Energy systems in the periurban interface

Periurban Project WP4 Report

October 2005

Mattias Nordstrom
Stockholm Environment Institute

Prepared for the
Periurban project
https://www.periurban.org

Contents

1. Introduction

The periurban project

Periurban is a thematic network, financed by the European Commission, which brings together six core partner institutions and a wide range of experts and stakeholders. The ultimate objective of this project is to bring together local communities, researchers, and responsible authorities at the local and national level to investigate periurban settlements. It will build upon research carried out at national and international level to understand the environmental and economic problems and opportunities created in the rural areas around the urban settlements.

The specific objectives are:

- To identify linkages between environmental and socio-economic processes in the peri-urban interface (PUI). Social and economic factors affecting the natural resources use within peri-urban areas will be identified and this will be used to develop a conceptual framework. Practical definitions of economic, social and environmental aspects will be made with respect to natural resources use.

- To understand the existing institutional mechanisms within PUI in India. This work will lead to a greater understanding of the existing institutional mechanism in PUI in order to identify alternative institutional mechanisms to strengthen environmental management in PUI.

- To identify and understand energy and transport sector pressures on natural resources in peri-urban areas. The inter-relationships between energy, transport and environment will be identified; energy and transport needs and expectations of local people will be evaluated.

- To formulate a set of policy options to promote economically and environmentally favourable settlements in the fringe areas around urban settlements in India.

- Using a range of dissemination tools delivering the knowledge generated through this project to public, scientists and policy makers. The new knowledge will be delivered in technical and non-technical formats to a wide range of stakeholders.

As this is a thematic network research project, the primary purpose of the project is to bring together researchers from different disciplines.

The energy aspects

The purpose of the study is to provide a framework within which energy needs of the peri-urban communities and the inter-relationships between energy use and natural resources can be investigated. The approach used is a combination of secondary literature research, and highlight gaps in existing published peri-urban literature on the energy aspects, and to use insights from the familiarisation visits and case studies carried out by project partners to link desk studies to realities on the ground.

2. Approach and methodology

The Periurban project, being a thematic research network rather than a primary research project includes a number of primarily secondary methodologies to solicit input and synthesise information.

Literature review

The initial literature review aimed at collecting and reviewing the existing literature on periurban research in general, and energy systems in the periurban interface, in particular. This activity was primarily geared towards published information.
This literature review revealed that although there is an emerging, albeit still limited, literature specifically treating rural-urban interaction, published work on the energy sector in this context is small.

Internet discussion forum

In order to also access unpublished work, an Internet discussion forum was set up under each of the substantive work packages, including energy. In order to get a maximum response to the discussion forum, a wide group of individuals and organisations involved in energy and development research were invited. The target group was selected from SEI's large contact database of collaborators globally.

Though the discussion forum generated some interesting input is was also evident that very few researchers are explicitly working on linkages between energy systems and urbanisation. Traditionally the energy research communities have been divided into the urban infrastructure planning school and the rural development school, neither of which has published widely on the interface where these meet.

Workshops

The main activity under the Periurban project has been the series of workshops organised by the different partners. During these workshops, lively discussions among core partners and external collaborators around specific project outputs have given raise to refined definitions of the periurban interface, how to analyse the specific questions arising in the PUI context and also new insights into the complexity of finding a common framework of analysis.
So far, five workshops have been organised in India and one in Europe and in each there have been presentations and sessions held by external partners to highlight aspects of ongoing research relevant to the periurban project. A number of papers with a bearing on energy have been presented at these workshops, including work carried out around Bangalore, Chennai, Delhi and Anand – as well as international experiences.

Background paper

In preparation for the joint energy and transport workshop held in Bangalore in July 2004, a background paper on energy was produced. This background paper summarised the literature review, the approach used and also the initial findings of the work package on energy, and was used as a basis for discussions during the Bangalore workshop.

Familiarisation visits

The Periurban project is a thematic network, and thus not intended to include new primary research. However, the partner institutes in India all have ongoing research with aspects applicable to the project. Familiarisation studies of these ongoing efforts were organised in connection with the project workshops, which provided valuable insights into the situation on the ground in the settings identified as “peri-urban”.

These visits proved essential to the understanding of the periurban interface, and to agree on a common definition of the PUI. Furthermore, these exercises facilitated closer collaboration with ongoing, yet unpublished, research activities on the ground that proved an invaluable addition to the limited published literature. Some of the findings from these visits are included later in this report, and serve to highlight the complexity and width of energy aspects of the PUI.

3. Definitions

The periurban interface

The simplest description of the peri-urban interface is where urban and rural activities meet. To scientifically define this, however, is significantly more complex. Peri-urban areas are a mosaic of agricultural and urban ecosystems, affected by material and energy flows demanded by urban and rural areas. They are socially and economically heterogeneous and subject to rapid change. Small farmers, informal settlers, industrial entrepreneurs and urban middle class commuters may all coexist in the same territory but with different and often competing interests, practices and perceptions (id21). It has been pointed out that rural institutions are often ill suited to cope with urban encroachment problems, while the urban institutions adhere to clearly demarcated jurisdictions and are prone to leave anything outside these aside (van Dijk 2000).

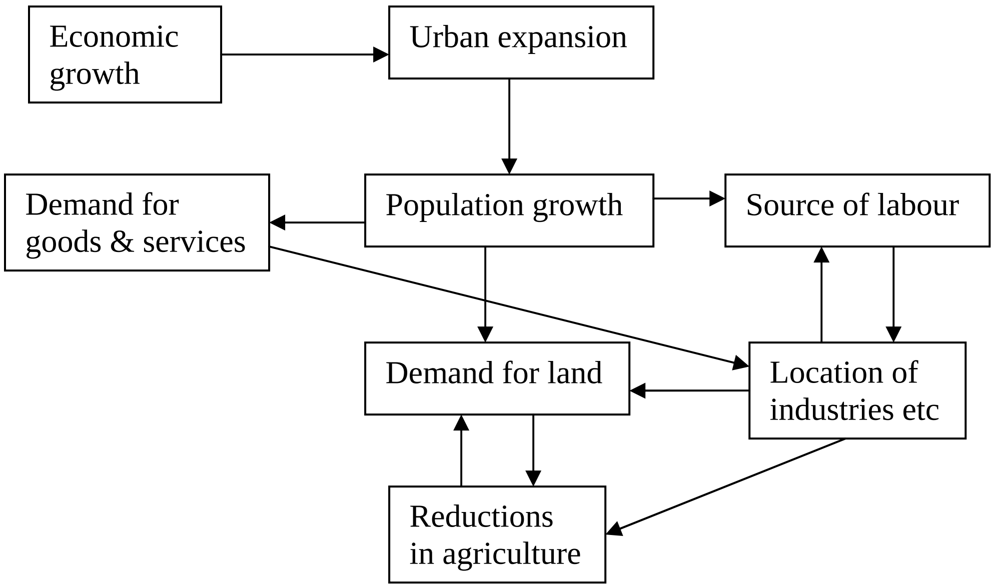
Other authors (Iaquinta & Drescher 2000) have more systematically identified and classified a range of aspects needed to be understood in order to analyse the PUI:

1. Rural, Periurban, and Urban form a linked system (R/PU/U) - an uneven or lumpy, multidimensional continuum.
2. In terms of migration and urbanisation periurban environments play a mediating role between rural and urban.
3. Periurban environments are places of social compression and dynamic social change.
4. The potential for access to goods and services must be evaluated across the entire R/PU/U system.
5. Understanding the nature and operation of the system requires a focus on the underlying dynamic processes rather than the "fixed states."
6. Effective policy interventions rest on interdisciplinary understanding, which incorporates physical, biological and socio-cultural paradigms.

