 40-60% of waste is compostable matter, with the majority of the rest being ash or cinders. As a country develops, the composition of waste changes and incineration becomes a more viable option (e.g. Malaysia now carries out incineration of municipal solid waste). Biogas can be collected directly from landfill sites if they are well managed. This is not such an appropriate option at present in many developing countries as in general land fill sites are not properly managed or maintained.

Where environmental legislation prevents untreated waste discharged from industries, there can be an energy benefit. For example, India has over 200 distilleries which generate effluents which need treatment before they can be discharged. At present their are 145 bio-methanation plants installed which produce biogas from the effluent. If bio-methanation plants were installed in all the distilleries in India, around 2 million $m^3$/day of biogas would be produced, equivalent of 2240 tonnes of coal/day (ETSU, 1995a).

**An additional rung on the energy ladder**

As described in Section A1, Annex A, the transition from traditional to commercial fuels is in general from using dung, leaves and Wood, to using charcoal, then to using kerosene, LPG and eventually linking up with an electricity grid. The jump from the use of wood, charcoal and kerosene to LPG is often too costly and too big a jump for most poor households and the jump to grid electricity is even bigger. It seems there is a need for an additional rung on the energy ladder to help the transition from unsustainable use of traditional energy sources to a more sustainable use of traditional and commercial energy. This additional rung could be satisfied by decentralised electricity grids, run on appropriate sustainable energy technologies, most of which will be renewable energy technologies.

**Figure A2.3 Inclusion of an additional rung on the energy ladder**



The energy ladder should include this additional rung as shown in Figure A2.3. The additional rung will help bridge the gap between Kerosene and LPG and also the gap between LPG and grid electricity. The transition from traditional sources of energy to commercial energy will not be in strict sequence, but will happen as a mix of energy sources are adopted.

**Renewable energy sources**

Alternative renewable energy resources such as wind, solar, hydro and biomass energy are being field tested in developing countries. The two main applications of wind power are electricity generation and mechanical power. Peri-urban areas are characterised by having relative shortages of land. This limits the availability of land for wind turbines sites, although use of land under wind turbines is possible (e.g. for animal husbandry). There are also physical constraints in peri-urban areas such as the presence of forests which are very important for woodfuel resources. Electricity generation from wind has the greatest potential in wind farms feeding into an electricity grid, or for rural communities with isolated systems than for direct peri-urban application. For example, the Muppandal wind farm in the State of Tamil Nadu, on the Southern tip of India, has several hundred wind turbines operating, which help the state's chronic power shortfall and is a successful advertisement for the Indian wind turbine manufacturing industry (ETSU 1995a).

Wind pumps for irrigation, milling and grinding have a greater potential in peri-urban farming systems as the technology is simpler to maintain, can be applied on an individual farm basis, and the technology can be manufactured and maintained locally. Wind pumps are used for irrigating fields improving productivity of crops, and are used to produce mechanical power for grinding and milling.

The two main solar applications are process heat and electricity. Process heat can be used for cooking, water heating, space heating, and drying. Electricity generated using photovoltaics (PV) have been applied at a household level in developing counties to produce electricity for domestic lighting and appliances, refrigeration and lighting for clinics, water pumps, street lighting and lighting for schools. PV systems require batteries for storage of electricity. The cost of solar PV is relatively high, but for small scale applications solar PV is cheaper on a life-cycle basis than remote grid electricity connection. However the initial cost of hardware still puts solar PV systems beyond the reach of many low-income peri-urban households. Good financing schemes need to be established for large scale adoption of such systems. Like most new energy systems, training is required on system maintenance and repair. Table A2.1 is a simple analysis showing the technologies most likely to have an impact on development. Photovoltaics, solar water heating, water pumping and solar drying appear to hold the greatest potential for peri-urban areas.

Small scale hydro power is used for shaft power (pumping, grinding) and electricity generation in developing countries. Where topography is right in peri-urban areas, hydro power has a high potential to provide electricity and shaft power. However, the topography which is most suitable for hydro power is in mountainous areas, which make transport of produce difficult and hence are not the typical location for peri-urban areas to develop. The assessment and identification of suitable sites for small scale hydro power should be given more attention in developing countries. More information on renewable energy technologies can be found in ETSU 1994b.

**Table A2.1 Evaluation of different solar applications and sub-sectors most likely to use them**

| | Agriculture | Household | Rural industry and a ro rocessin | Total |
|---|---|---|---|---|
| Cooking | | 1 | | 1 |
| Space heating | | 2 | | 2 |
| Water heating | | 2 | 2 | 4 |
| Drying | 2 | 1 | 2 | 5 |
| PV water um in | 2 | 1 | 2 | 5 |
| Refrigeration | | | 2 | 2 |
| Electricity:<br>PV<br>Solar thermal | <br>1<br>1 | <br>1<br> | <br>2<br>2 | <br>4<br>2 |

1= limited potential 2 = strong potential
(adapted from Best, 1992)

**Decentralised grid electricity**
Examples of decentralised grid electricity which might be appropriate to develop in peri-urban -- areas include:

- Hydro power generation;
- Biomass power generation - from agricultural residues or `modern' energy crops;
- Energy from waste - anaerobic digestion of industrial effluent, sewage or farm slurry;
- Industrial cogeneration - excess electricity could be supplied to the local area via a small grid;
- Wind power generation.