Earlier work (Thirumurthy et al, 2003) in the project around Chennai exemplified the above. This work clearly shows the uneven, multidimensional and rapid transformation taking place around large cities in India:
“***Peri-urban*** areas refer to the settlements beyond, about or around cities. These areas accommodate the spill over developments of the core cities. ***Peri-urban*** areas are in some form of transition from strictly rural to urban. These areas often form immediate urban rural interface and may eventually evolve into being fully urban. The majority of them are on the

fringe of established areas. But they may also be clusters of residential developments within rural landscape. They have significant ecological, bio-diversity, land and cultural heritage values. These areas may be within the planning areas but outside the administrative boundaries of the cities. The ***Peri-urban*** settlements and the core cities have very strong interactions, inter-dependence and inter-relationships." (Thirumurthy et al 2003)

The Periurban project also attempted to summarise the driving forces at work creating the PUI, such as the competing land use needs of settlements, manufacturing, transport systems and agriculture which all exist in parallel in the PUI.



Drivers behind competing periurban land use pressures.

The important feature, we argue, is to ensure that the PUI is treated neither as a place or a process, but both. It is a change over time, taking place in a specific geographic area. This process can never be "sustainable" if this term is limited to the meaning of a repetitive activity sustained over a longer period. When the process of urban expansion has slowed down (after a period of rapid urbanisation), experience tell us that we will find clearly delineated urban and rural jurisdictions with limited elements of both in each, but not too much and not under rapid transformation.

Energy services

Energy in itself is not useful. What is useful are the variety of services that are used to meet human needs such as cooking food, lighting rooms, adjusting indoor climate, transportation, communicating and mechanical work like pumping or grinding. Energy services are provided by a variety of combinations of technologies, infrastructure, labour, and primary energy resources.

Developing countries, in particular, are striving to satisfy many fundamental needs for their citizens. Well conceived and effectively implemented energy services provisions can both help direct development down an environmentally sustainable path and, at the same time, provide an integrated tool capable of addressing a broad range of human development goals.

In the long-run, modern energy services, particularly those generated by electricity, are indispensable for everything from productive employment to the provision of social services in schools and health centres. For the commercial and manufacturing sectors, affordable and reliable supply of electricity is crucial.

Though access to modern energy services that meet some basic needs is expanding, the household activity that consumes the most energy – cooking – is for many still too energy intensive (and thus expensive) to carry out with electricity or gas. Wood fuel, cow dung and charcoal are the cooking fuels available to a large share of the world's women. This situation is likely to persist for a long time, unless groundbreaking progress is made on large-scale electricity generation or gas production from renewable resources, major investments are made in high-intensity electricity generation (fossil or nuclear power plants) or fossil cooking gas is disseminated on a wide basis.

For many people currently using traditional methods of cooking, cooking with electricity is simply not an option, even if the house is connected to the power grid. Many of the renewable energy alternatives that have been suggested as solutions (biogas, agriculture residues, passive solar cookers to name a few), either do not have the energy economy needed – or do not constitute enough labour reductions for the women involved, to have achieved mass dissemination.

The concept of energy services, in addition to the traditional quantitative measures of supply and demand volumes, highlights the need to carefully analyse the end users and -uses of these services as well as the modalities for providing them. Household water pumping, lighting and refrigeration are three examples of energy services that can fundamentally transform the lives of people. The difference between electric light and alternatives such as candles or kerosene lamps means a difference between being able to read after sunset and not being able to. In fact, this has been pointed out as the single most notable difference for families that get access to reliable electric lighting (

Livelihoods framework

The Sustainable Livelihoods approach originates in individual interventions at the micro level of projects and participatory development. Energy supply and use systems are mentioned as forming a part of physical assets, which includes "access" to basic infrastructure. Because of this rather broad-based inclusion, however, energy is likely to impinge on many aspects of the approach and play a major part in determining the nature and range of livelihood strategies that are feasible. Thus, it does not deal with the indirect nature of the demand for energy services and the complexities introduced by the fact that that some energy systems are privately and individually owned (for example, the self collection of wood fuels for cooking), whereas others are best provided either at the level of the community (small hydro systems) or the nation (large electricity systems or the supply of kerosene and Liquefied Petroleum Gas (LPG)).

The use of livelihoods framework for holistic analysis is becoming part of the mainstream in development studies and is exhaustively explained in published literature. It will therefore not be further defined here, but rather used as one stream of analysis in the following chapter on interlinks between energy and society.

4. Energy in society

Energy is an integral part of development and a key ingredient to sustainable development, and has important connections with sustainable development in that:

- Services that are derived from the use of energy play a fundamental role in human development. This applies to meeting basic human needs such as food, shelter and sanitation as well as to enable activities that improve people's living standard, health, education and productive capacity.
- The energy sector has a major environmental impact. To achieve sustainable development, negative impacts have to be reduced through coordinated actions guided by consistent policies.

However, energy per se is an insufficient condition for development. Although energy strategies certainly need to become both more flexible and targeted, their impact on social and economic development can be ensured only when the following other factors are present:

- Complementary infrastructure, such as roads, communication facilities, water supply, access to markets, and credit.
- Production equipment and livelihood assets.
- Good governance in the form of proper policies, institutions, and delivery mechanisms.
- Integrated projects that combine energy services with the above.

Energy and human development

In order to achieve the targets set out in national and international development programmes, substantial improvements will have to be made towards the provision of modern energy and transport services. There is also an urgent need for a more equal distribution of these services. Moreover, with a view to achieving the objectives of the climate convention, energy services will have to become more sustainable with an increasing share of renewable energy and more efficient use of energy. This would lead to beneficial side effects, e.g. reduced emissions of health related substances such as particles. Improving the quality of energy services enables people to live healthier, give adults and children a better opportunity for education, and provide alternative sources of income.

The role of energy in social development

Energy has a facilitating role to play in creating a sustainable, equitable and peaceful development leading to social development. The poor are constrained by both the quantity (insufficient to meet their needs) and quality (fuels with poor properties and negative health impacts) of the energy sources which they have access to. Energy services are needed in meeting basic human subsistence needs such as food, shelter, sanitation and health care. Once these basic needs are satisfied, additional demand or energy services are driven by amenities and services that enhance welfare for example: access to information, entertainment and communication, provided by household radios and televisions, network receiving and switching stations and distance learning centres; or improved lighting at the household and community levels to enhance educational attainment, enable tasks to be performed more easily and reduce security risks.

The shift to modern, high-quality energy services has had profound impacts on our lifestyle and living condition. When particularly electricity is made available at the household level, it is very difficult to imagine a life without it. Most of the changes at the household level make home life more convenient and household work easier:

- Illumination in the form of electric lighting is the foremost benefit of electricity because it contributes to convenience, safety, and other benefits. It also results in cash savings because its alternatives (kerosene, batteries) are more expensive.
- Alleviation of isolation, through TV and radio, is considered the next highest benefit of electricity because it serves to bring remote rural communities closer to the outside world.
- Home improvement is made possible by electrical appliances, such as water heaters, clothes irons, cookers, and grinders.
- The impacts on education of electricity are also conditional upon the availability of schools and educational facilities. In most cases, the very low level of illumination in electrified households does not add to children’s study time.
- Electricity results in time savings in the daily lives of both men and women. Men use these savings primarily for recreation and leisure, whereas women redirect them to other household chores. On the whole, time savings from electricity do not reduce the overall workload of women, although they make work easier.

The role of energy in economic development

Economic development can be promoted by making production processes more efficient (in terms of energy, raw materials and labour input), and thereby making end-products more affordable. Without access to high-quality energy services, a great deal of time and physical energy must be spent on basic subsistence activities. At local and national levels, access to energy services is essential for economic stability and growth, jobs and improved living standards. Diversification of energy supply systems can have many advantages such as directing countries down more sustainable economic development paths; geographically spread economic growth in both rural and urban areas (including more evenly over the periurban interface), increase economic security by lowering dependence on a limited number of primary energy sources.

Following are some examples of when economic development is directly dependant on access to modern energy services (such as water pumping, shaft power or light):

- Agricultural activities such as irrigation water pumping and agricultural product processing, increases productivity. Although the resultant income growth is often modest, it has a high impact among the poor because it forms a significant part of their income.
- Households can more easily employ develop home-based enterprises.
- Income from manufacturing and businesses depends on the quantity and quality of energy services, investment capacity, and access to markets. On average, income from enterprises and businesses that use electricity is double that of unelectrified enterprises and businesses.
- Cash savings of 30–40 per cent as compared to pre-electrification expenditures on simple services such as lighting, using kerosene and candles. The savings could be even greater if efficient appliances, such as compact fluorescent lamps (CFLs), were used. However,

over time, these savings are offset by increased electricity consumption as households tend to acquire more appliances.

- Appropriate energy services can contribute to asset building through increases in the values of land and property. This is further enhanced when community facilities develop over time.

Energy needs and aspirations

The differentiation between what is considered a need and an aspiration varies, mainly depending on the level of affluence of the person asked. In today's world it is considered parts of basic human rights to have access to health care and education facilities. It may thus be useful to distinguish between basic needs and productive needs when discussing energy services. Basic needs are necessary to lead a dignified and healthy life, while productive needs are for those who aspire to take control over their own productivity. After all, energy use is never an end in itself.

- *Basic needs,* such as cooking, heating, lighting, and comfort or convenience in households; and community uses, such as public lighting, health facilities, and schools.
- *Productive needs,* such as applications in agriculture, home-based enterprises (both manufacturing and services).

In meeting the needs for both basic and productive needs, one has to look at the following factors:

- *Access* to appropriate energy services
- The *affordability* of these services
- The extent of *choice* that the user has in acquiring and making use of these services

Energy and livelihoods

Here follows two examples of how energy systems can be used within the livelihood framework, using the capital assets approach. The first example is an attempt to examine the various capital assets that form the basis of the livelihood approach. The second example illustrates a few livelihood strategies within the energy sector itself (Adapted from Farrington et al 2002).

<u>Capital assets and energy</u>

Natural capital

(Natural resource stocks from which resource flows useful for livelihoods are derived)

- The main natural capital asset for many people is likely to be biomass (wood, twigs, crop residues, dung) that can be used as fuels. In some cases, hand-dug coal and peat are natural assets for poor people. Access to these natural resources is affected by many factors (e.g., land ownership, climate) and their sustainability is affected not only by their use as fuel, but also changes in land use (fuel wood becomes less available when land is cleared for food production).
- Other energy related natural capital assets include falling water, wind, and solar insolation. However, these sources require other forms of capital to convert them into useful energy.

- Animate energy in the form of human and draft animal power also form a significant "natural" energy asset.
- Changes in land use and improved access can increase exploitation of local natural resources, e.g., forests, and increased competition for land and resources.

Social capital
(Social resources on which people draw in pursuit of livelihoods, that is, relationships, membership of networks)

- Networks and social relations often determine an individual's access to natural resources (who can collect fuel wood from a particular location), access to energy conversion technology that is owned by others (grain mills, baking ovens, machines for preparing land, irrigation water pumps), access to other people's skills (electricians, engine repairers), information about technical (and managerial) alternatives and so on.
- Because women are the main users and suppliers of inanimate energy in poor communities, their social capital of friendships and networks is likely to be particularly important.

Human capital
(Skills, knowledge, ability to work, and good health that enable people to pursue different livelihood strategies)

- Formal and informal employment generation in construction, maintenance and provision of energy services.
- Indigenous knowledge of local energy sources and their use in a sustainable environment.
- Improved health of women and children as a result of access to improved energy services for cooking, which reduces indoor air pollution—one of the biggest causes of death and ill health.
- Improved healthcare, education and communication as a result of energy for lighting, pumping, communication and transport.
- Access required to skills for many aspects of energy service delivery, and for some aspects of energy use (e.g., people with knowledge of electric installations).

Physical capital
(Basic infrastructure for the supply of energy, shelter, water, transport and communications, production equipment)

- Access to energy sources (electricity) and fuels (fossil and biomass fuels).
- Access to the technology required to convert energy into a useful form, particularly end-use technologies, such as stoves, lamps, machines, radios, motors, and engines.
- Production technology that enables inanimate energy to replace the drudgery of human labour.
- Transport services depend on access to reliable and reasonably priced fuels.

Financial Capital
(Financial resources that provide livelihood options, e.g., savings, credit, remittances, pensions)

- The "lumpiness" of the investment in energy conversion devices or the lack of enough cash to make bulk purchase of (lower cost) fuels means that poor people often cannot get together enough cash to buy them, even though there would be considerable cash savings over the medium-term future (kerosene is often bought by the cupful).
- Modern renewable energy conversion technologies share a characteristic that militates against their use by poor people—they generally have higher initial capital costs and lower recurrent (fuel) costs relative to fossil fuel based technologies.
- The increases in productivity and subsequent lower prices that result from increased access to improved energy services help improve savings and other financial capital.