## A2.3 THE TRANSPORT LADDER

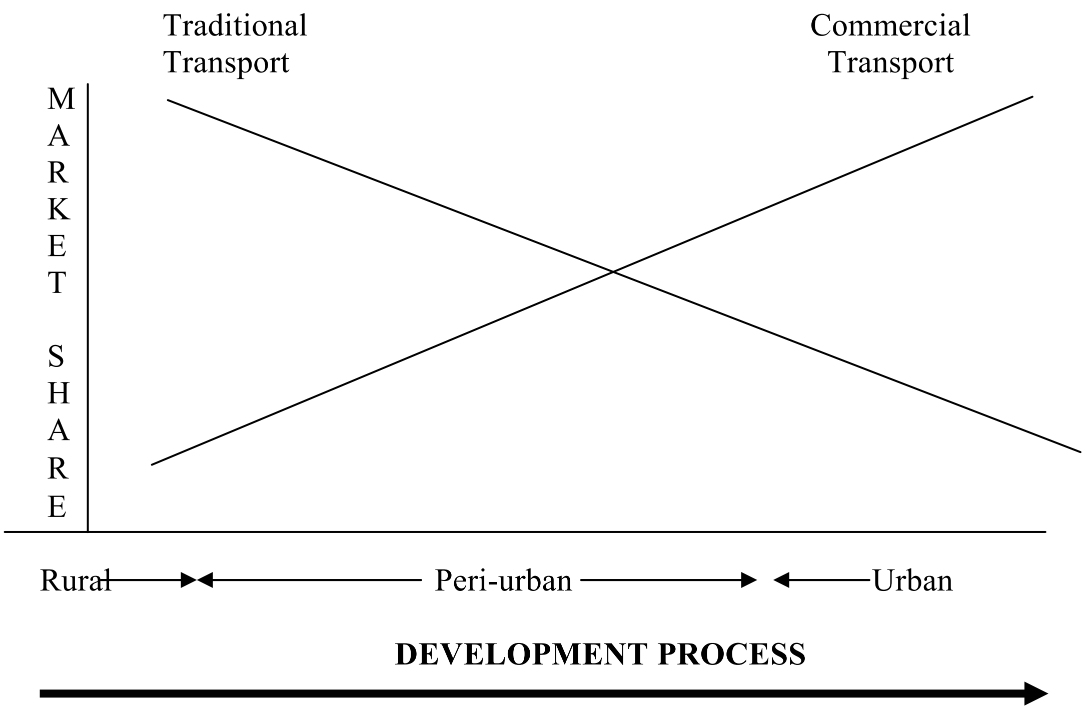
Transport is an important factor in peri-urban development. It brings in essential agricultural inputs such as fertiliser, improved seeds and packaging materials. It is also required to deliver surplus agricultural products to local markets. The location and character of peri-urban areas are strongly influenced by the trading patterns which develops, which in turn is due to the availability speed and capacity of different transport options.

As with the energy sector there is a transition from traditional modes of transport to commercial modes of transport as an area moves from being rural in character to being peri-urban and urban in character. This transition is shown by a shift from human to animal and mechanical power. As with the energy ladder, this shift between modes can define where you are in the peri-urban zone. Figure A2.4 is a simple representation of this.

Traditional transport is walking, with the progression to animal and cart. Mechanised transport spreads a wide span of transport modes from bicycle and rickshaws to motorised transport such as autorickshaws, motorbikes, lorries, buses, trains and cars.

The transition from human to animal and mechanical transport generally allows greater quantities of produce to be carried to and from markets and can give access to more distant markets if the speed of travel is increased. A knock on effect of increasing travel speeds and reducing travel times is that peri-urban areas will be able to spread further away from urban areas, but still remain within a days travel to market.

**FIGURE A2.4 The Change in Mode of Transport from Rural to Peri-urban and Urban areas**




As with the energy ladder a move up the transport ladder puts greater demands on energy sources, particularly liquid fossil fuels (e.g. diesel and gasoline). The energy requirements of non-motorised transport arise from the human or animal energy use involved, as opposed to fossil fuel energy in most forms of motorised transport.

**Table A2.2 Transport Energy Consumption by Mode in Developing Countries**

| Passenger Trans ort | MJ/ assen er-km | Freight Transport | MJ/tonne-km |
|---|---|---|---|
| Cycle | 0.1 | Cycle | 0.01 |
| Motor cycle | 0.8 | Donkey cart | 0.05 |
| Car | 2.0 | Ox cart | 0.4 |
| **Bus** | 0.5 | Light truck | 1.5 |
| Rail | 1.0 | Heavy truck | 1.0 |

(source: ETSU, 1995b)