Energy and livelihood strategies

In addition to the necessity to have access to energy services for any sort of livelihood, one can also think about livelihood strategies that are directly linked with energy services provision.

Generating income through energy resource refining or retailing

- Refining raw fuel (e.g. wood to charcoal, drying of dung cakes) for selling
- Retailing of energy carriers (e.g. shop selling LPG, kerosene, batteries)

Generating income through technical expertise

- Maintenance of energy conversion equipment

Access improved energy services through fuel switching

- Changing cooking fuel to cleaner one, or improving hygiene by improving ventilation
- Changing light source from candles, to kerosene and eventually electricity

Generate income through switching to improved energy services

- Changing from manual to mechanical agro processing
- Serve hot or cool beverages (stove or refrigerator) in bars and restaurants

Grouping with others to access improved energy services

- Community-based activities such as health care, school or security lighting
- Collectively pay for installation of either grid connection or stand-alone generating capacity
- Collectively acquire motorized transport

Energy and natural resources

Energy is an essential ingredient for both social and economic development. However, it is all too often the cause of environmental degradation (e.g. local air and water pollution, mineral depletion). In India, with a combination of high population density and reliance on electricity generated through combustion processes (over 85% of generated electricity (IEA 2004), imported petroleum fuels as well as indigenous (and often inefficiently used) biomass (about 30% of total energy consumption (TERI 2002)), this is particularly evident.

If both the rate of access to electricity, as well as overall energy use, are to significantly increase in the short- and mid-term there will have to be important advances in both the energy efficiency of existing systems, as well as introduction of new renewable energy sources.

Environmental degradation is a significant obstacle to development. The livelihoods of the periurban population can be particularly dependant on scarce natural resources – more so than the urban population who is in a sense decoupled from direct need of natural resources, and the rural population who often has more living space per capita.

An overwhelming majority of the population in developing countries depend on biomass (wood, charcoal, dung and straw) to meet their basic energy service.

5. Periurban energy systems characteristics

The two main characteristics of the generic periurban energy system are:

- A wide diversity of energy services are used in parallel
- A rapidly changing energy mix

Diversity and dynamics

Who are the users?

A number of processes are happening in parallel, leading to a diverse and dynamic periurban energy system:

- Industrial out localisation (due to lower land prices, cheaper labour, lower environmental standards)
- Planned satellite towns around major cities
- Agriculture shifts towards urban market products (vegetables, flowers etc)
- Spontaneous densification among transport arteries
- Migrant squatters occupying (currently) unused land
- Urban middle class move into the periurban zone
- Farmers selling agriculture land, when real estate prices go up enough, and change to another profession, or move farther away and buy larger lands for continued agriculture. This leads to a transition period in which former agriculture land lay fallow.

So far, we have found no literature with detailed information on who the typical periurban dweller is. The dominant groups seem to be the original villagers, migrants from further afar who have come to the periurban zone for wage or farm labour, and finally urban middle class moving out to the fringes of the city to find cheaper land to build their house on.

According to studies (DFID 2001) in Hubli-Dharwad, there is no evidence that the ratio of poor/very poor to medium/rich households varies according to distance from the city (up to 15km from city centre). Poor and very poor families have tended to diversify their livelihood strategies in response to opportunities afforded by the city. However, this study confirms that there is scant knowledge about what can be said to characterise peri-urban dwellers.

Energy use in periurban communities

Due to the wide variation in household income levels and livelihood basis, as well as the mix of large manufacturing industry with small commercial enterprises, the whole spectrum of energy services is found in the periurban zone.

On the household side, this spectrum spans what are still essentially rural villages without modern amenities, to communities with full electricity connection and access to other modern energy sources. For business and institutions, the situation is the same. Traditional industries such as leather tanneries can run on fuel wood, while heavy automated manufacturing industry (cars, for example) need uninterrupted, stable and high-volume electricity supply. However, from what we have seen so far in the project there is a clear shift towards electricity and LPG in the periurban zone – and frequently it seems a rather rapid transition is taking place. To what extent it is the use pattern or the actual users – periurban dwellers – that change is still not entirely clear.

To highlight the household energy use in periurban areas, some findings from the familiarisation visits are presented below. These are presented in the form of summarised examples of mostly a “snapshot” character. In order to actually identify real trends in the development of the energy systems in these communities large amounts of field data would be needed – data that is not presently available within the Periurban project.

The discussions where framed around the following questions:

1. What energy sources are currently used? For lighting, cooking, water pumping, entertainment, other?
2. Have there been any changes in the energy use in the community?
3. Is there a shortage of energy?
4. How much does it cost?
5. Is energy relatively costly?
6. What are the negative effects of the energy use?
7. Is there a need for protection of forests?
8. Are there other energy sources than what’s currently using? Could these be useful to?
9. Could the energy supply be better organised?

Due to the fact that there were no provisions for comprehensive survey techniques being used during these interviews, the results have to be treated as indicative only. There seems to be large uncertainties (or at least disparities) in the communities about a great many questions. Large variations in what people say they pay for a service could indicate large variations in the actual access to services, but at this stage we have no means of correcting for these variations.

There are indications from the field visits that periurban dwellers are not normally pushed towards shifting from fuel wood to kerosene or LPG due to scarcity of wood. Rather, in some instances we’ve heard that most of the households switched to LPG directly when delivery started by truck, and fuel wood was exported from the village. Apparently, the deciding factor was convenience.

These are of course only scattered indications, and there may well be areas within the periurban zone where wood shortage is actually pushing users to switch to other fuels.

Case 1 (Chennai)

- *Electricity is available but almost exclusively used for lighting.*
- *The approximate share of energy sources for household cooking:*
- *LPG – 60% to 90%*
- *Wood – 10% to 20%*
- *Kerosene – 20% to 30%*

- *The users of wood and kerosene use cow dung during rainy season or when kerosene is in short supply.*
- *At current domestic tariffs, small household PV systems are not economical.*

Case 2 (Delhi)

- *80% have shifted to LPG from wood for cooking in recent time due to better distribution.*
- *Almost all households connected to the electricity grid.*
- *Industry moves from city into the periurban zone to reduce cost and escape environmental legislation.*
- *Commuting for wage labour outside community has decreased interest in managing common natural resources*

Case 3 (Bangalore)

Fuel wood

- *Most households use wood for cooking (although some also use other fuel)*
- *Views on wood scarcity vary between no problems at all and severe depletion of forests*
- *Buy wood at 12 rps/10 kgs*
- *200 households used smokeless cook stoves (with chimney) – not government scheme but the practice spread by word of mouth.*
- *Preferred tree used for fuel wood is Neem.*

LPG

- *Only a few (4?) households use LPG for cooking*
- *Not available nearby, purchased at 5-10 km distance @290-390 rps per cylinder (14.2 kgs)*
- *Most families would like to cook with LPG (more convenient than wood, cheaper than kerosene), but the up-front cost of the cylinder is too high for most. (between 2,300 and 3,500 rps for cylinder, regulator and stove)*

Kerosene

- *Rationed at 3 litres, rationed kerosene cost 10-11 rps/litre, while the peddler market price is between 11 and 27 rps per litre (!)*
- *Some households cook almost exclusively with kerosene, which is expensive (300-800 rps per month)*
- *Apparently, the availability of non-subsidised kerosene is good, but the price varies widely.*

Electricity

- *All households connected, pay per unit based on meter readings (normal monthly bill is 200 rps)*
- *Stated connection fee between 250 and 5,000 rps(!)*
- *Used for light, fans, TVs and 3 families cook with electric plates*
- *Limited access due to less than 24h service*

Irrigation

- *Used to power irrigation pumps (no rainwater harvesting)*

Alternative sources of energy

- *Biogas plants in village not functioning, but also the people do not want to use them.*
- *One solar water heater is installed by private individual, which has raised the interest for solar energy.*

- *Do not know where and how (and at what cost) solar heaters or PV systems are available – but know that these exist and what they are used for (heater for hot water, PV for lights).*

Local initiatives

- *Have asked local government for improved electricity supply and free LPG cylinders, but nothing has happened.*
- *Would like to know more about solar energy (water heaters for domestic water and solar PV for lighting), but do not know who to turn to.*
- *The project team asked about the feasibility of starting local LPG retail scheme, but the answer we got was that this is problematic due to lack of standardised components in the cylinder-regulator-stove system.*
- *If cylinder was given away for free, most would switch to LPG.*

Case 4 (Bangalore)

Size: 400 households, little agriculture land left, most have sold the land and now have jobs in industries nearby. Discussion group: Female members of local self-help groups (SHG, collective credit schemes). The SHG credits are funded by the members, who pay a weekly fee of 20 rps per week per member. The credits are member loans with an interest rate of 2%. No credits had been given for energy appliances or fuel.

Currently used energy:

Cooking

- *LPG (15 households), Kerosene and wood (100), wood only (rest). No biogas plant in community.*
- *Wood collected ca 3 km away, which is preferred but restricted by forest management scheme enforced by government. When not possible to collect wood, it is bought from sawmill @ 1.20 rps/kg. Normal quantity is 200-300 kgs every 20-30 days, and transport charge is 100 rps.*
- *LPG is sold 18 km away, and is brought to village by the villagers themselves. A 14.2 kg cylinder costs 310 rps, and the auto trip costs 110-120 rps. LPG cylinders are not allowed on public transports for safety reasons.*
- *Kerosene is available at the main road (1 km away), and is rationed at 3 litres per family per month. The subsidised kerosene costs 32 rps/3 litres, and the peddler market price is 15 rps/litre.*

Electricity

- *All households electrified, and power is available 24 hours per day. Until 4 years ago1 power was only available a few hours per day (6-12 hours per day).*
- *Used to power lighting, fans, mosquito repellents. 150-200 households have TV, but no fridges.*
- *The connection fee is 2,000 rps.*
- *The tariff starts with a flat charge of 40 rps per month, and the unit price is based on consumption level.*
- *We did not ask about irrigation pumps.*
- *No piped water in houses, water available at public taps.*

Changes in energy use

- *Government promised free LPG[2], but they never got it.*

Is there a supply shortage?

[1] When the area was declared an industrial development zone.
[2] Probably refering to government scheme in which cylinders were provided free of charge.

- *As government has restricted access to fuel wood collection, people want LPG for cooking. The reasons for not using it already are distance to retailer and cost of cylinder. People are prepared to pay ca 250 rps per cylinder.*

Case 5 (Bangalore)

Size: 250 households. Main occupations are agriculture workers and koolie work. About 1-2 cattle per household. Only 5-6 people go to work in nearby Pepsi-cola bottling plant. There are two local self-help groups (SHG, collective credit schemes).
Only a few (7-8) people have sold land for industrial development, and this was wasteland sold for 6-7 lakhs per acre (good agriculture land valued at 10-11 lakhs per acre).
Currently used energy:
<u>Cooking</u>

- *LPG (4 households), kerosene only (at least one), kerosene and wood (100), wood only (rest). Four biogas plants in community, but none functioning and there seems to be no interest in reviving them.*
- *Wood collected from farmland or from private non-agriculture land. No one buy wood. Fuel wood not considered a problem.*
- *LPG is sold 3 km away, and is brought to village by the villagers themselves. A 14.2 kg cylinder costs 290 rps, and the auto trip costs 4(?) rps. One cylinder lasts 2 months for 3-4 people, and 20 days for large families. One person said he didn't want to use LPG for safety reasons; there had been an explosion in nearby village.*
- *Kerosene is available at the main road (3 km away), and is rationed at 3 litres per family per month. The subsidised kerosene costs 32 rps /3 litres and the peddler market price is the same, at least for the one man who said his household used 30 litres per month and got it at subsidised price without any problem.*

<u>Electricity</u>

- *All households electrified, 100 got connected in government scheme (connection fee 2,000-3,000 rps) earlier. Last year the remaining 150 houses got connected (connection fee 5,000 rps), and all customers got individual meters.*
- *1-phase power for domestic use available only during nighttimes (18.00 to 9.00 hours).*
- *Used to power lighting, fans (80 houses), TV (20), radio (20). No fridges.*
- *20 electric irrigation pumps using 3-phase power. These are only possible to run during 6 hours at night when power is on. Tariff for irrigation pump is calculated on 300 rps per installed horsepower per annum.*
- *No piped water in houses, water available at public taps.*

<u>Water heating</u>

- *One privately installed solar water heater in the village, but not yet commissioned (very new).*

<u>Is there a supply shortage?</u>

- *Miss wood from forests and want more plantations, but land is scarce.*

Case 6 and 7 (Anand)

Reference salary level for day wage unskilled labour is 60-70 rps per day. In Lambha and Laxmipura, four cooking fuels used are firewood, dung cakes, kerosene and LPG. The combination of these fuels varies from community to community. Only the people living in housing societies are fully dependant on LPG for their cooking needs.
The salient features are:

- *The households that have access to cooking LPG (circa 20%), which is mainly used for minor activities such as making tea and cooking vegetables with one cylinder lasting for maybe 3 to 4 months (for a six person household).*
- *The average family use 25-30 dung cakes (@200 g) and 2-3 kg of firewood for daily cooking.*
- *Produce and sell surplus dung cakes to other communities at 10-20 rps for 100 dung cakes.*
- *Firewood collected from wasteland or bought from village market at 20-25 rps per 20 kgs.*
- *Kerosene is not used for cooking in some groups, while widespread in others.*
- *An average family with access to LPG also uses 2.5 kg of firewood, 5-6 dung cakes and 1/3 litres of kerosene for daily cooking. In this case, an LPG cylinder lasts for about 1.75 months.*
- *Kerosene is purchased from official ration shop at 8.10 Rps per litre.*

Both villages are connected to the electricity grid, and electricity is used for lighting and irrigation.
(Saxena (2004))

It has to be noted that the several case communities represent slightly different locations in the PUI, ranging from the predominantly urban, with more modern infrastructure and access, and less agriculture land, to the predominantly rural.