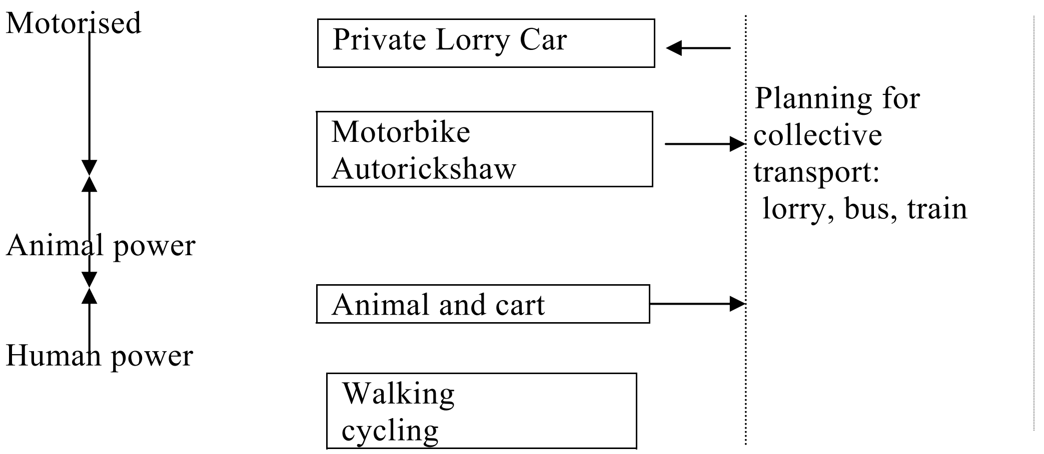
The specific energy consumption of various modes of transport for vehicle load factors representative of developing countries are shown in Table A2.2. It is clear from this table that, where appropriate, non-motorised transport should be encouraged to prevent an unsustainable pattern of transport demand developing. Where motorised transport is adopted, however, there is scope for energy savings through improved vehicle operation and maintenance procedures (ETSU, 1995b). This will also apply to tractors and other farm machinery. Demonstration and information dissemination programmes in western Europe have show significant savings in vehicle fuel consumption. Similar best practice programmes have potential in developing counties where motorised transport is used.

### A2.3.1 An additional rung on the transport ladder

As with the energy ladder, the step from walking, cycling and animal drawn cart to motorised transport is a big jump to make. An additional rung is needed on the transport ladder which would help close this gap. The additional rung should make provision for planned collective transport. Figure A2.5 shows where this additional rung could fit in on the transport ladder.

Collective transport needs to be planned and implemented on a local or community wide scale. For example, on a local scale, a farmer co-operative could get together and invest in a lorry to transport produce to market. A farmer co-operative could have several advantages. For example, they could set up a co-operative agroprocessing industry which would process produce before transporting it to market, thus reducing the bulkiness of some goods and adding value to others. They could transport only as many goods between them as they thought the market would bare in any one day. This has the potential to reduce spoilage of unsold goods being transported back from the market. A community wide example of planned collective transport would be for local authorities or governments to provide public transport facilities such as buses or trains and a good transport infrastructure (e.g. roads and railways). This could provide rapid and economical transport allowing people to commute into the urban areas from isolated peri-urban hubs, rather than encouraging urban sprawl and extension of shanty towns (see Case study 2 in Annex B for more information).

**Figure A2.5 Inclusion of an additional rung on the transport ladder**



Transport of produce or people to markets or places of work is desirable as it brings productivity and economic benefits. However, individual mobility although highly desired does not automatically bring high economic benefit. Thus there needs to be a focus on transport that maximises economic benefit (i.e. getting produce to market and people to work).

Liquid biofuels such as bioethanol, biomethanol or biodiesel could be one way of making fuel used in transport more sustainable, but production cost and pressures on land are likely to make this option unlikely in many areas (see ETSU, 1994a for more information on the production and use of liquid biofuels in transport).

## A2.4 SUMMARY

In general the cost of new energy technology is prohibitive for low-income households, and the cost structure is radically different and not very compatible with traditional life styles (especially with regard to the need for regular planned, cash payments) i.e. the ability to pay is low. The majority of households in peri-urban areas are Iow income, so opportunities for improved energy utilisation will be based on low cost systems. One of the most important critical success factors for improved energy utilisation and associated rise in productivity is the provision of credit systems which allow farmers to invest in appropriate technologies made available to them. People in urban areas where access to "free" energy sources such as wood, dung and leaves is limited, are willing to spend a significant proportion of their incomes on energy services. For example poor urban households in Tanzania spend up to 30% of their household income on energy (Hosier and Kiponday, 1993).

When alternative energy sources are planned and valued, other factors apart from the economic benefits must be taken into consideration. For example it is difficult to compare the benefits of mechanical and electrical power in monetary terms. The increased productivity and other benefits to the household or farm must be measured in some way and accounted for in the assessment of alternative energy options. There is a gap in the knowledge and methods of comparing the costs and benefits of alternative energy sources in developing countries. Costs related to the burdens placed upon women and children should be considered, along with the benefits in productivity and sustainability, and social and cultural issues.

### A2.4.1 Energy management strategies

There is a lack of competitive markets in developing countries for energy services. This makes it difficult to introduce alternative energy sources. Pricing controls such as fuel taxes, fuel subsidies and variable electricity tariffs aimed at trying to influence the uptake of new energy technologies and use of alternative energy resources have had varying degrees of success.