From the energy point of view it is notable that while most periurban settlement has a wide coverage of electric power connections, the actual service varies considerably. In some instances, areas have been designated "industrial development area" and are supplied full power 24 hours per day, while the others have seriously less supply. In one of the cases, single phase distribution was given between 1800 in the evening and 0900 in the morning. In addition, three phase power was provided for 6 hours each night, but it was not exactly determined which hours. This power allotment was inconvenient, because farmers had to stand by all night waiting for power for irrigation. Also the power was not enough to fully irrigate the fields.

Typically, not all households have access to LPG in each of the communities. LPG is sometimes acquired from a distance of 4-15 km at variable prices (Rps 300-400) plus transport charges. Although many stated they would like to use LPG, apparently lack of cylinders was a reason for poor distribution facilities. It is, for example, not allowed to carry LPG cylinders on public transport, on account of safety restrictions.

All cases have different access to wood or biomass fuel, and some have to resort to buying wood from nearby sawmills or markets, if they did not chose to encroach upon a nearby forest, running the risk to be caught by the forest guards. In other places there is no nearby forest, but trees on the farmland and agricultural residues were sufficient for most households. Notably, in only one instance did households use electric hotplates for cooking.

The table below is an attempt to compile a matrix of the energy services and associated technology options as found in the PUI. In the matrix, items marked with blue indicate energy sources which were used only to a limited degree or not at all in the villages, but which might be feasible. The matrix is not completely logically consistent, in that a great number of conversions might have been indicated more clearly. As it is, "Electricity" generally refers to grid power, while what electric services come under, for instance, "Solar" refers to low-voltage, low power applications.

Ordering the energy sources in the way done in the matrix, those energy sources to the right indicate traditional energy use, and hence a more rural location on the PUI. Those energy sources in the centre indicate a more urban location on the continuum.

The new and renewable energy sources (particularly solar and wind) might be feasible both in rural and urban areas *per se*, however, it is noted that they might be more feasible in a more rural setting, mostly because they would have less competition from easily available high-quality modern energy sources.

	Wood/ biomass	Cowdung	Animal/ human	Kerosene	LPG	Diesel (petrol)	Electricity	Solar	Wind
Cooking	Traditional + improved stove	Traditional stove		Pressure + wick stoves	LPG stove		Hotplate, stove	Hotbox, parabolic cookers	
Lighting	Traditional + improved stove	biogas lamp, electricity		Wick lamp		(oil lamp)	Incandescent bulb, fluorescent tubes. Street light	Lantern, fluorescent tube, street light	Electricity
Heating	Traditional + improved stove	Biogas					space heating	Solar water heater	
Cooling							Fans, cooler, AC, fridge	(fan)	
Entertainment & info			Dancing, theatre, story telling				TV, radio, computer, cell phone + battery charging	TV, radio, charging	Radio (TV)
Water pumping			hand pumping, carrying			Irrigation, drinking water	Irrigation, drinking water	Drinking water (irrigation)	Irrigation, (drinking water)
Transport			Walking, carrying, ox- donkey carts		Auto	Auto, 2W, tractor, bus, lorry, car			
							Generally grid electricity		

Figure 1 Energy services vs technology options

Sustainability issues

The issue of sustainability is complex and all-encompassing. As the Periurban project has placed a special emphasis on natural resource use in the PUI, the sustainability discussed here is focussing on the general definition of sustainable as a process which is utilising local resources in a regenerative manner - i.e. they are not depleted. However, due to factors external to the energy scenario, such as shifting land-use and income generation patterns in the PUI, ecological sustainability is not easy to achieve. While new and renewable sources of energy might be proposed as sustainable energy solutions, these measures would – at least during a transitional period - have to be strongly subsidized. There are encouraging examples of e.g. low-emission vehicle fuels being introduced for urban metropolises, but the pace of urbanisation and growth will make it difficult to introduce sufficient mitigating measures such as emissions reduction and natural resources protection.

The traditional energy sources, mainly in the form of wood, are not seen as solutions in the PUI. This is based on experience with “Social forestry” and “Peri-urban fuel wood plantations” elsewhere. Such efforts have mostly failed for various reasons. One reason has been that access to wood under the Forest Department was strongly restricted to the people who wanted to use it. On the other hand, forest plantations operated by the local people for their own benefit was also not used for fuel, but for income-earning purposes. Local people favour high-value timber or fruit trees when they themselves have to contribute, in order to gain some income from their toil. Wood for fuel is rarely seen as worth the trouble or capital invested.

Then, in a village near the outer edge of the PUI, i.e. more rural in character, with agriculture, fields and animals, there is always enough fuel, although this might not necessarily consist in heartwood of mature trees. Instead, agricultural residues, shrubs, branches and bark may be used. If burned in appropriate devices, this use is sufficient, and is sustainable in the local scale.

Closer to the urban side of the PUI, such resources are growing scarce, and alternatives need to be found. As illustrated in the case examples above, agricultural residues are not always easily obtained due to lack of production, and wood has to be purchased. However, here is a richer variety of alternatives, including modern fuels such as LPG, and electric power from the grid.

Energy issues in the PUI

The energy issues raised in the peri-urban time-space must then focus on securing the access to those modern energy sources that might be the most appropriate to fill the energy needs of people in the PUI. This must take into account the social diversity and ability to demand (pay for) energy.

As seen from Figure 1, electricity is by far the most versatile energy resource, able to provide most energy services of all. Although electric cooking is slowly becoming an alternative, LPG might still be the strongest contender for a convenient and efficient cooking fuel, although ecologically sustainable it is not, at least in a longer perspective, as it is a fossil, non-renewable, resource.

The major issue here is one of adequate distribution of energy. This is true for gas, as well as for electric power, although the options and distribution modes are very different. Below, the specific issue of supply is discussed more in depth.

Distribution of electricity

India is trying to expand electric power generation capacity, as current generation is seriously below peak demand. Although about 80% of the population has access to electricity, power outages are common, and the unreliability of electricity supplies is severe enough to constitute a constraint on the country's overall economic development (IEA 2004). Furthermore, the net import of oil has grown from 250,000 barrels per day in 1985 to more than 1.5 million barrels per day in 2005 (US Department of Energy 2004).

The further to the rural side of the PUI the poorer is the supply of electricity, at least in the most common case. This is an effect of insufficient supply, and the supply is further reduced by technical and non-technical losses in the system. In many instances, one reason for this is that the power utility is not equipped to provide either the services needed to the customers, or the maintenance necessary for optimal distribution. This in turn is due to lack of funds, since revenue collected is less than the cost to provide service and maintenance, in addition to other management costs. While there has been a large number of independent power production schemes proposed and approved, many of the larger ones have been fraught with delays.

The first step is to improve distribution is to improve the general operation of the utility. This implies standard measures such as training of staff, enforcement of cost-efficiency and cost-sensitivity, good accountancy and collection of outstanding debts from customers and disconnect defaulters. It may also imply revision of tariff levels to reflect cost in a more appropriate way, so that it is indeed possible to meet the costs incurred.

It may also be feasible to consider reducing the tasks of the utility, especially in the PUI. One such solution is to establish small utilities in the peri-urban settlements, either as part of the village council, or as private or cooperative companies. Such companies would purchase bulk power from the main utility, and would be charged with the duties to provide low-tension power to individual clients. In this way, the obligation of the main utility would be to provide high-medium tension power and maintain the transmission, while the local utility would maintain and operate the local grid. This operation would include revenue collection, a task that might be much more efficiently done by a local company with local knowledge and presence, than by a remote actor whose servicemen only rarely can afford to visit the location. This also gives the possibility for quicker rectification of local faults, better upkeep of the network and less technical and non-technical losses at the local level. In addition, especially in case it is a cooperative company, there might be factors of common benefit that can be realised, for instance a greater sense of ownership of the infrastructure and less of negligence and vandalisation. This would lead to higher reliability, lower operation costs and feasibly lower power charges. Obviously there would have to be an investment in employment of staff, but if this were achieved through training of local people it would add to the income earning possibilities in the location.
In order for this local utility approach to be feasible, it may be necessary to review electricity laws and codes in some states.

Distribution of LPG

There are two major barriers to the widespread distribution of LPG, which, to a great extent already includes private operators. The first is obviously the supply of sufficient quantities of LPG all over the country to meet the demand. The second is to make the demand technically feasible, which means that each client must have (at least) one gas cylinder. This is an investment of Rps 2,000-3,000, which may be too much for many households to accommodate. After this has been obtained, however the actual cost of LPG fuel is lower

although still higher than the kerosene in widespread use for cooking purposes. There have been campaigns where state government has supplied cylinders to households at reduced cost or even free of charge. This has resulted in a substantial growth of the distribution chain. There is no reason to believe that it would be otherwise if such campaigns were propagated in the PUI as well as in other areas. The effect would be that distributors of gas would be more inclined to service settlements with a greater number of cylinder-owners.
Poorer households may find it more difficult to come up with the money needed to replace the larger cylinders, but might find it feasible to replace smaller ones, under the tragic logic of "the poor pays more for less". The proposed idea would not necessarily change this grim logic, but at least it would ensure that versatile cooking fuel were available to all households.

New electricity installations outside Anand…but dinner is prepared using wood (photos by Mattias Nordstrom, SEI)

Is there a periurban supply problem?

It is evident that the patchiness and rapid pace of change present both opportunities and barriers to a stable energy supply to cover all needs. However, it may seem like the periurban interface presents opportunities in that a wide range of options are available, and users may pick and choose among the options available. This would make it possible to get the best of both worlds - modern, mainly urban, energy services where it is most valuable, while keeping traditional and presumably cheaper energy options where it is not as critical.

The question whether periurban energy systems offer a wider array of choice for consumers, or whether periurban consumers are on the receiving end in a fierce competition for energy sources is a question that has not been properly researched. A World Bank study (Floor & Massé 2001) argues that periurban areas should be prioritised for purposes of electrification, as there is already a latent demand for more high quality energy services and a relatively dense mass of customers.

With reference to the systematic review of what the supply options are (Figure 1), below is an example of problems faced (supply and otherwise) in one of the case studies presented during the project (Panda 2003).

Energy need	Energy source	Problems faced
Cooking	LPG: 43% Kerosene: 9% Biogas: 2% Fire wood: 32% Dung cake: 3% Crop residue: 11%	Fast disappearance of biomass Un-affordability of commercial energy Health hazard
Lighting	Electricity:98% Kerosene: 2%	Brownout: 4-13 hour Voltage fluctuation:+/- 40%
Ventilation	Electricity: 98% Natural: 2%	
Entertainment and communication	Radio: 95% TV: 67% Telephone: 22%	Damage to the equipment because of high voltage fluctuation
Drinking Water	Tap and Tube well: 74%	Supply when electricity available
Irrigation	Electricity: 100%	Unreliable and poor quality of electricity Un-affordability of diesel
Commercial	Electricity: 100%	Brownout: 4-13 hour Voltage fluctuation:+/- 40%
Industry	Electricity: 100%	Normally reliable and good quality of grid electricity

Despite this seemingly gloomy outlook, there are also special opportunities present in the periurban setting:

- Willingness to pay for modern energy services, especially electricity, for lighting and basic household needs, is higher than in purely rural communities.
- Reduction of monopolistic powers of public energy supply utilities under ongoing sector reforms, offering increased prospects for private initiative that may be better at capturing the rapidly changing energy landscape in periurban areas. These new actors can benefit from rapidly expanding demand, and more easily move with the market as they are not geographically bound to a specific administrative unit.
- Improved performance and lower costs of decentralised alternative energy technologies offer alternatives to the main electricity grid. This is one avenue that smaller and more flexible energy service providers can stay ahead of the often more slowly expanding national grid based energy systems.

6. Technical options

Due to the particular scope of the Periurban project, this section will be limited to discussing technical alternatives that could be implemented within the PUI geographical area. Grid-based supply options (i.e. electricity in most cases) are not fundamentally different when employed in different situations, apart from the cost of infrastructure extension depending on user density. Thus, the analysis of the options available to provide appropriate generation capacity to feed the electricity grid is not specific to the periurban setting. Furthermore, this is a field well researched and also where planning is highly developed and mainstreamed, and there is no point in (or space for) reproducing it in this paper.

Approaches to alternative energy development

Off-grid (using renewable resources or not) energy technologies have come a long way since their modest beginnings more than three decades ago in the developing world. Many of them now cost much less, perform far better, and are economically viable solutions to meet at least the basic energy needs of even relatively poor people. Unfortunately, the barriers are still often formidable in that regulatory and financial incentives favour traditional centralised grid systems.

For instance, even though the initial cost of solar photovoltaic (PV) technology is high and, in practical conditions, is capable of providing only small amounts of electricity, it has some distinct advantages that are not easily matched by other options. Small, stand-alone systems could be viewed as pre-grid solutions for those who cannot realistically be expected to be connected to the electricity grid in the foreseeable future. The conditions for disseminating alternatives among the poor can be made more favourable, for example, through credit schemes and/or capital cost subsidies. India has for example a vigorous programme for promotion of household sized PV systems.