The use of pricing controls such as subsidies and taxes to increase the access of poor people to sustainable energy supplies must be handled very carefully, as the desired result is often not achieved. For example if subsidies are introduces on energy supplies, the rich gain as well as the poor. If a tax is placed on modern fuels (such as LPG, diesel or electricity), which higher income households can afford, this is not of benefit to the poor, even **if** the **aim was** invcsting the revenues to benefit access of energy to the poor, as dealers would be tempted to increase the market price of traditional fuels in parallel to fossil fuels. As poor people pay a much higher percentage of their income on fuels the effect is much more drastic to them. The opportunity cost of these subsidies must be considered.

Alternative energy management techniques which should be investigated for application in peri-urban areas include:

- demand side management;
- load shifting;
- energy efficiency.

Energy efficiency has been mentioned previously with application to traditional and commercial energy sources, and has been the subject of much research.

Demand side management and load shifting are two other energy management techniques which have not been investigated with application to peri-urban areas in much detail. Demand side management could play a particularly important role in transport and load shifting could play a prominent role when decentralised grids start to link together, or to a larger `national' grid. Together demand side management and load shifting can be used to smooth diurnal fluctuations in electricity demand, reducing the difference between peaks and troughs.

**A2.4.2 Organisations**

Much of the relevant work done on alternative energy options is funded by the following organisations:

- World Bank Group (e.g. via ESMAP, ASTAE, the Solar Initiative);
- International Energy Agency (e.g. via REWP, CERT, CADDET-RE);
- European Commission (e.g. via THERMIE, INCO-DC, SYNERGY);
- United Nations (e.g. via UNDP, UNIDO, UNESCO);
- G7 countries and other OECD countries putting money into aid (e.g. UK Government via the ODA, German Government via GTZ, USA Government via NREL, USAID) and private sector foundations such as the Winrock Foundation via REPSO.

Examples of Institutions and consultants active in this field of work include:

- IT Power, UK
- ITDG, UK
- ESD, UK
- ETC, UK and Netherlands
- The Royal Institute of International Affairs, UK
- TATA Energy Research Institute (TERI), India
- Ministry of non-conventional energy (MMES), and the Indian Renewable Energy Development Agency (IREDA)

ETSU, UK
• IDAE, Spain

• CRES, Greece
• FEM, France

• ADEME, France

• Stockholm Environment Institute

• UK renewable energy industries: Dulas Engineering, Renewable energy systems, Garrad Hassan and Partners, Manx Wind Energy Services, Proven Engineering, Marlec
• British Biogen

• University departments

# ANNEX B: CASE STUDY MATERIAL

## CASE STUDY 1. GAMBIA AND HOUSEHOLD MANAGEMENT

Gambia is located in Western Africa, bordering the North Atlantic Ocean and Senegal. It has a total area of 11,300 sq. km, with a land area of 10,000 sq. km. The climate is tropical, with a hot, rainy season (June to November), and a cooler, dry season (November to May). Table B1.1 indicates some key demographic indicators.

**Table B1.1. Population and Urbanisation in the Gambia, 1993.**

| **Area km$^2$** x $10^3$ | **11.3** |
|---|---|
| Population (millions) | |
| total | 0.98 |
| urban | 0.3 |
| urban share | 32 |
| Growth rates (%/year) | |
| total natural | 2.4 |
| total net | 3.3-3.0 |
| urban | 3.7-4.7 |
| Po ulation densit o ulation/km$^2$ | 75 |

**Source: RPTES (1993).**

The Gambia has no important mineral or other natural resources and has a limited agricultural base. About 75% of the population is engaged in crop production and livestock raising, *which* contribute 30% to GDP. Small-scale manufacturing activity (processing peanuts, fish, and hides) accounts for less than 10% of GDP.

Exports in 1993 totalled $81 million. The major export crop is peanuts; other principal crops include millet, sorghum, rice, corn, cassava and palm kernels. livestock, forestry and fishing resources are not fully exploited. Over the same time period, imports totalled $154 million, with the main import commodities foodstuffs, manufactures, raw materials, fuel, machinery and transport equipment.

A sustained structural adjustment programme, including a liberalised trade policy, had fostered a respectable 4% rate of growth in recent years. However, these developments have been overshadowed by the military take-over in July I994. By October, traffic at the Port of Banjul had fallen dramatically as importers nervously scaled back their activities with the commencement of the anti-corruption drive by the new regime. The Gambia faces additional problems if, as is likely, economic sanctions by Western governments remain in effect in response to indications that the military regime intends to stay in power.

The vast majority of the Gambian population depends on natural resources and especially on forest products (Gambia's electricity capacity is 30,000 kW, with a consumption per capita of 64 kWh). The rapid degradation of Gambian forests therefore constitutes a threat to the country's development.

The main cause of deforestation is forest degradation rather than forest clearance. Whilst there is still about 453,400 ha forest area (covering 43 per cent of total land area), most of it (around 75%) is already in a poor condition and is classified as a tree and bush savannah which has less than 10 per cent tree cover.

The RPTES (1995) notes that whilst the size of the population in the capital city Banjul would suggest severe pressure on the land and the forests, it is actually very difficult to assess the situation because:

- the official ban on charcoal production and trade (enforced in 1980) has hindered the collection of reliable statistics on woodfuel demand. During surveys, householders are not likely to reveal activities that may be construed as illegal, but there appears to be widespread use of charcoal and the Government measure did not provide for immediate substitutes.