New strategies for alternative energy technologies must, however, recognize that these technologies have a genuine role to play in development. To begin with, interventions should encompass technologies other than those that produce electricity, for example biogas and liquid fuels. Marketing strategies should also match real world economic conditions by combining conventional top-down market penetration approaches with new bottom-up market creation approaches.

A user-driven approach to alternative energy technology promotion will involve the following:

- Shifting from a technology fixation to a more need-based strategy.
- Resolving tradeoffs between environmental goals and poverty reduction goals.
- Greater diversity of technological options, especially for fuels.
- Larger-scale systems to enhance supply capacity to cater to productive uses.
- Increased focus on “packaged” systems incorporating efficient appliances.

Role of alternative energy technologies

Massive technical change in recent years has altered people’s ideas of what is possible. Improvements in small-scale energy conversion technology have increased efficiency and reduced costs, as well as more efficient centralised systems using locally available resources (e.g. municipal waste, agricultural residues, wood).

In the periurban zone, where there is less than full access to modern energy services, while still normally a surplus of biomass is available, there are opportunities to improve both the modern and the traditional.

The main drawbacks of off-grid renewable technologies, such as solar photovoltaics (PV), small hydropower, and wind power, are the limited supply capacity and relatively high initial investment cost. If initial investments can be managed, though, the energy services provided can be both more stable than the electricity grid, and at a lower system lifetime cost. However, they are prone to supply irregularities from resource fluctuations (light, rain and wind), poor component performance (for example, batteries), lack of know-how for maintenance, and poor project design and management. If high-quality services from renewable sources are to be disseminated on a wide basis, there is a need for capacity building to keep large number of small technical systems working.

Examples of interventions that improve modern and traditional energy systems

Improving the modern	Improving the traditional
Augmenting the existing grid with backup capacity for power cuts (reserve generator)	Use locally available bio material (agricultural residues, dung, wood) to generate gas or electricity on site
Using solar photovoltaics, wind generators or combustion generator for the electricity base load	Making the use of traditional fuels more efficiently and healthy through improved cooking facilities
Replacing LPG for cooking with locally produced cooking gas (biogas or gasified biomass)	

Demand management and appliance efficiency

Promoting the efficient use of energy is always desirable, as low efficiency on the demand side means high gross primary energy consumption. At present, with the exception of solar PV systems that are usually supplied with energy-efficient tailor made lights, most alternative energy solutions are not overly concerned with demand management or appliance efficiency.

However, if the user see no problems in high consumption of primary energy, for example if electricity is given away for free, or if there is no shortage of free fuel wood, then all interventions to increase efficiency of appliances will probably fail.

7. Policy options

Of course, technology alone will not be sufficient to transform energy systems in periurban areas. The dynamics and diversity will also require a systematic approach to a wide range of softer issues, including regulations, standards, tariffs, start-up support, fair subsidies and dissemination of know-how.

Instruments for influencing energy systems development:
- Policies – political objectives and agendas
- Subsidies – means to achieve social objectives not achieved by market forces
- Tariffs – the visible result of the policy and subsidy compromise
- Regulations - market limits, ensure fair competition
- Standards - technical and safety limits for energy system design

The last few decades have shown that the issue of reducing poverty globally and providing a growing world population with the energy services demanded will probably not be straightforward. While the trend is that economic development allows people to shift adverse environmental and health impacts away from themselves – both spatially and temporally[3] – vast shares of today's world population will not see the result of this shift for themselves. In many countries, people will face the simultaneous energy- and transport systems induced impacts of local health problems, regional pollution problems and global climate change. This will put high demands on policymakers to address a range of issues in parallel.

There are no universal solutions that will suit every country, or every group within a country. Hence, when extensions of basic services are planned, it is important that there are adequate resources set aside for decentralised and flexible solutions to cater for those who will not get access to the centrally planned system.

1 A number of key challenges have emerged over the last decade concerning reforms of traditionally state-run bodies and the increasing emphasis on sustainability and equity.

2 In order to provide basic household energy services for large shares of poor populations, decentralised and cheaper systems will have to be available. These can take the form of small isolated grids around a locally available energy resource (a factory with surplus electricity generation capacity or a stream used for hydroelectric generation), or of individual diesel or gasoline generators (maybe converted to run on bio fuel that can be locally produced). Using renewable energy such as solar photovoltaic, wind electricity generators, hydropower or bio-fuelled power generation will simultaneously contribute to the improved security of energy supply and enhance sustainable development. While large centralised grid-based systems provide unique advantages in terms of economy of scale and access to large volumes of energy, they are not always the most cost-effective solution and they may be too expensive to cater for a poor population without being heavily subsidised.

[3] Negative impacts are moved from the immediate user level (toxics and soot), to regional level (eutrophication, acidification) to global level (climate change). The impacts are also shifted in time, from the directly inhaled, to the indirect effects on water and forests, to extremely complex and diffuse impacts on a global scale.

3 Even in times of large-scale deregulations and privatisations of providers of public services such as energy and transport, governments should continue to supervise the planning processes. Otherwise, there is a risk that the accessibility of important public sector functions and institutions is diminished. In particular rural and peri-urban health stations and schools appear to be affected, which is part of the explanation why they are routinely deprived of modern energy and transport services, while at the same time catering for the segments of the population with the usually least access to health care and education.

4 Government policy should include giving the same status, conditions and public backing to small private companies and cooperatives as to larger state utilities in servicing poor and dispersed populations. Locally based energy utilities can have the advantage of being flexible, sensitive and above all accountable to paying customers or members.

8. Conclusions

In order to properly understand and analyse energy systems in the peri-urban interface, the PUI need to be seen as a both a geographic area and as a set of dynamic interactions between the urban and the rural activities.

- The periurban interface is not only a physical place, but also an evolving process of social, economic and ecological transformation. The PUI is difficult to define, and more difficult to showcase. In this report, definitions and typology developed elsewhere was adapted.

- There is a lack of published information about PUI in general and energy sector in PUI in particular. However, several studies of social, economic and environmental aspects of the PUI also include energy aspects.

- The PUI is where one finds a mix of all available technical options for energy supply, compressed and with rapid evolution of the end user profile from rural to urban characteristics.

- In order to suggest possible improvements in energy services provision in the PUI, the specific institutional setting needs to be refined. Currently, the knowledge of formal institutional mandates over the periurban processes is fragmented and sometimes contradicting.

9. Questions for future research

This is a shortlist of what we would see as next steps for researchers trying to better understand the energy aspects of the PUI:

1. Further investigate whether or not it actually makes sense to treat PUI as something that cannot be defined within the context of sound urban and rural planning.

2. Conduct systematic field surveys to better grasp the time dimension in the PUI process in terms of energy systems evolution.

3. Identify tools for energy system analysis and planning that integrate aspects of spatial, social and economic dynamics that can capture the specificities of the PUI.

4. Tailor and deploy an energy model that incorporates the qualitative and diffuse aspects of the PUI such as quality of services, user access to influence on appropriate services and time series.

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