The regional economy is quite open. If there is a significant consumption of charcoal, it is probably imported from the nearby western Casamance, and part of the fuelwood supplied to Banjul may originate from the same area.

**Table B1.2. Condensed Energy Balances for Gambia, 1992. (1000, TOE)**

| | |
|---|---|
| **Primary Energy** | |
| woodfuels | 197 |
| petroleum fuels | 87 |
| other | - |
| total | 266 |
| **Losses** | |
| charcoal conversion | - |
| electricity (thermal) | 10 |
| other | 3 |
| total | 13 |
| **End Uses** | |
| Households | 172 |
| (of which traditional) | (152) |
| transport | 62 |
| industry | 10 |
| other | 9 |
| total | 253 |
| **Shares of End Uses** (%} | |
| households | 68 |
| transport | 24 |
| industry | 4 |
| other | 4 |
| **Ratios** | |
| population (millions) | 0.9 |
| end use per capita (kg) | 280 |
| trad./total (%) | 60 |
| trad./total household use | 88 |

**Source: RPTES (1995)**

An indication of cross-sectoral energy use in Gambia is provided by Table B1.2. It is clear that the woodfuel sector predominates, and that the household is the single largest user *of* energy. RPTES (1993) states that the average end use per capita for Gambia is relatively high (280 kg oil equivalent); this is possibly because petroleum products for re-export are included in the national consumption.

**B U Woodfuel**

RPTES (1995) indicate that with good management practices, many rural areas will be able to look after their local woodfuel needs without major supply problems. However, distance to gather wood may become longer, and 'free' labour of women and children cannot be taken for granted if the objective is to advance the rural economy.

Table B1.3 summarises the demand estimates in 1990 and 2020. The most striking change in the 30 year period is evident from the numbers on woodfuel equivalents, which combine direct fuelwood consumption and the primary input of fuelwood converted to charcoal.

**Table B1.3. Comparison of Demand and potentially sustainable Supply *of* Woodfuels in Gambia, *1992* (in thousands of tonnes *of* woodfuel equivalent)**

| | |
|---|---|
| **Demand *1990*** | |
| **urban** | 130 |
| rural | 320 |
| total | 450 |
| **Est. Supply 1990** | |
| thousands of tonnes | 300 |
| **Demand 2020** | |
| urban | 800 |
| rural | 600 |
| total | 1,400 |
| **Average Growth *1990* - 2020** (%) | |
| urban | 6.0 |
| rural | 2.1 |
| total | 3.8 |
| **Est. Supply *2020*** | |
| thousands of tonnes | 240 |

**Source: RPTES *(1995)***

In crude numbers, the trend is towards a quadrupling of urban consumption, while rural consumption increases by just over one half over the period. This indicates that in rapidly urbanising countries, environmental pressure on natural resources originates in the cities, and the exploitation of rural resources by urban interests is likely to become a growing source of conflict with the rural populations unless legal and institutional reform occurs. It is also indicates that by the year 2020, woodfuel demand could be nearly six times in excess of local supply.

### B1.2 Charcoal Switch

In general, a consumer switch from fuelwood to charcoal is regarded with concern. In the literature on traditional energy, charcoal as a household fuel is viewed as a positive step on the energy ladder from smoky, bulky fuels towards a more convenient product, better adapted to urban use and the last step in a transition to modern fuels. From a resource use standpoint, the high transformation losses in charcoal manufacture make it an inefficient fuel. Large-scale changeover from fuelwood to charcoal, as has occurred in Senegal, can only accelerate the demand for wood.

A fuel switch from fuelwood directly to kerosene would avoid an acceleration of deforestation. However, RPTES (1995) do not expect that the charcoal phase will be omitted 'in Gambia, as consumer preferences develop clearly in the direction of charcoal; the real problem is how can this be avoided as long as personal incomes remain low. The projection of urban demand assumes that the gradual changeover to charcoal will continue for at least two reasons:

- in metropolitan areas with increasing density of habitat, cooking habits will change to avoid the problems of smoke, dirt and handling of bulky fuelwood; replacing fuelwood by charcoal is one of the ways of doing so;

- growing distances between woodfuel supply areas and urban markets will induce more competition from charcoal because of lower transportation costs (higher calorific value per tonne offsets to some extent the low efficiency of converting wood into charcoal)

It is difficult to see how consumer preference for charcoal can be retarded if there are no affordable alternatives. Indeed, the useful energy delivered by charcoal, after allowing for different stove efficiencies, is about three times that of fuelwood, which implies that at some point the inefficiency of conversion in the charcoal production stage is offset by lower transportation costs. In concluding this debate, RPTES (1995) recommend examining the legalisation of the import and trade of charcoal in Gambia, without removing the ban on domestic production of charcoal.

### B1.3 Peri-Urban Conflict

In Gambia, urban interests dominate forest exploitation and the woodfuel trade. Consequently, the rural population gains little from the resources with which they were traditionally associated. In various degrees, the prevailing production and marketing systems have disenfranchised the rural population. They have only limited access rights and see the nationalised natural resources invaded by strangers who take the fuelwood away for sale by urban traders. Breaking into the commerce of vested economic interests requires money that villagers do not have. Entering production is difficult enough by itself, and the barriers to transportation and marketing are even more difficult to overcome.

RPTES (1995) identify five major access factors which influence the utilisation of energy resources in the peri-urban environment:

- *The road network.* Paved primary and secondary roads provide easy access to forests, but they can also cause severe degradation of bands of land up to about 10 km wide bordering the roads.

- *Cost of market access. No* matter how good the roads are, distance will impose limits on the extent of economic exploitation of forests.

- *The size of the market,* i.e. the larger the urban market, the larger the required supply area. For the same reason, the cost of market access is affected by economies of scale.

- *The distribution of resources relative to markets.* Low-productivity land close to the market may be exploited in preference to more distant high-yielding zones. This can often be seen from the deforested immediate surroundings of both small and large urban centres.

- *Seasonality.* During the rainy season, for example, forests may be less accessible, transportation costs may rise, and exploitation may shift to drier and more fragile regions.

These factors typically reflect the interests of urban transporters in maximising their profits. If left to their own devices, they will overexploit zones close to the markets and move to more remote areas when the cheapest resources are exhausted. Thus access to energy resources in the peri-urban environment is to a large extent a function of man-made infrastructure and of profit-seeking behaviour.

### B1.4 Changing habits in the urban and peri-urban areas

A study by Howorth, 1991, looked at various energy projects in The Gambia in the urban and periurban areas and examined their impacts. The results showed that while having some impact the single largest impact on energy use was the changing household energy management practices in both urban and peri-urban areas in response to urbanisation and increasing prices. The study looked at the three major urban areas in The Gambia; Banjul, the capital, Serekunda, the largest urban conurbation, and Brikama, which, although originally an independent village, is now classed as periurban.

When identifying woodfuel shortages as a condition for woodfuel intervention care must be taken in interpreting demand and supply figures. If per capita woodfuel consumption figures are available over time, they can demonstrate declines in woodfuel consumption that indicates shortage. Table B1.4 shows a marked decline in wood consumption over the last decade. But does this mean a woodfuel crisis?

**Table B1.4. Per capita/day urban domestic consumption of wood in kg**

| 1971/2 | 1981 | 1983 | 1990 | |
|---|---|---|---|---|
| | | | | Western Division |
| 2.96 | 1.60 | 0.73 | 0.29 | Banjul |
| | | 0.96 | 0.73 | Serekunda |
| | | | 0.78 | Brikama |

Source: Howorth, 1991

This was a question not clearly addressed in The Gambia before energy intervention. Although there were no peri-urban fuelwood plantations in response to shortages, there are stove programmes and there have been fuel switching programmes.

The fuel switching programme concentrated on substituting groundnut shell briquettes for woodfuel for approximately 2 years from 1986 to 1988. (The prohibitive cost and poor availability of LPG and kerosene prevented wide scale acceptance and so was not attempted). The briquettes had such a poor uptake that the programme was disbanded - they created too much smoke, availability was poor and they were cumbersome to use.

The stove programme was directed by The Department of Community Development with support from Intermediate Technology Development Group and has been in operation for eight years with varying levels of success. In 1985, around 2000 portable metal improved Noflie' stoves were sold -' in the Greater Banjul area, and that number is now believed to be considerably higher. The stove programme in the urban areas has been helped because wood in these areas is relatively expensive as opposed to the rural areas where the stoves have generally failed because wood is still a free good.

The three generic strategies available for woodfuel intervention - supply enhancement, fuel switching, and demand mitigation with efficient technologies - have been considered, tried and abandoned. But, as wood consumption continues to decline, what is happening in The Gambia?

**B1.5 Household management strategies**

There are various household management strategies that are employed by women in the household to minimise external resource pressures. There is a careful and meticulous management of the household environment particularly in households under stress. The stress comes in the form of an increase in price of fuelwood and, to a certain extent, a decline in availability. What this means is that the consumer is putting her house in order by conserving resources and switching 'downwards' rather than 'upwards' in their adaptation to difficulties. This is done at the simplest and most basic level of changing the way they use fuelwood.

The changes in household management manifest themselves in a number of ways. The most notable changes have been:

• A more efficient use of less wood;
• A move to prepared food;
• Fewer meals cooked.

To a lesser extent, households have changed to communal cooking and to foods requiring less cooking.

In Serekunda, the largest urban area, such changes are apparent. The expected 'normal' habits of a household would be the cooking of three daily meals - breakfast, lunch and dinner. Cooking habits change with urbanisation; for example, breakfast is often omitted, the cooking of the afternoon meal becomes increasingly later in the day and there is less emphasis on a big evening meal. There are thus, two types of changed cooking habits: one caused by urban life influences and one caused by the shortage of woodfuel by price increase. These changes in cooking habits vary in each urban situation.

WoodfueI shortages were most apparent in Brikama, because:

- the wooded area around Brikama has been seriously depleted by expanding farmland and so the ability to gather free wood was limited;
- it is a semi-rural/peri-urban area, where there is more emphasis on the traditional extended family households and household eating habits, i.e. large family meals, three or four times a day,
- incomes, in Brikama are lower than in Serekunda and wood demands a higher proportion of that income.

In Brikama, it is shortages that have changed cooking habits, not a change of life style associated with towns. However, the change in cooking style has been much the same as those caused by urbanisation trends, i.e. fewer meals are cooked, one is omitted or eaten cold, less wood used, and sometimes food type is changed for faster cooking varieties. Experienced shortages, rather than urban tastes, produced a more acute perception of woodfuel shortages in Brikama than in Serekunda. Although women in Serekunda commented on the sharp price increases in woodfuel, their feelings of hardship were not on a par with those in Brikama. Women in Brikama complained of wood shortage and not just price increase; wood was of an inferior quality, and there was constant reference to how they used to cook, and consequently eat, before the shortages developed.

Whether it be due to urban trends or woodfuel shortages, women are actively managing their household economies. They are responding to individual hardship without external assistance and with creative and innovative techniques.

## CASE STUDY 2. INDIA AND TRANSPORT

In 1991, the urban population stood at approximately 230 million, about 28 percent of the total Indian population (Vijayaraghavan, 1993). Almost 30 percent of this figure live below the poverty line and 30 to 40 percent live in urban and peri-urban slums. These 218 million people are living in over 3768 towns of different sizes and in different parts of India (Joshi, 1993). By the start of the next millennium, the urban population is set to grow to 350 million. Table B2.1 gives details.

**Table B2.1. Urbanisation in India (urban population in millions and percentage of total population)**

| | 1961 | 1971 | **1981** | 1991 |
|---|---|---|---|---|
| India | 78.9<br>18% | 109.1<br>20% | 159.7<br>24% | 230.1<br>28% |
| Andhra Pradesh | 63<br>17% | 8.4<br>19% | 12.5<br>23% | 17.9<br>28% |
| Karnataka | 5.3<br>22% | 7.1<br>24% | 10.7<br>29% | 15.7<br>35% |
| Kerala | 2.6<br>15% | 3.5<br>16% | 4.8<br>19% | 6.6<br>22% |
| Tamil Nadu | 9.0<br>27% | 12.5<br>30% 133% | 16 | 20.2<br>36% |

Source: Vijayaraghavan, 1993.

While the rate of urbanisation can be seen in a positive light in terms of national development, creating skills and wealth and also finding employment for migrants, it also has implications for urban overcrowding, health problems, poor sanitation, water and energy shortage. The actual and projected high urbanisation rate has implications for high peri-urbanisation growth, as cities spread horizontally (as well as vertically) into the urban fringe areas. The urban boundaries are thus ever changing as peri-urban becomes urban and as rural becomes periurban. Joshi, (1993) characterises the urban energy sector as having the following constraints:

• the energy demand exceeds supply;
• the power generating capacity is less than existing demand; • indigenous production of petroleum fuels is limited;
• the foreign exchange situation limits the import of petroleum products; • the quality of coal is deteriorating;
• biofuels continue to be used as solid fuels in low efficiency devices; -- • the contribution of other renewable sources of energy is negligible;
• with urbanisation, the demand for a clean and convenient energy systems is increasing.

### B2.1 Transport

*"People today travel five times faster than they once did, but they have to travel five* ***times*** *further" (Singh, 1993)*

One of the major energy issues that affects India is caused by the extremely high rate of urban growth; urban transport. Transport within and between urban settlements (including from the rural to the urban, from the peri-urban to the urban and back again) accounts for a major share of current urban energy requirements. The spatial pattern of urban and peri-urban development and the mix of urban function strongly influences the amount and type of transport required (Singh, 1993). Singh (1993) observes the following in regard to urban structures and land-use policies which can reduce travel demand and hence energy for transport:

• urban expansion is inevitable. If the proliferation of mega cities studded with slums is to be avoided, it will be essential to accord priority to the development of rapid and economical transportation systems which enable people to live in small towns or villages [or peri-urban sites near major cities and commute to work without difficulty;
• service and trade sectors which generate or attract the maximum number of commuter trips in urban areas need to be properly located in relation to residential areas;
• some studies indicate that clusters of smaller settlements are more energy efficient than one large area. Development in secondary centres in a polynucleated form is more energy efficient than continued growth based on a larger single centre;
• a greater mix of various land uses, residential commercial, shopping, recreational educational, etc, should reduce traffic and demand for energy;
• planning of residential areas around more dispersed clusters of employment and services in relatively compact urban sub-units.

**B2.2 Transport in Madras (adapted from Vijayaraghavan,1993)**

Madras, the capital of Tamil Nadu (which is the most urbanised state), is the fourth biggest urban conurbation in India and it has a population of 5.3 million. Madras has a significant number of migrants, and, according to the 1981 census, there are 1.48 million migrants who make up 34 percent of the population. Population growth in the next twenty years has been forecast to increase by 4.2 million to 9.5 million. Of this figure, about two million will be added to the inner urban area, and an equal number of people in the peri-urban areas. Because of increasing land prices in the central city region, large proportions of the population have settled on the urban fringe as have many industries. This has resulted in increased demand for transport facilities along the urban periphery, and it has also resulted in increased length of journeys.

The major modes of transport in Madras are: buses (45.5%); walking (28%); cycle (10.7%); trains (9%); and two wheelers (3.2%). The total number of person trips in 1984 was estimated to be 6.75 million as against 2.65 million in 1970.

The bus system has a fleet of about 2000 buses providing around three million trips per day compared with 1000 buses and 1 million trips in 1970. The service is provided by the State owned Pallavan Transport Corporation (PTC), which gives one of the best services in India. The area coverage is fairly good and the service is generally reliable. However, the service still suffers from serious overcrowding and long travel times during peak times, which are caused by: greater congestion (34% of total road length is over-saturated); delays en-route and in-vehicle delays; higher ticketing delay and delay due to boarding and alighting.

Bicycles are the most widely owned means of transport, with over 60% of households having access to a bicycle, implying 150 bicycles per 1000 people. In Madras City, the bicycle population has risen from 500,000 in 1984 to 700,000 in 1990. Although bicycles are one of the most energy efficient and `green' means of transport, the increasing predominance of periurban settlements far away from the CBD means that bicycles are becoming less appropriate.

The transport system in Madras is severely overburdened and, it is also inefficient in energy terms. This is partly due to the excessive road congestion but also from inefficient engines and poor maintenance. This in turn produces significant pollution, both noise pollution and ambient air pollution.

The National Commission on Urbanisation (India, 1988) estimates that the travel in the four mega cities of Bombay, Calcutta, Delhi and Madras is likely to grow from 32.5 million person-trips to 60 million person trips by the turn of the century, which is equivalent to having a 50,000 bus fleet. It is recognised that urban transportation can be developed optimally only when transport, land-use and energy are coordinated. This has not happened and the absence of co-ordinated policy has resulted in the growth of transport in a rapid and haphazard way.

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# ANNEX D: INTERNET RESOURCES AND BIBLIOGRAPHY

## D1. INTERNET RESOURCES

### 1. Bioenergy e-mail List

The bioenergy mailing list (bioenergy@crest.org) is hosted by the Centre for Renewable Energy & Sustainable Technologies(CREST) for industry, academia and government to -" discuss biomass production and conversion to energy.

Current subscribers to the list are from 21 countries and engage in the research and commercial production of biomass crops and fuels, the conversion of biomass to more that 200 MWe in operating plants, the construction and testing of commercial scale pilot facilities for combustion, gasification and anaerobic digestion, testing and analysis of environmental impacts for bioenergy, and promotion and planning of future bioenergy resources. Current topics of discussion and pending issues are listed below.

**Some Recent Topics On The Bioenergy List**

Cook stoves competition
Open core gasifiers
Biofuel heating values
Biogas from manures
Conference Announcements
Conversion of Biofuels to Alcohol
Emissions from Bioenergy Plants
Bioenergy Newsletters: NBIA, Energy Crops
European Technologies for Converting Grasses to Electricity
Cofiring Coal and Switchgrass, Firing Tests
Small scale Wood Chip Burners, Gasifiers
Literature on Biomass Energy in Rural Areas
Alfalfa Energy Project
Energy Crops: Poplar, Switchgrass
Bioenergy List Directory, Archives, Comments
Electronic Bioenergy Information: Kiosk Online, Biomass Information Networks, EREN
Economic Impacts of Bioenergy in the Northeast
Rice Hull Combustion and Gasification
Commercial Gasifiers, Hawaii Gasifier, Battelle Gasifier
Bioenergy Spreadsheet Models
Alkali and Particulate Emissions, Deposits

2. **Bioenergi** (Swedish Bioenergy internet site - English version forthcoming).
http://www.novator.se

**3. Energy Efficiency and Renewable Energy Clearinghouse (USA). An internet gateway** to energy efficiency and renewable energy information from national and international organisations.
E-mail: energyinfo@delphi.com
http://www.eren.doe.gov

4. **Hydroelectric and Other Renewable Energy**
http://www.eia.doe.gov/oiaf/ieo95/hydro.html

**5. Non-OECD Energy Consumption by Region, 1970 - 2010**

http://www.eia.doe.gov/oiaf/ieo95/tables/tbIO7.txt

6. **Renewable Energy Education Model.** Theoretical and practical basics of renewable energy. http://solstice.crest.org/renewables/re-kiosk/index.shtml

7. **The Source for Renewable Energy.** Database of renewable energy information, including the renewable energy business locator
http://www.rmii.com/the source/renewableEnergy/

8. **Renewable Energy Group**
http://www.hrz.uni-oldenburg.de/-kblutn/re.htnl

9. **Solstice: Renewables and Alternative Sources of Energy**
http://solstice.crest.org/renewables/

10. **Energy Yellow Pages**
http://www.ccnet.com/-nep/yellow.htm

11. **World Energy Projection** http://www.eia.doe.gov/oiaf/ieo95/appendix.html

12. **World Total Energy Consumption by Region, 1990-2010**
http://www.eia.doe.gov/oiaf/ieo95/tables/tblal4.txt

13. **World Total Energy Consumption by Region, 1990-2010**
http://www.eia.doe.gov/oiaf/ieo95/tables/tbla2.txt

**14. World Total Energy Consumption by Region and Fuel**
http://www. eia. doe. gov/oiaf/ieo95/tables/tbla 13. txt

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